

TGD UNIVERSE AS
A CONSCIOUS HOLOGRAM

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Preface

This book belongs to a series of online books summarizing the recent state Topological Geometro-dynamics (TGD) and its applications. TGD can be regarded as a unified theory of fundamental interactions but is not the kind of unified theory as so called GUTs constructed by graduate students at seventies and eighties using detailed recipes for how to reduce everything to group theory. Nowadays this activity has been completely computerized and it probably takes only a few hours to print out the predictions of this kind of unified theory as an article in the desired format. TGD is something different and I am not ashamed to confess that I have devoted the last 32 years of my life to this enterprise and am still unable to write The Rules.

I got the basic idea of Topological Geometro-dynamics (TGD) during autumn 1978, perhaps it was October. What I realized was that the representability of physical space-times as 4-dimensional surfaces of some higher-dimensional space-time obtained by replacing the points of Minkowski space with some very small compact internal space could resolve the conceptual difficulties of general relativity related to the definition of the notion of energy. This belief was too optimistic and only with the advent of what I call zero energy ontology the understanding of the notion of Poincare invariance has become satisfactory.

It soon became clear that the approach leads to a generalization of the notion of space-time with particles being represented by space-time surfaces with finite size so that TGD could be also seen as a generalization of the string model. Much later it became clear that this generalization is consistent with conformal invariance only if space-time is 4-dimensional and the Minkowski space factor of imbedding space is 4-dimensional.

It took some time to discover that also the geometrization of also gauge interactions and elementary particle quantum numbers could be possible in this framework: it took two years to find the unique internal space providing this geometrization involving also the realization that family replication phenomenon for fermions has a natural topological explanation in TGD framework and that the symmetries of the standard model symmetries are much more profound than pragmatic TOE builders have believed them to be. If TGD is correct, main stream particle physics chose the wrong track leading to the recent deep crisis when people decided that quarks and leptons belong to same multiplet of the gauge group implying instability of proton.

There have been also longstanding problems.

- Gravitational energy is well-defined in cosmological models but is not conserved. Hence the conservation of the inertial energy does not seem to be consistent with the Equivalence Principle. Furthermore, the imbeddings of Robertson-Walker cosmologies turned out to be vacuum extremals with respect to the inertial energy. About 25 years was needed to realize that the sign of the inertial energy can be also negative and in cosmological scales the density of inertial energy vanishes: physically acceptable universes are creatable from vacuum. Eventually this led to the notion of zero energy ontology which deviates dramatically from the standard ontology being however consistent with the crossing symmetry of quantum field theories. In this framework the quantum numbers are assigned with zero energy states located at the boundaries of so called causal diamonds defined as intersections of future and past directed light-cones. The notion of energy-momentum becomes length scale dependent since one has a scale hierarchy for causal diamonds. This allows to understand the non-conservation of energy as apparent. Equivalence Principle generalizes and has a formulation in terms of coset representations of Super-Virasoro algebras providing also a justification for p-adic thermodynamics.
- From the beginning it was clear that the theory predicts the presence of long ranged classical electro-weak and color gauge fields and that these fields necessarily accompany classical electromagnetic fields. It took about 26 years to gain the maturity to admit the obvious: these fields are classical correlates for long range color and weak interactions assignable to dark matter. The only possible conclusion is that TGD physics is a fractal consisting of an entire hierarchy of fractal copies of standard model physics. Also the understanding of electro-weak massivation and screening of weak charges has been a long standing problem, and 32 years was needed to discover that what I call weak form of electric-magnetic duality gives a satisfactory solution of the problem and provides also surprisingly powerful insights to the mathematical structure of quantum TGD.

I started the serious attempts to construct quantum TGD after my thesis around 1982. The original optimistic hope was that path integral formalism or canonical quantization might be enough to construct the quantum theory but the first discovery made already during first year of TGD was that these formalisms might be useless due to the extreme non-linearity and enormous vacuum degeneracy of the theory. This turned out to be the case.

- It took some years to discover that the only working approach is based on the generalization of Einstein's program. Quantum physics involves the geometrization of the infinite-dimensional "world of classical worlds" (WCW) identified as 3-dimensional surfaces. Still few years had to pass before I understood that general coordinate invariance leads to a more or less unique solution of the problem and implies that space-time surfaces are analogous to Bohr orbits. Still a couple of years and I discovered that quantum states of the Universe can be identified as classical spinor fields in WCW. Only quantum jump remains the genuinely quantal aspect of quantum physics.
- During these years TGD led to a rather profound generalization of the space-time concept. Quite general properties of the theory led to the notion of many-sheeted space-time with sheets representing physical subsystems of various sizes. At the beginning of 90s I became dimly aware of the importance of p-adic number fields and soon ended up with the idea that p-adic thermodynamics for a conformally invariant system allows to understand elementary particle massivation with amazingly few input assumptions. The attempts to understand p-adicity from basic principles led gradually to the vision about physics as a generalized number theory as an approach complementary to the physics as an infinite-dimensional spinor geometry of WCW approach. One of its elements was a generalization of the number concept obtained by fusing real numbers and various p-adic numbers along common rationals. The number theoretical trinity involves besides p-adic number fields also quaternions and octonions and the notion of infinite prime.
- TGD inspired theory of consciousness entered the scheme after 1995 as I started to write a book about consciousness. Gradually it became difficult to say where physics ends and consciousness theory begins since consciousness theory could be seen as a generalization of quantum measurement theory by identifying quantum jump as a moment of consciousness and by replacing the observer with the notion of self identified as a system which is conscious as long as it can avoid entanglement with environment. "Everything is conscious and consciousness can be only lost" summarizes the basic philosophy neatly. The idea about p-adic physics as physics of cognition and intentionality emerged also rather naturally and implies perhaps the most dramatic generalization of the space-time concept in which most points of p-adic space-time sheets are infinite in real sense and the projection to the real imbedding space consists of discrete set of points. One of the most fascinating outcomes was the observation that the entropy based on p-adic norm can be negative. This observation led to the vision that life can be regarded as something in the intersection of real and p-adic worlds. Negentropic entanglement has interpretation as a correlate for various positively colored aspects of conscious experience and means also the possibility of strongly correlated states stable under state function reduction and different from the conventional bound states and perhaps playing key role in the energy metabolism of living matter.
- One of the latest threads in the evolution of ideas is only slightly more than six years old. Learning about the paper of Laurent Nottale about the possibility to identify planetary orbits as Bohr orbits with a gigantic value of gravitational Planck constant made once again possible to see the obvious. Dynamical quantized Planck constant is strongly suggested by quantum classical correspondence and the fact that space-time sheets identifiable as quantum coherence regions can have arbitrarily large sizes. During summer 2010 several new insights about the mathematical structure and interpretation of TGD emerged. One of these insights was the realization that the postulated hierarchy of Planck constants might follow from the basic structure of quantum TGD. The point is that due to the extreme non-linearity of the classical action principle the correspondence between canonical momentum densities and time derivatives of the imbedding space coordinates is one-to-many and the natural description of the situation is in terms of local singular covering spaces of the imbedding space. One could speak about effective value of Planck

constant coming as a multiple of its minimal value. The implications of the hierarchy of Planck constants are extremely far reaching so that the significance of the reduction of this hierarchy to the basic mathematical structure distinguishing between TGD and competing theories cannot be under-estimated.

From the point of view of particle physics the ultimate goal is of course a practical construction recipe for the S-matrix of the theory. I have myself regarded this dream as quite too ambitious taking into account how far reaching re-structuring and generalization of the basic mathematical structure of quantum physics is required. It has indeed turned out that the dream about explicit formula is unrealistic before one has understood what happens in quantum jump. Symmetries and general physical principles have turned out to be the proper guide line here. To give some impressions about what is required some highlights are in order.

- With the emergence of zero energy ontology the notion of S-matrix was replaced with M-matrix which can be interpreted as a complex square root of density matrix representable as a diagonal and positive square root of density matrix and unitary S-matrix so that quantum theory in zero energy ontology can be said to define a square root of thermodynamics at least formally.
- A decisive step was the strengthening of the General Coordinate Invariance to the requirement that the formulations of the theory in terms of light-like 3-surfaces identified as 3-surfaces at which the induced metric of space-time surfaces changes its signature and in terms of space-like 3-surfaces are equivalent. This means effective 2-dimensionality in the sense that partonic 2-surfaces defined as intersections of these two kinds of surfaces plus 4-D tangent space data at partonic 2-surfaces code for the physics. Quantum classical correspondence requires the coding of the quantum numbers characterizing quantum states assigned to the partonic 2-surfaces to the geometry of space-time surface. This is achieved by adding to the modified Dirac action a measurement interaction term assigned with light-like 3-surfaces.
- The replacement of strings with light-like 3-surfaces equivalent to space-like 3-surfaces means enormous generalization of the super conformal symmetries of string models. A further generalization of these symmetries to non-local Yangian symmetries generalizing the recently discovered Yangian symmetry of $\mathcal{N} = 4$ supersymmetric Yang-Mills theories is highly suggestive. Here the replacement of point like particles with partonic 2-surfaces means the replacement of conformal symmetry of Minkowski space with infinite-dimensional super-conformal algebras. Yangian symmetry provides also a further refinement to the notion of conserved quantum numbers allowing to define them for bound states using non-local energy conserved currents.
- A further attractive idea is that quantum TGD reduces to almost topological quantum field theory. This is possible if the Kähler action for the preferred extremals defining WCW Kähler function reduces to a 3-D boundary term. This takes place if the conserved currents are so called Beltrami fields with the defining property that the coordinates associated with flow lines extend to single global coordinate variable. This ansatz together with the weak form of electric-magnetic duality reduces the Kähler action to Chern-Simons term with the condition that the 3-surfaces are extremals of Chern-Simons action subject to the constraint force defined by the weak form of electric magnetic duality. It is the latter constraint which prevents the trivialization of the theory to a topological quantum field theory. Also the identification of the Kähler function of WCW as Dirac determinant finds support as well as the description of the scattering amplitudes in terms of braids with interpretation in terms of finite measurement resolution coded to the basic structure of the solutions of field equations.
- In standard QFT Feynman diagrams provide the description of scattering amplitudes. The beauty of Feynman diagrams is that they realize unitarity automatically via the so called Cutkosky rules. In contrast to Feynman's original beliefs, Feynman diagrams and virtual particles are taken only as a convenient mathematical tool in quantum field theories. QFT approach is however plagued by UV and IR divergences and one must keep mind open for the possibility that a genuine progress might mean opening of the black box of the virtual particle.

In TGD framework this generalization of Feynman diagrams indeed emerges unavoidably. Light-like 3-surfaces replace the lines of Feynman diagrams and vertices are replaced by 2-D partonic

2-surfaces. Zero energy ontology and the interpretation of parton orbits as light-like "wormhole throats" suggests that virtual particles do not differ from mass shell particles only in that the four- and three- momenta of wormhole throats fail to be parallel. The two throats of the wormhole defining virtual particle would contact carry on mass shell quantum numbers but for virtual particles the four-momenta need not be parallel and can also have opposite signs of energy. Modified Dirac equation suggests a number theoretical quantization of the masses of the virtual particles. The kinematic constraints on the virtual momenta are extremely restrictive and reduce the dimension of the sub-space of virtual momenta and if massless particles are not allowed (IR cutoff provided by zero energy ontology naturally), the number of Feynman diagrams contributing to a particular kind of scattering amplitude is finite and manifestly UV and IR finite and satisfies unitarity constraint in terms of Cutkosky rules. What is remarkable that fermionic propagators are massless propagators but for on mass shell four-momenta. This gives a connection with the twistor approach and inspires the generalization of the Yangian symmetry to infinite-dimensional super-conformal algebras.

What I have said above is strongly biased view about the recent situation in quantum TGD and I have left all about applications to the introductions of the books whose purpose is to provide a bird's eye view about TGD as it is now. This vision is single man's view and doomed to contain unrealistic elements as I know from experience. My dream is that young critical readers could take this vision seriously enough to try to demonstrate that some of its basic premises are wrong or to develop an alternative based on these or better premises. I must be however honest and tell that 32 years of TGD is a really vast bundle of thoughts and quite a challenge for anyone who is not able to cheat himself by taking the attitude of a blind believer or a light-hearted debunker trusting on the power of easy rhetoric tricks.

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The collaboration with Lian Sidorov was extremely fruitful and she also helped me to survive economically through the hardest years. The participation to CASYS conferences in Liege has been an important window to the academic world and I am grateful for Daniel Dubois and Peter Marcer for making this participation possible. The discussions and collaboration with Eduardo de Luna and Istvan Dienes stimulated the hope that the communication of new vision might not be a mission impossible after all. Also blog discussions have been very useful. During these years I have received innumerable email contacts from people around the world. In particular, I am grateful for Mark McWilliams and Ulla Matfolk for providing links to possibly interesting web sites and articles. These contacts have helped me to avoid the depressive feeling of being some kind of Don Quixote of Science and helped me to widen my views: I am grateful for all these people.

In the situation in which the conventional scientific communication channels are strictly closed it is important to have some loop hole through which the information about the work done can at

least in principle leak to the publicity through the iron wall of the academic censorship. Without any exaggeration I can say that without the world wide web I would not have survived as a scientist nor as individual. Homepage and blog are however not enough since only the formally published result is a result in recent day science. Publishing is however impossible without a direct support from power holders- even in archives like arXiv.org.

Situation changed for five years ago as Andrew Adamatsky proposed the writing of a book about TGD when I had already got used to the thought that my work would not be published during my life time. The Prespacetime Journal and two other journals related to quantum biology and consciousness - all of them founded by Huping Hu - have provided this kind of loop holes. In particular, Dainis Zeps, Phil Gibbs, and Arkadiusz Jadczyk deserve my gratitude for their kind help in the preparation of an article series about TGD catalyzing a considerable progress in the understanding of quantum TGD. Also the viXra archive founded by Phil Gibbs and its predecessor Archive Freedom have been of great help: Victor Christianto deserves special thanks for doing the hard work needed to run Archive Freedom. Also the Neuroquantology Journal founded by Sultan Tarlaci deserves a special mention for its publication policy. And last but not least: there are people who experience as a fascinating intellectual challenge to spoil the practical working conditions of a person working with something which might be called unified theory: I am grateful for the people who have helped me to survive through the virus attacks, an activity which has taken roughly one month per year during the last half decade and given a strong hue of grey to my hair.

For a person approaching his sixty year birthday it is somewhat easier to overcome the hard feelings due to the loss of academic human rights than for an inpatient youngster. Unfortunately the economic situation has become increasingly difficult during the twenty years after the economic depression in Finland which in practice meant that Finland ceased to be a constitutional state in the strong sense of the word. It became possible to depose people like me from the society without fear about public reactions and the classification as dropout became a convenient tool of ridicule to circumvent the ethical issues. During last few years when the right wing has held the political power this trend has been steadily strengthening. In this kind of situation the concrete help from individuals has been and will be of utmost importance. Against this background it becomes obvious that this kind of work is not possible without the support from outside and I apologize for not being able to mention all the people who have helped me during these years.

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Chapter 1

Introduction

1.1 Basic Ideas of TGD

The basic physical picture behind TGD was formed as a fusion of two rather disparate approaches: namely TGD as a Poincare invariant theory of gravitation and TGD as a generalization of the old-fashioned string model.

1.1.1 Background

T(opological) G(eometro)D(ynamics) is one of the many attempts to find a unified description of basic interactions. The development of the basic ideas of TGD to a relatively stable form took time of about half decade [K2]. The great challenge is to construct a mathematical theory around these physically very attractive ideas and I have devoted the last twenty-three years for the realization of this dream and this has resulted in seven online books about TGD and eight online books about TGD inspired theory of consciousness and of quantum biology.

Quantum *T(opological) G(eometro)D(ynamics)* as a classical spinor geometry for infinite-dimensional configuration space, p-adic numbers and quantum TGD, and TGD inspired theory of consciousness and of quantum biology have been for last decade of the second millenium the basic three strongly interacting threads in the tapestry of quantum TGD.

For few years ago the discussions with Tony Smith initiated a fourth thread which deserves the name 'TGD as a generalized number theory'. The basic observation was that classical number fields might allow a deeper formulation of quantum TGD. The work with Riemann hypothesis made time ripe for realization that the notion of infinite primes could provide, not only a reformulation, but a deep generalization of quantum TGD. This led to a thorough and extremely fruitful revision of the basic views about what the final form and physical content of quantum TGD might be. Together with the vision about the fusion of p-adic and real physics to a larger coherent structure these sub-threads fused to the "physics as generalized number theory" th

A further thread emerged from the realization that by quantum classical correspondence TGD predicts an infinite hierarchy of macroscopic quantum systems with increasing sizes, that it is not at all clear whether standard quantum mechanics can accommodate this hierarchy, and that a dynamical quantized Planck constant might be necessary and certainly possible in TGD framework. The identification of hierarchy of Planck constants whose values TGD "predicts" in terms of dark matter hierarchy would be natural. This also led to a solution of a long standing puzzle: what is the proper interpretation of the predicted fractal hierarchy of long ranged classical electro-weak and color gauge fields. Quantum classical correspondences allows only single answer: there is infinite hierarchy of p-adically scaled up variants of standard model physics and for each of them also dark hierarchy. Thus TGD Universe would be fractal in very abstract and deep sense.

Every updating of the books makes me frustrated as I see how badly the structure of the representation reflects my bird's eye of view as it is at the moment of updating. At this time I realized that the chronology based identification of the threads is quite natural but not logical and it is much more logical to see p-adic physics, the ideas related to classical number fields, and infinite primes as sub-threads of a thread which might be called "physics as a generalized number theory". In the

following I adopt this view. This reduces the number of threads to four! I am not even sure about the number of threads! Be patient!

TGD forces the generalization of physics to a quantum theory of consciousness, and represent TGD as a generalized number theory vision leads naturally to the emergence of p-adic physics as physics of cognitive representations. The seven online books [K89, K67, K53, K49, K68, K77, K75] about TGD and eight online books about TGD inspired theory of consciousness and of quantum biology [K82, K12, K60, K10, K34, K41, K44, K74] are warmly recommended to the interested reader.

1.1.2 TGD as a Poincare invariant theory of gravitation

The first approach was born as an attempt to construct a Poincare invariant theory of gravitation. Space-time, rather than being an abstract manifold endowed with a pseudo-Riemannian structure, is regarded as a surface in the 8-dimensional space $H = M^4 \times CP_2$, where M^4 denotes Minkowski space and $CP_2 = SU(3)/U(2)$ is the complex projective space of two complex dimensions [A15, A4, A10, A3].

The identification of the space-time as a submanifold [A2, A14] of $M^4 \times CP_2$ leads to an exact Poincare invariance and solves the conceptual difficulties related to the definition of the energy-momentum in General Relativity.

It soon however turned out that submanifold geometry, being considerably richer in structure than the abstract manifold geometry, leads to a geometrization of all basic interactions. First, the geometrization of the elementary particle quantum numbers is achieved. The geometry of CP_2 explains electro-weak and color quantum numbers. The different H-chiralities of H -spinors correspond to the conserved baryon and lepton numbers. Secondly, the geometrization of the field concept results. The projections of the CP_2 spinor connection, Killing vector fields of CP_2 and of H -metric to four-surface define classical electro-weak, color gauge fields and metric in X^4 .

1.1.3 TGD as a generalization of the hadronic string model

The second approach was based on the generalization of the mesonic string model describing mesons as strings with quarks attached to the ends of the string. In the 3-dimensional generalization 3-surfaces correspond to free particles and the boundaries of the 3- surface correspond to partons in the sense that the quantum numbers of the elementary particles reside on the boundaries. Various boundary topologies (number of handles) correspond to various fermion families so that one obtains an explanation for the known elementary particle quantum numbers. This approach leads also to a natural topological description of the particle reactions as topology changes: for instance, two-particle decay corresponds to a decay of a 3-surface to two disjoint 3-surfaces.

This decay vertex does not however correspond to a direct generalization of trouser vertex of string models. Indeed, the important difference between TGD and string models is that the analogs of string world sheet diagrams do not describe particle decays but the propagation of particles via different routes. Particle reactions are described by generalized Feynman diagrams for which 3-D light-like surface describing particle propagating join along their ends at vertices. As 4-manifolds the space-time surfaces are therefore singular like Feynman diagrams as 1-manifolds.

1.1.4 Fusion of the two approaches via a generalization of the space-time concept

The problem is that the two approaches to TGD seem to be mutually exclusive since the orbit of a particle like 3-surface defines 4-dimensional surface, which differs drastically from the topologically trivial macroscopic space-time of General Relativity. The unification of these approaches forces a considerable generalization of the conventional space-time concept. First, the topologically trivial 3-space of General Relativity is replaced with a "topological condensate" containing matter as particle like 3-surfaces "glued" to the topologically trivial background 3-space by connected sum operation. Secondly, the assumption about connectedness of the 3-space is given up. Besides the "topological condensate" there could be "vapor phase" that is a "gas" of particle like 3-surfaces (counterpart of the "baby universes" of GRT) and the nonconservation of energy in GRT corresponds to the transfer of energy between the topological condensate and vapor phase.

What one obtains is what I have christened as many-sheeted space-time. One particular aspect is topological field quantization meaning that various classical fields assignable to a physical system

correspond to space-time sheets representing the classical fields to that particular system. One can speak of the field body of a particular physical system. Field body consists of topological light rays, and electric and magnetic flux quanta. In Maxwell's theory system does not possess this kind of field identity. The notion of magnetic body is one of the key players in TGD inspired theory of consciousness and quantum biology.

This picture became more detailed with the advent of zero energy ontology (ZEO). The basic notion of ZEO is causal diamond (CD) identified as the Cartesian product of CP_2 and of the intersection of future and past directed light-cones and having scale coming as an integer multiple of CP_2 size is fundamental. CD s form a fractal hierarchy and zero energy states decompose to products of positive and negative energy parts assignable to the opposite boundaries of CD defining the ends of the space-time surface. The counterpart of zero energy state in positive energy ontology is in terms of initial and final states of a physical event, say particle reaction.

General Coordinate Invariance allows to identify the basic dynamical objects as space-like 3-surfaces at the ends of space-time surface at boundaries of CD : this means that space-time surface is analogous to Bohr orbit. An alternative identification is as light-like 3-surfaces at which the signature of the induced metric changes from Minkowskian to Euclidian and interpreted as lines of generalized Feynman diagrams. Also the Euclidian 4-D regions would have similar interpretation. The requirement that the two interpretations are equivalent, leads to a strong form of General Coordinate Invariance. The outcome is effective 2-dimensionality stating that the partonic 2-surfaces identified as intersections of the space-like ends of space-time surface and light-like wormhole throats are the fundamental objects. That only effective 2-dimensionality is in question is due to the effects caused by the failure of strict determinism of Kähler action. In finite length scale resolution these effects can be neglected below UV cutoff and above IR cutoff. One can also speak about strong form of holography.

There is a further generalization of the space-time concept inspired by p-adic physics forcing a generalization of the number concept through the fusion of real numbers and various p-adic number fields. Also the hierarchy of Planck constants forces a generalization of the notion of space-time.

A very concise manner to express how TGD differs from Special and General Relativities could be following. Relativity Principle (Poincare Invariance), General Coordinate Invariance, and Equivalence Principle remain true. What is new is the notion of sub-manifold geometry: this allows to realize Poincare Invariance and geometrize gravitation simultaneously. This notion also allows a geometrization of known fundamental interactions and is an essential element of all applications of TGD ranging from Planck length to cosmological scales. Sub-manifold geometry is also crucial in the applications of TGD to biology and consciousness theory.

The worst objection against TGD is the observation that all classical gauge fields are expressible in terms of four imbedding space coordinates only- essentially CP_2 coordinates. The linear superposition of classical gauge fields taking place independently for all gauge fields is lost. This would be a catastrophe without many-sheeted space-time. Instead of gauge fields, only the effects such as gauge forces are superposed. Particle topologically condenses to several space-time sheets simultaneously and experiences the sum of gauge forces. This transforms the weakness to extreme economy: in a typical unified theory the number of primary field variables is countered in hundreds if not thousands, now it is just four.

1.2 The threads in the development of quantum TGD

The development of TGD has involved several strongly interacting threads: physics as infinite-dimensional geometry; TGD as a generalized number theory, the hierarchy of Planck constants interpreted in terms of dark matter hierarchy, and TGD inspired theory of consciousness. In the following these threads are briefly described.

1.2.1 Quantum TGD as spinor geometry of World of Classical Worlds

A turning point in the attempts to formulate a mathematical theory was reached after seven years from the birth of TGD. The great insight was "Do not quantize". The basic ingredients to the new approach have served as the basic philosophy for the attempt to construct Quantum TGD since then and have been the following ones:

1. Quantum theory for extended particles is free(!), classical(!) field theory for a generalized Schrödinger amplitude in the configuration space CH consisting of all possible 3-surfaces in H . "All possible" means that surfaces with arbitrary many disjoint components and with arbitrary internal topology and also singular surfaces topologically intermediate between two different manifold topologies are included. Particle reactions are identified as topology changes [A9, A17, A19]. For instance, the decay of a 3-surface to two 3-surfaces corresponds to the decay $A \rightarrow B + C$. Classically this corresponds to a path of configuration space leading from 1-particle sector to 2-particle sector. At quantum level this corresponds to the dispersion of the generalized Schrödinger amplitude localized to 1-particle sector to two-particle sector. All coupling constants should result as predictions of the theory since no nonlinearities are introduced.
2. During years this naive and very rough vision has of course developed a lot and is not anymore quite equivalent with the original insight. In particular, the space-time correlates of Feynman graphs have emerged from theory as Euclidian space-time regions and the strong form of General Coordinate Invariance has led to a rather detailed and in many respects un-expected visions. This picture forces to give up the idea about smooth space-time surfaces and replace space-time surface with a generalization of Feynman diagram in which vertices represent the failure of manifold property. I have also started introduced the word "world of classical worlds" (WCW) instead of rather formal "configuration space". I hope that "WCW" does not induce despair in the reader having tendency to think about the technicalities involved!
3. WCW is endowed with metric and spinor structure so that one can define various metric related differential operators, say Dirac operator, appearing in the field equations of the theory. The most ambitious dream is that zero energy states correspond to a complete solution basis for the Dirac operator of WCW so that this classical free field theory would dictate M-matrices which form orthonormal rows of what I call U-matrix. Given M-matrix in turn would decompose to a product of a hermitian density matrix and unitary S-matrix.

M-matrix would define time-like entanglement coefficients between positive and negative energy parts of zero energy states (all net quantum numbers vanish for them) and can be regarded as a hermitian square root of density matrix multiplied by a unitary S-matrix. Quantum theory would be in well-defined sense a square root of thermodynamics. The orthogonality and hermiticity of the complex square roots of density matrices commuting with S-matrix means that they span infinite-dimensional Lie algebra acting as symmetries of the S-matrix. Therefore quantum TGD would reduce to group theory in well-defined sense: its own symmetries would define the symmetries of the theory. In fact the Lie algebra of Hermitian M-matrices extends to Kac-Moody type algebra obtained by multiplying hermitian square roots of density matrices with powers of the S-matrix. Also the analog of Yangian algebra involving only non-negative powers of S-matrix is possible.

4. By quantum classical correspondence the construction of WCW spinor structure reduces to the second quantization of the induced spinor fields at space-time surface. The basic action is so called modified Dirac action in which gamma matrices are replaced with the modified gamma matrices defined as contractions of the canonical momentum currents with the imbedding space gamma matrices. In this manner one achieves super-conformal symmetry and conservation of fermionic currents among other things and consistent Dirac equation. This modified gamma matrices define as anticommutators effective metric, which might provide geometrization for some basic observables of condensed matter physics. The conjecture is that Dirac determinant for the modified Dirac action gives the exponent of Kähler action for a preferred extremal as vacuum functional so that one might talk about bosonic emergence in accordance with the prediction that the gauge bosons and graviton are expressible in terms of bound states of fermion and antifermion.

The evolution of these basic ideas has been rather slow but has gradually led to a rather beautiful vision. One of the key problems has been the definition of Kähler function. Kähler function is Kähler action for a preferred extremal assignable to a given 3-surface but what this preferred extremal is? The obvious first guess was as absolute minimum of Kähler action but could not be proven to be right or wrong. One big step in the progress was boosted by the idea that TGD should reduce to almost topological QFT in which braids would replace 3-surfaces in finite measurement resolution, which could

be inherent property of the theory itself and imply discretization at partonic 2-surfaces with discrete points carrying fermion number.

1. TGD as almost topological QFT vision suggests that Kähler action for preferred extremals reduces to Chern-Simons term assigned with space-like 3-surfaces at the ends of space-time (recall the notion of causal diamond (CD)) and with the light-like 3-surfaces at which the signature of the induced metric changes from Minkowskian to Euclidian. Minkowskian and Euclidian regions would give at wormhole throats the same contribution apart from coefficients and in Minkowskian regions the $\sqrt{g_4}$ factor would be imaginary so that one would obtain sum of real term identifiable as Kähler function and imaginary term identifiable as the ordinary action giving rise to interference effects and stationary phase approximation central in both classical and quantum field theory. Imaginary contribution - the presence of which I realized only after 33 years of TGD - could also have topological interpretation as a Morse function. On physical side the emergence of Euclidian space-time regions is something completely new and leads to a dramatic modification of the ideas about black hole interior.
2. The manner to achieve the reduction to Chern-Simons terms is simple. The vanishing of Coulombic contribution to Kähler action is required and is true for all known extremals if one makes a general ansatz about the form of classical conserved currents. The so called weak form of electric-magnetic duality defines a boundary condition reducing the resulting 3-D terms to Chern-Simons terms. In this manner almost topological QFT results. But only "almost" since the Lagrange multiplier term forcing electric-magnetic duality implies that Chern-Simons action for preferred extremals depends on metric.
3. A further quite recent hypothesis inspired by effective 2-dimensionality is that Chern-Simons terms reduce to a sum of two 2-dimensional terms. An imaginary term proportional to the total area of Minkowskian string world sheets and a real term proportional to the total area of partonic 2-surfaces or equivalently strings world sheets in Euclidian space-time regions. Also the equality of the total areas of strings world sheets and partonic 2-surfaces is highly suggestive and would realize a duality between these two kinds of objects. String world sheets indeed emerge naturally for the proposed ansatz defining preferred extremals. Therefore Kähler action would have very stringy character apart from effects due to the failure of the strict determinism meaning that radiative corrections break the effective 2-dimensionality.

1.2.2 TGD as a generalized number theory

Quantum T(opological)D(ynamics) as a classical spinor geometry for infinite-dimensional configuration space, p-adic numbers and quantum TGD, and TGD inspired theory of consciousness, have been for last ten years the basic three strongly interacting threads in the tapestry of quantum TGD. The fourth thread deserves the name 'TGD as a generalized number theory'. It involves three separate threads: the fusion of real and various p-adic physics to a single coherent whole by requiring number theoretic universality discussed already, the formulation of quantum TGD in terms of hyper-counterparts of classical number fields identified as sub-spaces of complexified classical number fields with Minkowskian signature of the metric defined by the complexified inner product, and the notion of infinite prime.

p-Adic TGD and fusion of real and p-adic physics to single coherent whole

The p-adic thread emerged for roughly ten years ago as a dim hunch that p-adic numbers might be important for TGD. Experimentation with p-adic numbers led to the notion of canonical identification mapping reals to p-adics and vice versa. The breakthrough came with the successful p-adic mass calculations using p-adic thermodynamics for Super-Virasoro representations with the super-Kac-Moody algebra associated with a Lie-group containing standard model gauge group. Although the details of the calculations have varied from year to year, it was clear that p-adic physics reduces not only the ratio of proton and Planck mass, the great mystery number of physics, but all elementary particle mass scales, to number theory if one assumes that primes near prime powers of two are in a physically favored position. Why this is the case, became one of the key puzzles and led to a number

of arguments with a common gist: evolution is present already at the elementary particle level and the primes allowed by the p-adic length scale hypothesis are the fittest ones.

It became very soon clear that p-adic topology is not something emerging in Planck length scale as often believed, but that there is an infinite hierarchy of p-adic physics characterized by p-adic length scales varying to even cosmological length scales. The idea about the connection of p-adics with cognition motivated already the first attempts to understand the role of the p-adics and inspired 'Universe as Computer' vision but time was not ripe to develop this idea to anything concrete (p-adic numbers are however in a central role in TGD inspired theory of consciousness). It became however obvious that the p-adic length scale hierarchy somehow corresponds to a hierarchy of intelligences and that p-adic prime serves as a kind of intelligence quotient. Ironically, the almost obvious idea about p-adic regions as cognitive regions of space-time providing cognitive representations for real regions had to wait for almost a decade for the access into my consciousness.

There were many interpretational and technical questions crying for a definite answer.

1. What is the relationship of p-adic non-determinism to the classical non-determinism of the basic field equations of TGD? Are the p-adic space-time region genuinely p-adic or does p-adic topology only serve as an effective topology? If p-adic physics is direct image of real physics, how the mapping relating them is constructed so that it respects various symmetries? Is the basic physics p-adic or real (also real TGD seems to be free of divergences) or both? If it is both, how should one glue the physics in different number field together to get *The Physics*? Should one perform p-adicization also at the level of the configuration space of 3-surfaces? Certainly the p-adicization at the level of super-conformal representation is necessary for the p-adic mass calculations.
2. Perhaps the most basic and most irritating technical problem was how to precisely define p-adic definite integral which is a crucial element of any variational principle based formulation of the field equations. Here the frustration was not due to the lack of solution but due to the too large number of solutions to the problem, a clear symptom for the sad fact that clever inventions rather than real discoveries might be in question. Quite recently I however learned that the problem of making sense about p-adic integration has been for decades central problem in the frontier of mathematics and a lot of profound work has been done along same intuitive lines as I have proceeded in TGD framework. The basic idea is certainly the notion of algebraic continuation from the world of rationals belonging to the intersection of real world and various p-adic worlds.

Despite these frustrating uncertainties, the number of the applications of the poorly defined p-adic physics grew steadily and the applications turned out to be relatively stable so that it was clear that the solution to these problems must exist. It became only gradually clear that the solution of the problems might require going down to a deeper level than that represented by reals and p-adics.

The key challenge is to fuse various p-adic physics and real physics to single larger structures. This has inspired a proposal for a generalization of the notion of number field by fusing real numbers and various p-adic number fields and their extensions along rationals and possible common algebraic numbers. This leads to a generalization of the notions of imbedding space and space-time concept and one can speak about real and p-adic space-time sheets. The quantum dynamics should be such that it allows quantum transitions transforming space-time sheets belonging to different number fields to each other. The space-time sheets in the intersection of real and p-adic worlds are of special interest and the hypothesis is that living matter resides in this intersection. This leads to surprisingly detailed predictions and far reaching conjectures. For instance, the number theoretic generalization of entropy concept allows negentropic entanglement central for the applications to living matter.

The basic principle is number theoretic universality stating roughly that the physics in various number fields can be obtained as completion of rational number based physics to various number fields. Rational number based physics would in turn describe physics in finite measurement resolution and cognitive resolution. The notion of finite measurement resolution has become one of the basic principles of quantum TGD and leads to the notions of braids as representatives of 3-surfaces and inclusions of hyper-finite factors as a representation for finite measurement resolution.

The role of classical number fields

The vision about the physical role of the classical number fields relies on the notion of number theoretic compactification stating that space-time surfaces can be regarded as surfaces of either M^8 or $M^4 \times CP_2$. As surfaces of M^8 identifiable as space of hyper-octonions they are hyper-quaternionic or co-hyper-quaternionic- and thus maximally associative or co-associative. This means that their tangent space is either hyper-quaternionic plane of M^8 or an orthogonal complement of such a plane. These surface can be mapped in natural manner to surfaces in $M^4 \times CP_2$ [K80] provided one can assign to each point of tangent space a hyper-complex plane $M^2(x) \subset M^4$. One can also speak about $M^8 - H$ duality.

This vision has very strong predictive power. It predicts that the extremals of Kähler action correspond to either hyper-quaternionic or co-hyper-quaternionic surfaces such that one can assign to tangent space at each point of space-time surface a hyper-complex plane $M^2(x) \subset M^4$. As a consequence, the M^4 projection of space-time surface at each point contains $M^2(x)$ and its orthogonal complement. These distributions are integrable implying that space-time surface allows dual slicings defined by string world sheets Y^2 and partonic 2-surfaces X^2 . The existence of this kind of slicing was earlier deduced from the study of extremals of Kähler action and christened as Hamilton-Jacobi structure. The physical interpretation of $M^2(x)$ is as the space of non-physical polarizations and the plane of local 4-momentum.

One can fairly say, that number theoretical compactification is responsible for most of the understanding of quantum TGD that has emerged during last years. This includes the realization of Equivalence Principle at space-time level, dual formulations of TGD as Minkowskian and Euclidian string model type theories, the precise identification of preferred extremals of Kähler action as extremals for which second variation vanishes (at least for deformations representing dynamical symmetries) and thus providing space-time correlate for quantum criticality, the notion of number theoretic braid implied by the basic dynamics of Kähler action and crucial for precise construction of quantum TGD as almost-topological QFT, the construction of configuration space metric and spinor structure in terms of second quantized induced spinor fields with modified Dirac action defined by Kähler action realizing automatically the notion of finite measurement resolution and a connection with inclusions of hyper-finite factors of type II_1 about which Clifford algebra of configuration space represents an example.

The two most important number theoretic conjectures relate to the preferred extremals of Kähler action. The general idea is that classical dynamics for the preferred extremals of Kähler action should reduce to number theory: space-time surfaces should be either associative or co-associative in some sense.

1. The first meaning for associativity (co-associativity) would be that tangent (normal) spaces of space-time surfaces are quaternionic in some sense and thus associative. This can be formulated in terms of octonionic representation of the imbedding space gamma matrices possible in dimension $D = 8$ and states that induced gamma matrices generate quaternionic sub-algebra at each space-time point. It seems that induced rather than modified gamma matrices must be in question.
2. Second meaning for associative (co-associativity) would be following. In the case of complex numbers the vanishing of the real part of real-analytic function defines a 1-D curve. In octonionic case one can decompose octonion to sum of quaternion and quaternion multiplied by an octonionic imaginary unit. Quaternionicity could mean that space-time surfaces correspond to the vanishing of the imaginary part of the octonion real-analytic function. Co-quaternionicity would be defined in an obvious manner. Octonionic real analytic functions form a function field closed also with respect to the composition of functions. Space-time surfaces would form the analog of function field with the composition of functions with all operations realized as algebraic operations for space-time surfaces. Co-associativity could be perhaps seen as an additional feature making the algebra in question also co-algebra.
3. The third conjecture is that these conjectures are equivalent.

Infinite primes

The discovery of the hierarchy of infinite primes and their correspondence with a hierarchy defined by a repeatedly second quantized arithmetic quantum field theory gave a further boost for the speculations

about TGD as a generalized number theory. The work with Riemann hypothesis led to further ideas.

After the realization that infinite primes can be mapped to polynomials representable as surfaces geometrically, it was clear how TGD might be formulated as a generalized number theory with infinite primes forming the bridge between classical and quantum such that real numbers, p-adic numbers, and various generalizations of p-adics emerge dynamically from algebraic physics as various completions of the algebraic extensions of rational (hyper-)quaternions and (hyper-)octonions. Complete algebraic, topological and dimensional democracy would characterize the theory.

What is especially satisfying is that p-adic and real regions of the space-time surface could emerge automatically as solutions of the field equations. In the space-time regions where the solutions of field equations give rise to in-admissible complex values of the imbedding space coordinates, p-adic solution can exist for some values of the p-adic prime. The characteristic non-determinism of the p-adic differential equations suggests strongly that p-adic regions correspond to 'mind stuff', the regions of space-time where cognitive representations reside. This interpretation implies that p-adic physics is physics of cognition. Since Nature is probably an extremely brilliant simulator of Nature, the natural idea is to study the p-adic physics of the cognitive representations to derive information about the real physics. This view encouraged by TGD inspired theory of consciousness clarifies difficult interpretational issues and provides a clear interpretation for the predictions of p-adic physics.

1.2.3 Hierarchy of Planck constants and dark matter hierarchy

By quantum classical correspondence space-time sheets can be identified as quantum coherence regions. Hence the fact that they have all possible size scales more or less unavoidably implies that Planck constant must be quantized and have arbitrarily large values. If one accepts this then also the idea about dark matter as a macroscopic quantum phase characterized by an arbitrarily large value of Planck constant emerges naturally as does also the interpretation for the long ranged classical electro-weak and color fields predicted by TGD. Rather seldom the evolution of ideas follows simple linear logic, and this was the case also now. In any case, this vision represents the fifth, relatively new thread in the evolution of TGD and the ideas involved are still evolving.

Dark matter as large \hbar phase

D. Da Rocha and Laurent Nottale [E6] have proposed that Schrödinger equation with Planck constant \hbar replaced with what might be called gravitational Planck constant $\hbar_{gr} = \frac{GmM}{v_0}$ ($\hbar = c = 1$). v_0 is a velocity parameter having the value $v_0 = 144.7 \pm .7$ km/s giving $v_0/c = 4.6 \times 10^{-4}$. This is rather near to the peak orbital velocity of stars in galactic halos. Also subharmonics and harmonics of v_0 seem to appear. The support for the hypothesis coming from empirical data is impressive.

Nottale and Da Rocha believe that their Schrödinger equation results from a fractal hydrodynamics. Many-sheeted space-time however suggests astrophysical systems are not only quantum systems at larger space-time sheets but correspond to a gigantic value of gravitational Planck constant. The gravitational (ordinary) Schrödinger equation would provide a solution of the black hole collapse (IR catastrophe) problem encountered at the classical level. The resolution of the problem inspired by TGD inspired theory of living matter is that it is the dark matter at larger space-time sheets which is quantum coherent in the required time scale [K72].

TGD predicts correctly the value of the parameter v_0 assuming that cosmic strings and their decay remnants are responsible for the dark matter. The harmonics of v_0 can be understood as corresponding to perturbations replacing cosmic strings with their n-branched coverings so that tension becomes n^2 -fold: much like the replacement of a closed orbit with an orbit closing only after n turns. $1/n$ -sub-harmonic would result when a magnetic flux tube split into n disjoint magnetic flux tubes. Also a model for the formation of planetary system as a condensation of ordinary matter around quantum coherent dark matter emerges [K72].

The values of Planck constants postulated by Nottale are gigantic and it is natural to assign them to the space-time sheets mediating gravitational interaction and identifiable as magnetic flux tubes (quanta). The magnetic energy of these flux quanta would correspond to dark energy and magnetic tension would give rise to negative "pressure" forcing accelerate cosmological expansion. This leads to a rather detailed vision about the evolution of stars and galaxies identified as bubbles of ordinary and dark matter inside magnetic flux tubes identifiable as dark energy.

Hierarchy of Planck constants from the anomalies of neuroscience biology

The quantal effects of ELF em fields on vertebrate brain have been known since seventies. ELF em fields at frequencies identifiable as cyclotron frequencies in magnetic field whose intensity is about 2/5 times that of Earth for biologically important ions have physiological effects and affect also behavior. What is intriguing that the effects are found only in vertebrates (to my best knowledge). The energies for the photons of ELF em fields are extremely low - about 10^{-10} times lower than thermal energy at physiological temperatures- so that quantal effects are impossible in the framework of standard quantum theory. The values of Planck constant would be in these situations large but not gigantic.

This inspired the hypothesis that these photons correspond to so large value of Planck constant that the energy of photons is above the thermal energy. The proposed interpretation was as dark photons and the general hypothesis was that dark matter corresponds to ordinary matter with non-standard value of Planck constant. If only particles with the same value of Planck constant can appear in the same vertex of Feynman diagram, the phases with different value of Planck constant are dark relative to each other. The phase transitions changing Planck constant can however make possible interactions between phases with different Planck constant but these interactions do not manifest themselves in particle physics. Also the interactions mediated by classical fields should be possible. Dark matter would not be so dark as we have used to believe.

Also the anomalies of biology support the view that dark matter might be a key player in living matter.

Does the hierarchy of Planck constants reduce to the vacuum degeneracy of Kähler action?

This starting point led gradually to the recent picture in which the hierarchy of Planck constants is postulated to come as integer multiples of the standard value of Planck constant. Given integer multiple $\hbar = n\hbar_0$ of the ordinary Planck constant \hbar_0 is assigned with a multiple singular covering of the imbedding space [K29]. One ends up to an identification of dark matter as phases with non-standard value of Planck constant having geometric interpretation in terms of these coverings providing generalized imbedding space with a book like structure with pages labelled by Planck constants or integers characterizing Planck constant. The phase transitions changing the value of Planck constant would correspond to leakage between different sectors of the extended imbedding space. The question is whether these coverings must be postulated separately or whether they are only a convenient auxiliary tool.

The simplest option is that the hierarchy of coverings of imbedding space is only effective. Many-sheeted coverings of the imbedding space indeed emerge naturally in TGD framework. The huge vacuum degeneracy of Kähler action implies that the relationship between gradients of the imbedding space coordinates and canonical momentum currents is many-to-one: this was the very fact forcing to give up all the standard quantization recipes and leading to the idea about physics as geometry of the "world of classical worlds". If one allows space-time surfaces for which all sheets corresponding to the same values of the canonical momentum currents are present, one obtains effectively many-sheeted covering of the imbedding space and the contributions from sheets to the Kähler action are identical. If all sheets are treated effectively as one and the same sheet, the value of Planck constant is an integer multiple of the ordinary one. A natural boundary condition would be that at the ends of space-time at future and past boundaries of causal diamond containing the space-time surface, various branches co-incide. This would raise the ends of space-time surface in special physical role.

Dark matter as a source of long ranged weak and color fields

Long ranged classical electro-weak and color gauge fields are unavoidable in TGD framework. The smallness of the parity breaking effects in hadronic, nuclear, and atomic length scales does not however seem to allow long ranged electro-weak gauge fields. The problem disappears if long range classical electro-weak gauge fields are identified as space-time correlates for massless gauge fields created by dark matter. Also scaled up variants of ordinary electro-weak particle spectra are possible. The identification explains chiral selection in living matter and unbroken $U(2)_{ew}$ invariance and free color in bio length scales become characteristics of living matter and of bio-chemistry and bio-nuclear physics. A possible solution of the matter antimatter asymmetry is based on the identification of also antimatter as dark matter.

1.2.4 TGD as a generalization of physics to a theory consciousness

General coordinate invariance forces the identification of quantum jump as quantum jump between entire deterministic quantum histories rather than time=constant snapshots of single history. The new view about quantum jump forces a generalization of quantum measurement theory such that observer becomes part of the physical system. Thus a general theory of consciousness is unavoidable outcome. This theory is developed in detail in the books [K82, K12, K60, K10, K34, K41, K44, K74].

Quantum jump as a moment of consciousness

The identification of quantum jump between deterministic quantum histories (configuration space spinor fields) as a moment of consciousness defines microscopic theory of consciousness. Quantum jump involves the steps

$$\Psi_i \rightarrow U\Psi_i \rightarrow \Psi_f ,$$

where U is informational "time development" operator, which is unitary like the S-matrix characterizing the unitary time evolution of quantum mechanics. U is however only formally analogous to Schrödinger time evolution of infinite duration although there is *no* real time evolution involved. It is not however clear whether one should regard U-matrix and S-matrix as two different things or not: U -matrix is a completely universal object characterizing the dynamics of evolution by self-organization whereas S-matrix is a highly context dependent concept in wave mechanics and in quantum field theories where it at least formally represents unitary time translation operator at the limit of an infinitely long interaction time. The S-matrix understood in the spirit of superstring models is however something very different and could correspond to U-matrix.

The requirement that quantum jump corresponds to a measurement in the sense of quantum field theories implies that each quantum jump involves localization in zero modes which parameterize also the possible choices of the quantization axes. Thus the selection of the quantization axes performed by the Cartesian outsider becomes now a part of quantum theory. Together these requirements imply that the final states of quantum jump correspond to quantum superpositions of space-time surfaces which are macroscopically equivalent. Hence the world of conscious experience looks classical. At least formally quantum jump can be interpreted also as a quantum computation in which matrix U represents unitary quantum computation which is however not identifiable as unitary translation in time direction and cannot be 'engineered'.

Can one say anything about the unitary process? Zero energy states correspond in positive energy ontology to physical events and break time reversal invariance. This because either the positive or negative energy part of the state is prepared whereas the second end of CD corresponds to a superposition of (negative/positive energy) states with varying particle numbers and single particle quantum numbers just as in ordinary particle physics experiment. State function reduction must change the roles of the ends of CD s. Therefore U -matrix should correspond to the unitary matrix relating zero energy state basis prepared at different ends of CD and state function reduction would be equivalent with state preparation.

The basic objection is that the arrow of geometric time alternates at imbedding space level but we know that arrow of time is universal. What one can say about the arrow of time at space-time level? Quantum classical correspondence requires that quantum mechanical irreversibility corresponds to irreversibility at space-time level. If the observer is analogous to an inhabitant of Flatland gaining information only about space-time surface, he or she is not able to discover that the arrow of time alternates at the level of imbedding space. The inhabitant of a folded bath towel is not able to observe the folding of the towel! Only by observing systems for which the imbedding space arrow of time is opposite, observer can discover the alternation. Living systems indeed behave as if they would contain space-time sheets with opposite arrow of geometric time (self-organization). Phase conjugate light beam is second example of this.

The notion of self

The concept of self is absolutely essential for the understanding of the macroscopic and macro-temporal aspects of consciousness. Self corresponds to a subsystem able to remain un-entangled under the

sequential informational 'time evolutions' U . Exactly vanishing entanglement is practically impossible in ordinary quantum mechanics and it might be that 'vanishing entanglement' in the condition for self-property should be replaced with 'subcritical entanglement'. On the other hand, if space-time decomposes into p-adic and real regions, and if entanglement between regions representing physics in different number fields vanishes, space-time indeed decomposes into selves in a natural manner.

It is assumed that the experiences of the self after the last 'wake-up' sum up to single average experience. This means that subjective memory is identifiable as conscious, immediate short term memory. Selves form an infinite hierarchy with the entire Universe at the top. Self can be also interpreted as mental images: our mental images are selves having mental images and also we represent mental images of a higher level self. A natural hypothesis is that self S experiences the experiences of its subselves as kind of abstracted experience: the experiences of subselves S_i are not experienced as such but represent kind of averages $\langle S_{ij} \rangle$ of sub-subselves S_{ij} . Entanglement between selves, most naturally realized by the formation of join along boundaries bonds between cognitive or material space-time sheets, provides a possible a mechanism for the fusion of selves to larger selves (for instance, the fusion of the mental images representing separate right and left visual fields to single visual field) and forms wholes from parts at the level of mental images.

An attractive possibility suggested by zero energy ontology is that the notions of self and quantum jump reduce to each other and that a fractal hierarchy of quantum jumps within quantum jumps is enough. CDs would serve as imbedding space correlates of selves and quantum jumps would be followed by cascades of state function reductions beginning from given CD and proceeding downwards to the smaller scales (smaller CDs). State function reduction cascades could also take place in parallel branches of the quantum state. One ends up with concrete ideas about how the arrow of geometric time is induced from that of subjective time defined by the experiences induced by the sequences of quantum jumps for sub-selves of self. One ends also ends up with concrete ideas about how the localization of the contents of sensory experience and cognition to the upper boundaries of CD could take place.

Relationship to quantum measurement theory

The third basic element relates TGD inspired theory of consciousness to quantum measurement theory. The assumption that localization occurs in zero modes in each quantum jump implies that the world of conscious experience looks classical. It also implies the state function reduction of the standard quantum measurement theory as the following arguments demonstrate (it took incredibly long time to realize this almost obvious fact!).

1. The standard quantum measurement theory a la von Neumann involves the interaction of brain with the measurement apparatus. If this interaction corresponds to entanglement between microscopic degrees of freedom m with the macroscopic effectively classical degrees of freedom M characterizing the reading of the measurement apparatus coded to brain state, then the reduction of this entanglement in quantum jump reproduces standard quantum measurement theory provide the unitary time evolution operator U acts as flow in zero mode degrees of freedom and correlates completely some orthonormal basis of configuration space spinor fields in non-zero modes with the values of the zero modes. The flow property guarantees that the localization is consistent with unitarity: it also means 1-1 mapping of quantum state basis to classical variables (say, spin direction of the electron to its orbit in the external magnetic field).
2. Since zero modes represent classical information about the geometry of space-time surface (shape, size, classical Kähler field,...), they have interpretation as effectively classical degrees of freedom and are the TGD counterpart of the degrees of freedom M representing the reading of the measurement apparatus. The entanglement between quantum fluctuating non-zero modes and zero modes is the TGD counterpart for the $m - M$ entanglement. Therefore the localization in zero modes is equivalent with a quantum jump leading to a final state where the measurement apparatus gives a definite reading.

This simple prediction is of utmost theoretical importance since the black box of the quantum measurement theory is reduced to a fundamental quantum theory. This reduction is implied by the replacement of the notion of a point like particle with particle as a 3-surface. Also the infinite-dimensionality of the zero mode sector of the configuration space of 3-surfaces is absolutely essential. Therefore the reduction is a triumph for quantum TGD and favors TGD against string models.

Standard quantum measurement theory involves also the notion of state preparation which reduces to the notion of self measurement. Each localization in zero modes is followed by a cascade of self measurements leading to a product state. This process is obviously equivalent with the state preparation process. Self measurement is governed by the so called Negentropy Maximization Principle (NMP) stating that the information content of conscious experience is maximized. In the self measurement the density matrix of some subsystem of a given self localized in zero modes (after ordinary quantum measurement) is measured. The self measurement takes place for that subsystem of self for which the reduction of the entanglement entropy is maximal in the measurement. In p-adic context NMP can be regarded as the variational principle defining the dynamics of cognition. In real context self measurement could be seen as a repair mechanism allowing the system to fight against quantum thermalization by reducing the entanglement for the subsystem for which it is largest (fill the largest hole first in a leaking boat).

Selves self-organize

The fourth basic element is quantum theory of self-organization based on the identification of quantum jump as the basic step of self-organization [K69]. Quantum entanglement gives rise to the generation of long range order and the emergence of longer p-adic length scales corresponds to the emergence of larger and larger coherent dynamical units and generation of a slaving hierarchy. Energy (and quantum entanglement) feed implying entropy feed is a necessary prerequisite for quantum self-organization. Zero modes represent fundamental order parameters and localization in zero modes implies that the sequence of quantum jumps can be regarded as hopping in the zero modes so that Haken's classical theory of self organization applies almost as such. Spin glass analogy is a further important element: self-organization of self leads to some characteristic pattern selected by dissipation as some valley of the "energy" landscape.

Dissipation can be regarded as the ultimate Darwinian selector of both memes and genes. The mathematically ugly irreversible dissipative dynamics obtained by adding phenomenological dissipation terms to the reversible fundamental dynamical equations derivable from an action principle can be understood as a phenomenological description replacing in a well defined sense the series of reversible quantum histories with its envelope.

Classical non-determinism of Kähler action

The fifth basic element are the concepts of association sequence and cognitive space-time sheet. The huge vacuum degeneracy of the Kähler action suggests strongly that the absolute minimum space-time is not always unique. For instance, a sequence of bifurcations can occur so that a given space-time branch can be fixed only by selecting a finite number of 3-surfaces with time like(!) separations on the orbit of 3-surface. Quantum classical correspondence suggest an alternative formulation. Space-time surface decomposes into maximal deterministic regions and their temporal sequences have interpretation a space-time correlate for a sequence of quantum states defined by the initial (or final) states of quantum jumps. This is consistent with the fact that the variational principle selects preferred extremals of Kähler action as generalized Bohr orbits.

In the case that non-determinism is located to a finite time interval and is microscopic, this sequence of 3-surfaces has interpretation as a simulation of a classical history, a geometric correlate for contents of consciousness. When non-determinism has long lasting and macroscopic effect one can identify it as volitional non-determinism associated with our choices. Association sequences relate closely with the cognitive space-time sheets defined as space-time sheets having finite time duration and psychological time can be identified as a temporal center of mass coordinate of the cognitive space-time sheet. The gradual drift of the cognitive space-time sheets to the direction of future force by the geometry of the future light cone explains the arrow of psychological time.

p-Adic physics as physics of cognition and intentionality

The sixth basic element adds a physical theory of cognition to this vision. TGD space-time decomposes into regions obeying real and p-adic topologies labelled by primes $p = 2, 3, 5, \dots$. p-Adic regions obey the same field equations as the real regions but are characterized by p-adic non-determinism since the functions having vanishing p-adic derivative are pseudo constants which are piecewise constant functions. Pseudo constants depend on a finite number of positive binary digits of arguments just like

numerical predictions of any theory always involve decimal cutoff. This means that p-adic space-time regions are obtained by gluing together regions for which integration constants are genuine constants. The natural interpretation of the p-adic regions is as cognitive representations of real physics. The freedom of imagination is due to the p-adic non-determinism. p-Adic regions perform mimicry and make possible for the Universe to form cognitive representations about itself. p-Adic physics space-time sheets serve also as correlates for intentional action.

A more precise formulation of this vision requires a generalization of the number concept obtained by fusing reals and p-adic number fields along common rationals (in the case of algebraic extensions among common algebraic numbers). This picture is discussed in [K79]. The application of this notion at the level of the imbedding space implies that imbedding space has a book like structure with various variants of the imbedding space glued together along common rationals (algebraics). The implication is that genuinely p-adic numbers (non-rationals) are strictly infinite as real numbers so that most points of p-adic space-time sheets are at real infinity, outside the cosmos, and that the projection to the real imbedding space is discrete set of rationals (algebraics). Hence cognition and intentionality are almost completely outside the real cosmos and touch it at a discrete set of points only.

This view implies also that purely local p-adic physics codes for the p-adic fractality characterizing long range real physics and provides an explanation for p-adic length scale hypothesis stating that the primes $p \simeq 2^k$, k integer are especially interesting. It also explains the long range correlations and short term chaos characterizing intentional behavior and explains why the physical realizations of cognition are always discrete (say in the case of numerical computations). Furthermore, a concrete quantum model for how intentions are transformed to actions emerges.

The discrete real projections of p-adic space-time sheets serve also space-time correlate for a logical thought. It is very natural to assign to p-adic binary digits a p -valued logic but as such this kind of logic does not have any reasonable identification. p-Adic length scale hypothesis suggest that the $p = 2^k - n$ binary digits represent a Boolean logic B^k with k elementary statements (the points of the k -element set in the set theoretic realization) with n taboos which are constrained to be identically true.

p-Adic and dark matter hierarchies and hierarchy of moments of consciousness

Dark matter hierarchy assigned to a spectrum of Planck constant having arbitrarily large values brings additional elements to the TGD inspired theory of consciousness.

1. Macroscopic quantum coherence can be understood since a particle with a given mass can in principle appear as arbitrarily large scaled up copies (Compton length scales as \hbar). The phase transition to this kind of phase implies that space-time sheets of particles overlap and this makes possible macroscopic quantum coherence.
2. The space-time sheets with large Planck constant can be in thermal equilibrium with ordinary ones without the loss of quantum coherence. For instance, the cyclotron energy scale associated with EEG turns out to be above thermal energy at room temperature for the level of dark matter hierarchy corresponding to magnetic flux quanta of the Earth's magnetic field with the size scale of Earth and a successful quantitative model for EEG results [K26].

Dark matter hierarchy leads to detailed quantitative view about quantum biology with several testable predictions [K26]. The general prediction is that Universe is a kind of inverted Mandelbrot fractal for which each bird's eye of view reveals new structures in long length and time scales representing scaled down copies of standard physics and their dark variants. These structures would correspond to higher levels in self hierarchy. This prediction is consistent with the belief that 75 per cent of matter in the universe is dark.

1. Living matter and dark matter

Living matter as ordinary matter quantum controlled by the dark matter hierarchy has turned out to be a particularly successful idea. The hypothesis has led to models for EEG predicting correctly the band structure and even individual resonance bands and also generalizing the notion of EEG [K26]. Also a generalization of the notion of genetic code emerges resolving the paradoxes related to the

standard dogma [K43, K26] . A particularly fascinating implication is the possibility to identify great leaps in evolution as phase transitions in which new higher level of dark matter emerges [K26] .

It seems safe to conclude that the dark matter hierarchy with levels labelled by the values of Planck constants explains the macroscopic and macro-temporal quantum coherence naturally. That this explanation is consistent with the explanation based on spin glass degeneracy is suggested by following observations. First, the argument supporting spin glass degeneracy as an explanation of the macro-temporal quantum coherence does not involve the value of \hbar at all. Secondly, the failure of the perturbation theory assumed to lead to the increase of Planck constant and formation of macroscopic quantum phases could be precisely due to the emergence of a large number of new degrees of freedom due to spin glass degeneracy. Thirdly, the phase transition increasing Planck constant has concrete topological interpretation in terms of many-sheeted space-time consistent with the spin glass degeneracy.

2. Dark matter hierarchy and the notion of self

The vision about dark matter hierarchy leads to a more refined view about self hierarchy and hierarchy of moments of consciousness [K25, K26] . The larger the value of Planck constant, the longer the subjectively experienced duration and the average geometric duration $T(k) \propto \hbar$ of the quantum jump.

Quantum jumps form also a hierarchy with respect to p-adic and dark hierarchies and the geometric durations of quantum jumps scale like \hbar . Dark matter hierarchy suggests also a slight modification of the notion of self. Each self involves a hierarchy of dark matter levels, and one is led to ask whether the highest level in this hierarchy corresponds to single quantum jump rather than a sequence of quantum jumps. The averaging of conscious experience over quantum jumps would occur only for sub-selves at lower levels of dark matter hierarchy and these mental images would be ordered, and single moment of consciousness would be experienced as a history of events. The quantum parallel dissipation at the lower levels would give rise to the experience of flow of time. For instance, hadron as a macro-temporal quantum system in the characteristic time scale of hadron is a dissipating system at quark and gluon level corresponding to shorter p-adic time scales. One can ask whether even entire life cycle could be regarded as a single quantum jump at the highest level so that consciousness would not be completely lost even during deep sleep. This would allow to understand why we seem to know directly that this biological body of mine existed yesterday.

The fact that we can remember phone numbers with 5 to 9 digits supports the view that self corresponds at the highest dark matter level to single moment of consciousness. Self would experience the average over the sequence of moments of consciousness associated with each sub-self but there would be no averaging over the separate mental images of this kind, be their parallel or serial. These mental images correspond to sub-selves having shorter wake-up periods than self and would be experienced as being time ordered. Hence the digits in the phone number are experienced as separate mental images and ordered with respect to experienced time.

3. The time span of long term memories as signature for the level of dark matter hierarchy

The basic question is what time scale can one assign to the geometric duration of quantum jump measured naturally as the size scale of the space-time region about which quantum jump gives conscious information. This scale is naturally the size scale in which the non-determinism of quantum jump is localized. During years I have made several guesses about this time scales but zero energy ontology and the vision about fractal hierarchy of quantum jumps within quantum jumps leads to a unique identification.

Causal diamond as an imbedding space correlate of self defines the time scale τ for the space-time region about which the consciousness experience is about. The temporal distances between the tips of CD as come as integer multiples of CP_2 length scales and for prime multiples correspond to what I have christened as secondary p-adic time scales. A reasonable guess is that secondary p-adic time scales are selected during evolution and the primes near powers of two are especially favored. For electron, which corresponds to Mersenne prime $M_{127} = 2^{127} - 1$ this scale corresponds to .1 seconds defining the fundamental time scale of living matter via 10 Hz biorhythm (alpha rhythm). The unexpected prediction is that all elementary particles correspond to time scales possibly relevant to living matter.

Dark matter hierarchy brings additional finesse. For the higher levels of dark matter hierarchy τ is scaled up by \hbar/\hbar_0 . One could understand evolutionary leaps as the emergence of higher levels at

the level of individual organism making possible intentionality and memory in the time scale defined τ .

Higher levels of dark matter hierarchy provide a neat quantitative view about self hierarchy and its evolution. Various levels of dark matter hierarchy would naturally correspond to higher levels in the hierarchy of consciousness and the typical duration of life cycle would give an idea about the level in question. The level would determine also the time span of long term memories as discussed in [K26]. The emergence of these levels must have meant evolutionary leap since long term memory is also accompanied by ability to anticipate future in the same time scale. This picture would suggest that the basic difference between us and our cousins is not at the level of genome as it is usually understood but at the level of the hierarchy of magnetic bodies [K43, K26]. In fact, higher levels of dark matter hierarchy motivate the introduction of the notions of super-genome and hyper-genome. The genomes of entire organ can join to form super-genome expressing genes coherently. Hyper-genomes would result from the fusion of genomes of different organisms and collective levels of consciousness would express themselves via hyper-genome and make possible social rules and moral.

1.3 Bird's eye of view about the topics of the book

Brain as a hologram is an old idea and it emerges naturally also in TGD framework both at quantum and classical level, which by quantum classical correspondence is expected to reflect what happens at the deeper quantum level.

The book is organized as follows.

1. The new view about the relationship between experienced and geometric time underlies the notion of 4-D dynamical hologram. Therefore the first part of the book contains three chapters about this topic reflecting the development of ideas. The first one is more than decade old. The third one written quite recently is inspired by zero energy ontology and provides a rather detailed vision about how the arrow of geometric time correlating with the arrow of experienced time and the localization of the contents of sensory experience to a narrow time interval emerge.
2. The second part of the book is devoted to the development of hologram idea. Also a general model of sensory qualia and a model for sensory receptor as electret, which are very abundant in living matter, are discussed.
3. The third part of the book is devoted to water memory and metabolism. The title suggests a connection between these two and this kind of connection has indeed emerged. A discovery - certainly one of the greatest surprises of my professional life - popped up as an outcome of an attempt to understand the mechanism behind water memory for which rather strong support exists now. The idea was that dark nuclei which sizes zoomed up to atomic size scale could provide a representation of genes with dark nucleons consisting of three quarks representing DNA codons. It turned out that the model for dark nucleon consisting of three quarks predicts counterparts of 64 DNAs, 64 RNAs, and 20 aminoacids and allows to identify vertebrate genetic code as a natural mapping of DNA type states to amino-acid type states. The population of dark nuclei would be new life-form possibly responsible for the water memory. The chapter about metabolism represents a model of metabolism based on the identification of universal metabolic energy quanta as increments of zero point kinetic energies emitted or absorbed as particles are transferred between space-time time sheets characterized by different p-adic primes.

The seven online books about TGD [K89, K67, K53, K49, K68, K77, K75] and eight online books about TGD inspired theory of consciousness and quantum biology [K82, K12, K60, K10, K34, K41, K44, K74] are warmly recommended for the reader willing to get overall view about what is involved.

1.4 The contents of the book

1.4.1 PART I: THE NOTION OF TIME IN TGD UNIVERSE

Time and Consciousness

In moments of consciousness as quantum jumps between quantum histories picture the basic challenge is to explain how psychological time arises: why the contents of at least sensory experiences are concentrated around a definite value of geometric time and what is the origin of the arrow of psychological time. It has become gradually clear that TGD cannot reproduce the common sense conception of time and that one can only require that the generalized view is consistent with our restricted conscious experiences and shows our position in the hierarchy of consciousness.

The understanding of the notion of psychological time and its arrow - or equivalently, the relationship between subjective and geometric time - turned out to be quite difficult challenge and led to a handful of proposals based on the identification of space-time sheet as a correlate of self and the idea that the experienced flow of geometric correspond to some kind of motion in space-time or in imbedding space. These identifications did not lead to anything practical and generated paradoxes.

The most recent proposal involves no ad hoc assumptions and relies on the formulation of quantum TGD using zero energy ontology. The correlate of self is now so called causal diamond (pair of future and past directed light-cones) which is 8-D sub-manifold of the imbedding space rather than space-time sheet. The flow of geometric time is apparent and due the change of quantum state in quantum jump which in the first approximation means a shift of the quantum superposition of space-time surfaces to the direction of the geometric past of the imbedding space. This proposal allows to understand the asymmetry between geometric future and past at the level of conscious experience and makes also precise quantitative predictions. Also a unification of the definition of self identifying it as a sequence of quantum jumps and of the definition based on the reduction of self hierarchy to a fractal hierarchy of quantum jumps within quantum jumps becomes possible.

The concept of self led to the understanding of the subjective memory as an average over experiences of self experienced after its "wake-up". Subjective memories are always about past. Geometric memories are predictions for the future/past assuming that no quantum jumps would occur after/had occurred before the one giving rise to the geometric memory. Pre-cognitions can be seen as geometric memories about future. Intentions are p-adic variants of precognitions. It seems that long term memories must correspond to geometric memories: this hypothesis, when combined with the spin glass model of brain, the notion of quantum self-organization, and some key aspects of many-sheeted physics, allows to understand the basic aspects of the long term memory and avoids the basic difficulties of the neural net models.

"Ontogeny recapitulates phylogeny" principle suggests that the structure of the many-sheeted space-time represents the structure of the cosmology of consciousness. This heuristic principle together with the concept of self, the hypothesis that also infinite primes are present in the topological condensate and association sequence concept, leads to a Grand Scenario for the cosmology of consciousness. There is no need to assume that different irreducible sub-experiences associated with given moment of consciousness correspond to a common value of the psychological time. Most naturally, the values of psychological time extending from zero to strictly infinite values of time and beyond(!) are present. This means that cosmology of consciousness has fractal like structure: there are sub-cosmologies which know nothing about each other's existence except in quantum jumps involving entanglement with larger space-time sheets: in this case the conscious experience could be regarded as a religious or mystic experience. Both future and past civilizations participate in each quantum jump. The allowance of infinite primes suggested strongly by various arguments, means that conscious intelligences which are God like as compared to us, participate in each quantum jump.

An especially important general consequence is the paradigm of 4-dimensional brain.

1. This paradigm trivializes the problem of long term memory. The desire to remember would be quantum communicated from the geometric now to the geometric past by sharing of mental images made possible by time-like quantum entanglement of sub-selves. In the case of episodal memories the sharing of mental images gives already rise to the memory. For non-episodal memories the memory is communicated classically to the geometric future. An essential element of the mechanism are negative energy MIEs ("massless extremals") which are ideal for generating

time-like quantum entanglement with the geometric past. Positive energy MEs are in turn involved with classical communications.

2. Second consequence is a model of cognition relying on the concept of cognitive neutrino pair: cognitive neutrino pair has almost vanishing total energy and consists of neutrino and antineutrino residing at different space-time sheets. The cornerstone of the model is the negative energy of the condensed matter neutrinos deriving from the classical Z^0 interaction with nuclear Z^0 charges. Thus one can say that TGD predicts that $k = 169$ space-time sheet ($L(169) \simeq 5$ microns) is the length scale in which cognitive consciousness emerges.

Quantum jumps between quantum histories concept explains the peculiar time delays of consciousness revealed in the experiments relating to active and passive roles of consciousness and the causal anomalies revealed by the experiments of Radin and Bierman. TGD predicts "tribar effect" as a general signature for the quantum jump between quantum histories concept.

Time, Space-Time, and Consciousness

In moments of consciousness as quantum jumps between quantum histories picture the basic challenge is to explain how psychological time arises: why the contents of at least sensory experiences are concentrated around definite value of geometric time and what is the origin of the arrow of psychological time. It has become gradually clear that TGD cannot reproduce the common sense conception of time and that one can only require that the generalized view is consistent with our restricted conscious experiences and shows our position in the hierarchy of consciousness.

The understanding of the notion of psychological time and its arrow - or equivalently, the relationship between subjective and geometric time - turned out to be quite difficult challenge and led to a handful of proposals based on the identification of space-time sheet as a correlate of self and the idea that the experienced flow of geometric correspond to some kind of motion in space-time or in imbedding space. These identifications did not lead to anything practical and generated paradoxes.

The most recent proposal involves no ad hoc assumptions and relies on the recent formulation of quantum TGD using zero energy ontology. The correlate of self is now so called causal diamond (pair of future and past directed light-cones) which is 8-D sub-manifold of the imbedding space rather than space-time sheet. The flow of geometric time is apparent and due the change of quantum state in quantum jump which in the first approximation means a shift of the quantum superposition of space-time surfaces to the direction of the geometric past of the imbedding space. This proposal allows to understand the asymmetry between geometric future and past at the level of conscious experience and makes also precise quantitative predictions. Also a unification of the definition of self identifying it as a sequence of quantum jumps and of the definition based on the reduction of self hierarchy to a fractal hierarchy of quantum jumps within quantum jumps becomes possible.

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1.4.2 PART II: BIO-SYSTEMS AS CONSCIOUS HOLOGRAMS

Macro-Temporal Quantum Coherence and Spin Glass Degeneracy

The neural realization of long term memories has remained to a high extent a mystery in the framework of the standard brain science. The TGD based quantum model for memory have developed gradually from the basic realization that in TGD framework the identification of quantum states as quantum histories makes it un-necessary to store information about the geometric past to the geometric now. This has deep implications.

a) It is possible to separate genuine geometric memory recall from apparent memory recalls such as feature recognition, associations, and implicit and procedural memories. There are no memory storages in brain and only memory representations abstracting the essential aspects of experience are needed.

b) The models of long term memory based on the assumption that information about the geometric past is stored in the recent state of the system predict that the new memories should mask the old ones. It is however known that childhood memories are the stablest ones. In TGD framework this ceases to be a problem.

Mirror mechanism provides a very general mechanism of long term memory. To remember something at a temporal distance T in the geometric past is to look at a mirror at a distance $cT/2$. If the mirror is quantum mirror only a timelike entanglement (allowed by the non-determinism of Kähler action) of the mental image of the geometric past with a mental image in brain now is needed. The un-necessity to communicate memories classically implies extreme generality of the mechanism: all kinds of memories: sensory, cognitive, verbal,... can be recalled in this manner. Even the mechanism of memory recall by cue can be generalized since the notion of tele association makes in principle sense.

The basic objections against this over-simplified picture is that there is no guarantee that the reflected ME returns to the brain and that there is no control over the time span of long term memories. The notion of magnetic body allows a more realistic formulation. Brain or the personal magnetic body generates spontaneously negative energy MEs with all fundamental frequencies. These MEs can be also curved and are parallel to the closed flux tubes defining the personal magnetic body and connect geometric now with the brain of the geometric past: multiple reflections are probably required to achieve this. The length of the closed magnetic loop defines the time span of the corresponding long term memory. The sharing of mental images by timelike entanglement allows to communicate the desire to remember to the geometric past, and gives rise to the memory recall in the case of episodal memories. In the case of non-episodal/declarative memories the memory is communicated from the brain of the geometric past by classical communications using positive positive energy MEs which

propagate with an effective phase velocity much lower than light velocity along closed magnetic flux tubes and generate in the receiving end symbolic representation of the memory.

Macrotemporal quantum coherence is further important piece of the model. The understanding of how macrotemporal quantum coherence is made possible by the spin glass degeneracy led to a concrete realization of the mirror model and also provided a connection with the ideas of Hameroff and Penrose. When a bound state is formed the zero modes of the bound state entangled subsystems become quantum fluctuating degrees of freedom. This means that state function reduction and state preparation cease to occur in these degrees of freedom. The bound state is in a kind of long-lasting multiverse state, or state of 'oneness' experientially, and the sequence of quantum jumps defined by the duration of the bound state behaves effectively as a single quantum jump. Macrotemporal quantum coherence making possible supercomputer like activities becomes possible.

The spin glass degeneracy associated with the join along boundaries bonds (the space-time correlates for the bound state formation) lengthens the lifetimes of the bound states dramatically and solves thus the basic objections against quantum consciousness. The spin glass degeneracy is due to classical gravitational energy of the system. The quantum jumps between different classical gravitational configurations involve the emission of gravitational (equivalently Z^0) MEs and the intention to remember is realized as a transformation of p-adic ME to negative energy gravitational ME. The fact that classical gravitational fields couple to classical gauge fields with a coupling which is about 10^8 stronger than the ordinary gravitational coupling, could play an important role too. Water clusters and macromolecules with sizes in the range of cell membrane thickness and cell size are good candidates for generating gravitonic MEs responsible for all geometric memories. Also classical Z^0 interaction might be involved since gravitonic MEs can be regarded also as Z^0 MEs.

A rather detailed neuro level model of long term memory is developed and the model conforms nicely with the basic facts known about the relationship of hippocampus and long term memory.

Bio-Systems as Conscious Holograms

The notion of conscious hologram is TGD based generalization of the idea about brain as a hologram. In nutshell, the notion of conscious hologram follows from the topological field quantization. Classical fields and matter form a Feynmann diagram like structure consisting of lines representing matter (say charged particles) and bosons (say photons). The matter lines are replaced by space-time sheets representing matter (elementary particles, atoms, molecules,...), and virtual bosons are replaced by topological light rays ("mass-less extremals", MEs). Also magnetic flux tubes appear and together with MEs they serve as correlates for bound state quantum entanglement.

The internal lines of the Feynmann diagram are analogous to wave guides and the classical fields and coherent light propagating along these wave guides interfere at the space-time sheets representing the vertices of the Feynmann diagram and the "points" of the conscious hologram. The formation of the hologram corresponds to the self-organization induced by the leakage of supra currents to smaller (say atomic) space-time sheets. This leakage is induced by the high frequency MEs propagating along low frequency MEs serving as correlates for quantum entanglement. The 3-D stereovision associated with ordinary hologram is generalized to stereo consciousness resulting, when the mental images associated with different 'points' of conscious hologram fuse to single mental image. Central nervous system can be regarded as a conscious hologram of this kind.

Time mirror mechanism is a key element of intentional action. The notion of four-wave interaction generalizes: the interference pattern of oppositely moving reference waves forming an archetypal standing wave (possibly moving as in case of nerve pulse) can be replaced by any synchronously oscillating periodic spatial pattern. Plasma waves for which the frequency does not depend on wave vector are ideal candidates for holograms in the generalized sense. Living matter is full of this kind of holograms: besides plasma oscillations associated with biologically important ions, also Z^0 plasma oscillations associated with atoms and molecules can define holograms. p-Adic length scale hypothesis predicts a hierarchy of plasma frequencies related by powers $2^{3k/4}$ so that even so called "non-living matter" could build this kind of sensory representations based on plasma oscillations.

p-Adic length scale hypothesis and dark matter hierarchy allow to quantify the notion of conscious hologram. The hierarchy of generalized EEGs associated with the dark matter hierarchy allows to propose concrete mechanism of remote mental interactions playing a key role also in the interaction of magnetic bodies with the biological body. Experimental findings related to anomalous pre-cognition support the view that even galactic magnetosphere acts as a conscious entity receiving sensory input

from bio-sphere and controlling it.

Bio-photons provide an application of the general theory. Simple mathematical facts about the delayed luminescence induced by an external perturbation combined with the model for a hierarchy of dark EEGs assignable to that of Josephson junctions, lead to a model in which positive and negative energy MEs transversal to DNA strand and representing dark photons generate coherent bio-photons via de-coherence. Rather detailed quantitative models for how MEs and supra current circuits interact and how bio-photons are generated during the gene expression emerge.

Peter Gariaev and his group have discovered a radio wave emission from DNA induced by laser light. The model explaining delayed luminescence covers also this phenomenon: now the decay of dark photons with energies above thermal threshold to radio-wave photons rather than de-coherence would be the mechanism. The findings allow an explanation in terms of a many-sheeted laser action, and a rather detailed view about how bio-system acts as a many-sheeted laser at a wide wave-length range emerges.

William Tiller in Stanford University has carried out impressive experimental work with what he calls intention imprinted electronic devices (IIED), and his results challenge that standard assumption that the intentions of experimenter do not affect the experimental apparatus. The analysis of the work of Tiller in the conceptual framework of TGD leads to the conclusion that four-wave interaction, which is a basic mechanism to produce phase conjugate waves (negative energy topological light rays), serves also as a basic mechanism of intentional action. This leads to a unified view allowing to see EEG and nerve pulse as a particular realization of four-wave interaction.

General Theory of Qualia

The connection between the general theory of qualia and quantum measurement theory and thermodynamics turned out to be a breakthrough in the development of the ideas related to qualia. In TGD framework the contents of consciousness is determined as some kind of average over the sequence of very large number of quantum jump and this suggests strongly that non-geometric qualia allow a statistical description generalizing ordinary thermodynamical ensemble to the ensemble formed by the prepared states in the sequence of quantum jumps after the last 'wake-up' of self.

1. There are geometric qualia corresponding to zero modes expressing the result of quantum measurement in each quantum jump. All geometric information about space-time surface should reduce to geometric qualia. For instance, geometric data given by visual, auditory, and tactile senses should reduce to conscious information about zero modes or about increments of zero modes in quantum jump.
2. The sequence of the prepared states can be modelled as a statistical ensemble of Fock states, which suggests that thermodynamics is basically part of theory of consciousness. The ensemble of prepared states gives rise to a large number of statistical qualia. The relationship $dE = TdS - PdV + \mu dN + B \cdot dM...$ generalizes to TGD context: note however that in case of ME selves energy is replaced with the Super Virasoro generator L_0 associated with the light cone boundary of ME. Each intensive-extensive variable pair in the differential should correspond to a non-geometric quale, which results only when there is a gradient (flow) of the extensive variable in the direction of the subjective time. Super-canonical thermodynamics should obviously map ordinary thermodynamics to the level of conscious experience.
3. Since subjective existence corresponds to quantum jumps, it is natural to assume that only the increments of zero modes and quantum numbers are experienced consciously. Statistical interpretation also suggests that an averaging over the increments occurs. The possibility of sub-selves makes possible to have sequences of sub-selves (mental images) of finite subjective time duration and this makes possible structured subjective memories (for instance, it becomes possible to remember the digits of a phone number). A further working hypothesis analogous to functionalism is universality: kinesthetic qualia depending on the quantum number increments are universal. Thus the increments of Poincare and color and electro-weak quantum numbers define what might be called universal kinesthetic qualia.

The thermodynamical expression for dE suggests a general classification of qualia consistent with the 'holy trinity' of existences implied by TGD.

1. *Emotions as order-disorder qualia*

$T - S$ pair correspond subjective existence and generalizes to disorder-order type, information theoretic qualia qualia about the state of self. The fact that emotions correlate strongly with peptides which are also informational molecules, supports the identification of the qualia associated with various entropy growth rates as emotions. The entropy of sub-self in turn characterizes the sharpness of the mental image.

2. *Kinesthetic qualia defined by generalized forces*

$p-V$ pair corresponds to the geometric existence and is replaced with generalized force-generalized coordinate pairs in quantum fluctuating degrees of freedom. Quite generally, the rates for the increase for a maximum number of mutually commuting Poincare, color and electro-weak quantum numbers define what might be called kinesthetic qualia. Senses of force and torque, hearing, and intensity of color sensation can be regarded as examples of generalized kinesthetic qualia.

3. *Generalized chemical qualia*

$\mu - N$ pair corresponds to 'objective existence' defined by quantum histories and N is generalized to a number of particle like excitations in the Fock state resulting in the state preparation. In this case there must be a flow of particle number in the direction of the subjective time, that is Bose-Einstein condensation type process for, say Cooper pairs. Quite generally, super-canonical and quaternion conformal super algebras should define these kind of qualia and the number of these qualia is very large. The particle numbers in question can be numbers of ions of Cooper pairs in various magnetic states, numbers of colored configuration space photons in various states of super-canonical representation, numbers of join along boundaries bonds, etc.. and one can understand chemical qualia, color vision, and sensations of pain and pleasure as generalized chemical qualia.

4. *Boolean qualia*

The transitions associated with the fermionic generators of super-canonical algebra can be identified as Boolean consciousness with intrinsic meaning ('This is true'). Boolean cognition without intrinsic meaning and/or conscious feeling of quantity can be understood as associated with temporal sequences of Z^0 magnetization directions for cognitive antineutrinos.

There are two basic mechanisms generating sensory qualia.

1. Quantum phase transition in which single particle transition occurs coherently for some macroscopic quantum phase produces qualia defined by the increments of quantum numbers in the transition. Quantum phase transition could be induced by the transition frequency: quantum phase transition leading to the generation of new kind of macroscopic quantum phase is in question. The magnetic quantum phase transitions at super-conducting magnetic flux tubes provide a basic example of this mechanism, and the quantum model of hearing relies on Z^0 magnetic quantum phase transitions.
2. The flow of particles with fixed quantum numbers between "electrodes" of what might be called a quantum capacitor induces qualia defined by the quantum numbers of the particles involved. The "electrodes" carry opposite net quantum numbers. Second electrode corresponds to the sub-self defining the quale mental image. Obviously cell interior and exterior are excellent candidates for the electrodes of the quantum capacitor. Also neuron and postsynaptic neuron. In fact, living matter is full of electrets defining capacitor like structures. The capacitor model applies to various chemical qualia and also to color vision and predicts that also cells should have senses.

5. *TGD based model for cell membrane as sensory receptor*

The emergence of zero energy ontology, the explanation of dark matter in terms of a hierarchy of Planck constants requiring a generalization of the notion of imbedding space, the view about life as something in the intersection of real and p -adic worlds, and the notion of number theoretic entanglement negentropy led to a breakthrough in TGD inspired quantum biology and also to the recent view of qualia and sensory representations including hearing allowing a precise quantitative model at the level of cell membrane. The ensuing general model of how cell membrane acts as a sensory receptor has unexpected implications for the entire TGD inspired view about biology.

1. The most important implication concerning the model of sensory receptors however relate to the vacuum degeneracy of Kähler action. It has been clear from the beginning that the nearly vacuum extremals of Kähler action could play key role in living systems. The reason is their criticality making them ideal systems for sensory perception. These extremals carry classical em and Z^0 fields related to each other by a constant factor and this could explain the large parity breaking effects characterizing living matter. The assumption that cell membranes are nearly vacuum extremals and that nuclei can feed their Z^0 charges to this kind of space-time sheets (not true for atomic electrons) in living matter leads to a modification of the model for the cell membrane as Josephson junction. Also a model of photoreceptors explaining the frequencies of peak sensitivity as ionic Josephson frequencies and allowing the dual identifications Josephson radiation as biophotons (energies) and EEG radiation (frequencies) emerge since the values of Planck constant can be very large. The value of the Weinberg angle in this phase is fixed to $\sin^2(\theta_W) = .0295$, whereas in standard phase the value is given by $\sin^2(\theta_W) = .23$. The significance of this quantitative success for TGD and TGD inspired quantum biology cannot be over-estimated.
2. DNA as topological quantum computer model plus certain simplifying assumption leads to the conclusion that the spectrum of net quantum numbers of quark antiquark pair define the primary qualia assignable to a nucleotide-lipid pair connected by a magnetic flux tube. The most general prediction is that the net quantum numbers of two quark pairs characterize the qualia. In the latter case the qualia would be assigned to a pair of receptor cells.
3. Composite qualia result when one allows the nucleotide-lipid pairs of the membrane to be characterized by a distribution of quark-antiquark pairs. Cell membrane -or at least the axonal parts of neurons- would define a sensory representation in which is a pair of this kind defines a pixel characterized by primary qualia. Cells would be sensory homunculi and DNA defines a sensory hologram of body of or of part of it. Among other things this would give a precise content to the notion of grandma cell.
4. Josephson frequencies of biologically important ions are in one-one correspondence with the qualia and Josephson radiation could re-generate the qualia or map them to different qualia in a one-one and synesthetic manner in the neurons of the sensory pathway. For large values of Planck constant Josephson frequencies are in EEG range so that a direct connection with EEG emerges and Josephson radiation indeed corresponds to both biophotons and EEG. This would realize the notion of sensory pathway which originally seemed to me a highly non-realistic notion and led to the vision that sensory qualia can be realized only at the level of sensory organs in TGD framework.
5. At the level of brain motor action and sensory perception look like reversals of each other. In zero energy ontology motor action can be indeed seen as a time reversed sensory perception so that the model of sensory representations implies also a model for motor action. Magnetic body serves as a sensory canvas where cyclotron transitions induced by Josephson frequencies induce conscious sensory map entangling the points of the magnetic body with brain and body.

1.4.3 PART III: WATER MEMORY AND METABOLISM

Homeopathy in Many-Sheeted Space-time

The claimed mechanisms of homeopathic healing and the method of manufacturing homeopathic potencies are not the only paradoxical aspects of homeopathy. Also the reported frequency imprinting and entrainment, codes based on field patterns, and associative learning of water look mysterious in the framework of standard physics.

1. *Frequency imprinting and entrainment*

Frequency imprinting and entrainment at preferred frequencies are believed to be fundamental for homeopathy and acupuncture. The data suggest that water builds representations for the chemicals it contains as space-time sheets containing water in liquid crystal form. These space-time sheets reproduce relevant part for the spectrum of rotational frequencies of the molecule in rigid rotor approximation. Also the mimicry of vibrational spectrum using sound waves can be considered possible.

Besides LC water blobs also magnetic mirrors consisting of magnetic flux tube plus parallel MEs pop up naturally in the original model of frequency imprinting and entrainment.

The basic objection is that if the space-time sheets are in thermal equilibrium, the scenario partially fails in the case of fundamentally important rotational and conformational spectra which are in microwave region. TGD however suggests that also inherently dark atoms identifiable as anyonic counterparts of ordinary atoms are possible and have the same energy spectrum as ordinary atoms, and that the notion of atom and molecule generalizes to what might be called N -atom/molecule having energy spectrum scaled up by a factor $1 \leq N \leq \lambda^k$, $\hbar(k) = \lambda^k \hbar_0$. In this case various vibrational and rotational frequencies would define a hierarchy of dark energies which can be above thermal threshold. In particular, rotational and conformational microwave spectra of bio-molecules have dark counterparts with energies above the thermal threshold. Otherwise only cyclotron energies and plasma oscillation energies can be above thermal threshold at sufficiently high levels of dark matter hierarchy.

2. *Scaling laws*

Homeopathy seems to involve two kinds of scaling laws which seem to be closely related. What I call scaling law of homeopathy states that homeopathic frequencies appear in pairs (f_h, f_l) of high and low frequencies such that their ratio is given by $f_h/f_l \simeq 2 \times 10^{11}$. TGD approach explains this ratio predicts a generalization of the law. $v = Lf_l$ scaling law tells in TGD framework how the frequencies associated with generalized EEG code for the velocities of physiological waves and their frequencies $f_h = cf_l/v$. The general model for motor control by magnetic body predicts this scaling law.

3. *Model for the homeopathy*

The model of homeopathy must explain the effectiveness of homeopathic remedies manufactured by a repeated dilution and succussion. This can be understood if part of chemical involved is transformed to dark matter and is also represented by water clusters or dark super-nuclei formed from protons. This minimal representation involves thermally stable dark cyclotron frequencies. If inherently dark atoms and molecules with essentially same energy spectrum as ordinary ones are possible, also the mimicry of vibrational and rotational spectrum is possible by clusters of dark water molecules.

One must also understand why homeopathic remedies are manufactured from molecules which basically cause the symptoms to be cured. The explanation is that the presence of molecules mimicking the poisonous molecule makes it possible to sweep the poisonous molecules "under the rug" if they enter the organism. In the presence of Bose-Einstein condensates of dark photons generated by the mimicking particles, the poisonous molecules drop to dark space-time sheets where they are harmless: the mechanism is generalization of induced emission.

The model should also explain the associative learning and field codes. The presence of a hierarchy of dark matter levels leads to a model for how magnetic body performs motor control in terms of dark plasmoids and their quantal plasma oscillation patterns and receives sensory input from the biological body and experiences it as a kind of somatosensory representation along entire magnetic body. It would be the magnetic bodies at higher levels of dark matter hierarchy which learn rather than mere water. Context sensitive field codes emerge naturally as codes involved with all bio-control, in particular that of gene expression.

The charge entanglement by W MEs is the essentially new element in the model for generalized motor actions by magnetic body. Also the telepathic sharing of mental images could rely on charge entanglement. The reduction of charge entanglement can induce a quantum jump to a state in which local Bose-Einstein condensates become exotically ionized with certain probability depending on the intensity of W field. These Bose-Einstein condensates define pixels of generalized motor maps. Plasma oscillations in turn induce various physiological responses such as Ca^{++} and Mg^{++} waves and nerve pulses in turn giving rise to the generalized motor action. Field code is the correspondence between the spatio-temporal pattern of plasma oscillations and generalized motor action.

4. *Dark nuclear strings as analogs of as analogs of DNA-, RNA- and amino-acid sequences and baryonic realization of genetic code*

A speculative picture proposing a connection between homeopathy, water memory, and phantom DNA effect is discussed and on basis of this connection a vision about how the tqc hardware represented by the genome is actively developed by subjecting it to evolutionary pressures represented by a virtual world representation of the physical environment. The speculation inspired by this vision is that genetic code as well as DNA-, RNA- and amino-acid sequences should have representation in terms

of nuclear strings. The model for dark baryons indeed leads to an identification of these analogs and the basic numbers of genetic code including also the numbers of aminoacids coded by a given number of codons are predicted correctly. Hence it seems that genetic code is universal rather than being an accidental outcome of the biological evolution.

5. *Some applications*

The model of the magnetic body and the mechanism of motor control based on plasma oscillations of plasmoids can be tested by finding whether it allows to understand various enigmatic findings. Priore's machine which is a device demonstrated to induce a cure of cancer by somehow stimulating the immune system defines one such application. The findings of Sue Benford about intentionally produced tracks and dots in nuclear emulsions and microwave hearing and closely related taos hum define further applications. There is experimental evidence that electromagnetic stimulation can be used to transfer genetic information imprinted in field patterns between organisms belonging to different species. The idea about genes responsible for genetic self engineering and responding to field patterns representing foreign genes pops up naturally in dark matter inspired vision.

The general model for the magnetic body allows also to sharpen the model of remote mental interactions. In fact, these effects would be only a scaled-up exogenous versions of the effects appearing endogenously in cellular length scales and also in astrophysical length scales in communications between magnetic bodies and corresponding biological bodies.

Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part I

The quantum view about metabolism has developed in two stages. First came the somewhat unbalanced vision about the connection of quantum metabolism and bound state formation. The second breakthrough was the discovery of dark matter hierarchy and associated hierarchy of generalized EEGs.

1. *Quantum metabolism and bound state formation*

Topological self-referentiality states that the topological field quanta of the classical fields associated with a material system provide a concrete representation for a theory about the material system. Actually this principle generalizes and implies an entire hierarchy of representations. An important outcome of the topological self-referentiality is that the 'buy-now' part of the buy now-pay later mechanism for energy production could be understood as a generation of bound states with binding energy liberated as a usable energy. 'Pay later' means that sooner or later thermal noise destroys the bound state.

This observation led to a quantum vision about energy economy in living matter: generation of the macroscopic coherence involving also binding of mental images to larger ones and liberation of a usable energy are different sides of the same coin. Besides, or perhaps even instead, the ordinary metabolism, quantum metabolism should be key element of living matter. Indeed, also ordinary metabolism might be accompanied by the effective over-unity energy production implied by the generation of quantum bound state entanglement: this implies a connection with the claimed over unity phenomena. This should reflect experimentally as apparently miraculous ability of the organism to cope without the use of the metabolic energy. Anomalies of this kind have been indeed observed at the level of neuronal metabolism and nano-biology is just challenging the basic assumptions of the Newtonian biology.

This vision can be criticized for over-emphasizing the formation of bound states: also the transitions to bound states with lower energy, say transitions between cyclotron states, can generate metabolic energy.

2. *Dark matter hierarchy and quantum metabolism*

The new vision about me relies on several new ideas that have emerged during years after writing the first draft of this chapter.

1. There are three different views about macroscopic quantum phases. As large \hbar phases with scaled up quantum lengths, as high T_c superconductor like systems, and as negentropically entangled structures (negentropic entanglement is purely TGD based notion and stabilized by Negentropy Maximization Principle). In this chapter arguments supporting the equivalence of these descriptions are developed.

2. The valence electron pairs with spin 1 instead of spin 0 emerge as natural candidates for the counterparts of Cooper pairs generating negentropic entanglement in long length scales. Spin 1 valence electron pairs would generate the magnetic flux tubes along which they propagate and this web of flux tubes would bind proteins to larger structures. The role of the phase transitions changing the value of Planck constant in quantum biology has been discussed already earlier. The fact that bio-molecules - in particular sugars and phosphate molecules - tend to maximize the number of covalent bonds supports this view.
3. The completely accidental observation that dark nucleon states corresponds under rather natural assumptions to DNA, RNA, tRNA, and amino-acid states and that vertebrate genetic code emerges under natural assumptions, leads to the idea that the dark nuclear physics realization of the genetic machinery is its primary realization and that chemical realization is secondary realization. This suggest that dark nuclei identified as nuclear strings of dark protons serve as templates for DNA, RNA, and amino-acids.
4. This leads to the vision that the basic purpose of metabolic energy is to make possible re-distribution of negentropic entanglement between distant bio-molecules using the reconnection of the magnetic flux tubes generated by spin 1 electron pairs as a control tool. In photosynthesis the incoming photons would suffer a phase transition to dark photons before being absorbed by dark electrons and eventually provide their energy to ATP to be used to re-organize negentropic entanglement assignable to the magnetic flux tubes going via ATP molecule. This picture is inspired also by the vision about DNA as topological quantum computer and leads to a more plausible view about how genetic code is realized.

3. *Many-sheeted photo-synthesis*

Photosynthesis is a fundamental metabolic function and a many-sheeted model allows to concretize the general ideas about quantum metabolism. What happens in photosynthesis at the level of energy balance seems to be relatively well-understood but the detailed molecular mechanisms remain obscure. Several strange features, such as the appearance of electron pairs, suggest that super-conductivity and atomic and molecular Bose-Einstein condensates are involved. p-Adic length scale hypothesis gives very strong quantitative guidelines in the attempt to understand photosynthesis in many-sheeted space-time, and one ends up to a general view about how Bose-Einstein condensates store metabolic energy as zero point kinetic energy and how this energy is utilized by remote metabolism by generating negative energy MEs. What is so remarkable is that the resulting simple model of photosynthesis is successful both at qualitative and quantitative level.

I have included in this chapter the earlier variant of the quantum model developed before 2007 as such to compare it with the recent view about macroscopic quantum aspects of photosynthesis involving several new ideas. Note that year 2007 is special in the sense that during 2007 the first evidence for the quantal nature of photosynthesis emerged.

Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part II

This chapter is second part of the chapter devoted to various aspects of metabolism. The basic topics is TGD inspired view about brain metabolism and molecular motors. I have included to the end of the chapter some rather weird sounding ideas such as an explanation of super-luminality in terms of remote metabolism.

1. *Dark matter hierarchy, sensory representations, motor action, and metabolism*

The vision about a hierarchy of generalized EEGs associated with dark matter hierarchy gave a decisive boost leading to new views about quantum metabolism. The crucial new element is that at higher levels of dark matter hierarchy photons with arbitrarily low frequencies can correspond to energies above the thermal threshold. This explains the observed mysterious effects of ELF radiation on living matter and implies that magnetic bodies are key participants in the metabolism. The equally mysterious findings about the ionic membrane currents can be understood if these currents are essentially non-dissipative and that ionic channels and pumps are actually ionic receptors. Hence it seems that generalized EEGs could take a lion share of the metabolic energy rather than ionic

currents as thought usually. This picture allows to understand various strange findings about neuronal metabolism.

2. Holy trinity of red blood cells, neurons, and astrocytes

The vision about dark matter hierarchy and various ideas about quantum metabolism allow to develop a general view about how the sensory representations and motor control are realized in terms of MEs. Time mirror mechanism is the basic elements in the general model for how magnetic body controls biological body and receives sensory information from it.

A model for motor control and sensory representations based on the trinity of red blood cells, astrocytes, and neurons emerges and raises astrocytes from a status of passive energy storage to an active link in the quantum control of brain by magnetic body. One can also identify mechanisms for the generation of coherent locomotion construct a quantum view about how ATP serves as a universal energy currency.

This view also allows a deeper interpretation of chemical communications and biological information molecules. There are full reasons to believe that substructures of these molecules can have bound state entanglement with the surrounding world. This entanglement can be interpreted in terms of 'telepathic' quantum communications. In fact, I introduced already few years ago the notion semitrance as entanglement with higher level selves but at this time I had not yet understood that quantum jump involves also state function preparation process realized as a cascade of self measurements against which only bound state entanglement is stable.

For a long time glial cells were believed to play a rather passive role in the functioning of brain taking care of basic services such as providing metabolic energy and serving as supporting structures for neurons. During the recent years the views about the role of glia have however changed dramatically. In TGD framework the very fact that metabolism relates very closely to the re-organization of negentropic entanglement forces to recheck this view. Also the slowness of glial dynamics as compared to neuronal dynamics suggests that large values of Planck constant responsible for long time time scales and therefore also for the highest levels of consciousness (including functions like long term memory) are assignable to glia.

3. Molecular motors

During last years molecular motors have become the hot topics of biology. The so called Brownian motors are the dominating theoretical paradigm but there are some empirical findings challenging the concept.

TGD suggests an alternative approach based on the notion of quantum motor. The basic idea is that all moving parts of the quantum motor move on the non-atomic space-time sheets so that momentum dissipation is minimal. It turns out that this picture might work but that TGD allows both quantum and classical modes for the molecular motors and it is quite possible that both modes are present. The model allows a new view about the real function of ATP leading to precisely correct quantitative predictions. Also the real function of membrane potential can be understood and quantum model for nerve pulse and EEG constructed.

The fascinating ability of molecular motors to co-operate finds an explanation in terms of the notion of super-genome: super-genome consists of sequences of nuclei analogous to text lines at the pages of book represented by magnetic flux sheets. Also the magnetic bodies of molecular motors can integrate in a similar manner to larger structures so that the population of molecular motors becomes a society.

4. Remote metabolism and effective super-luminal velocities

After the pioneering experiments of Nimtz and his collaborators 1992 a lot of evidence for effective super-luminal signal velocities has been accumulating. A possible model for the super-luminality and related effects is in terms of remote metabolism associated with detectors and other instruments. This idea belongs to the class of ideas which look like curiosity after decade.

I have included to the end of the chapter also other miscellaneous topics such as an old proposal for the possible role of four-wave interactions in the construction of conscious holograms.

Part I

**THE NOTION OF TIME IN TGD
UNIVERSE**

Chapter 2

Time and Consciousness

2.1 Introduction

The identification of moments of consciousness as quantum jumps between quantum histories suggests that our common sense picture about the time evolution of universe might be badly misguided by the restrictions posed by the basic features of our conscious experience. What one can do is to try to develop the most general picture about the cosmology of consciousness consistent with our own conscious experiences and try to identify our position in this picture. Already in its recent form TGD inspired theory of consciousness can give quite restrictive constraints on this Grand Scenario.

The understanding of how psychological time and its arrow emerge has been perhaps the most longstanding problem of quantum TGD and TGD inspired theory of consciousness. By quantum classical correspondence the arrow of subjective time should be mapped to the arrow of geometric time at the level of conscious experience. In similar manner the asymmetry between subjective future and past should correspond to an asymmetry between geometric future and past. What this means at the level of details has been far from clear and I have proposed many partial answers to the question about the arrow of geometric time. For instance: the geometric future inside light-cone contains much more room than geometric past so that the space-time region about which the contents of conscious experience are about tends to diffuse to the direction of the geometric future defined by light-cone proper time; perhaps the flow of geometric time corresponds to a wave front of intentional action identifiable as a phase transition changing intentions identified as p-adic space-time sheets transformed to real space-time sheets; maybe the space-time sheet assignable to self topologically condensed to a larger space-time sheet shifts in quantum jumps to the direction of geometric future some average temporal distance perhaps defined by CP_2 length scale. All these proposals have provided only partial answers, have led to paradoxes, and failed to give a firm quantitative grasp about the situation.

Also the original wrong view about the correspondence of real and p-adic numbers has generated a lot of confusion. The natural belief of topologist would be that p-adic space-time sheets are mapped to their real counterparts by a continuous map (some variant of what I called canonical identification making sense in p-adic thermodynamics). This map did not however respect symmetries and was inconsistent with field equations. Finally I was able to accept the natural belief of algebraist: reals and various p-adic number fields must be glued to together along rationals and common algebraic numbers to achieve generalization of the number concept and also that of imbedding space. What was difficult to accept was the highly non-intuitive implication that most points of p-adic space-time sheets are at spatial and temporal infinity in real (but not in p-adic) sense so that cognition and intentionality would be literally cosmic phenomena and only cognitive representations would be realized in a finite space-time volume in real sense (causal diamond) in terms of intersections of real and p-adic space-time sheets consisting of rational and some algebraic points.

I have tried to tidy up the chapters so that they would not contain too many mammoth bones. Since I can use only a finite amount of time to documentation purposes, I have not been completely successful and this chapter as also others might contain statements which represent earlier archeological strata. I hope that reader could forgive this. Benevolent reader might even take these chapters as documents about how ideas have developed.

2.1.1 The concepts of self and subjective memory

Self is identified as a subsystem able to remain unentangled during quantum jumps consisting of unitary processes U defining informational "time evolutions" followed by a state function reduction which in zero energy ontology includes also state preparation occurring for the negative energy part of the state (zero energy state corresponds to physical event in positive energy ontology with negative and positive energy parts of the state being identified as the counterparts of the initial and final states of the event). Bound state entanglement is stable against state function reduction so that consciousness would be lost the bound state entanglement is generated. This would stop the sequence of state function reductions initiated after the U -process. The notion of number theoretic entropy allows to assign entanglement negentropy to algebraic entanglement probabilities so that NMP favors the generation of entanglement in this kind of situation. This encourages the hypothesis that subsystem does not lose consciousness if it generates algebraic entanglement with environment. This would correspond to the fusion to the sea of consciousness in the spiritual terminology. Algebraic entanglement is possible in the intersection of real and p-adic worlds which in turn encourages the proposal that living matter corresponds to this intersection, and is therefore a critical phenomenon in number-theoretical sense so that evolution involves in an essential manner the generation of algebraic entanglement.

One can say that self is a subsystem behaving like its own sub-Universe (with respect to NMP). What this really means quantitatively is far from obvious and detailed view requires the introduction of zero energy

The hypothesis that the experiences of self associated with the quantum jumps occurred after the 'wake-up' sum up to single experience, implies that self can have memories about earlier moments of consciousness. Therefore self becomes extended object with respect to subjective time and has a well defined 'personal history'. If temporal binding of experiences involves kind of averaging, quantum statistical determinism makes the total experience defined by the heap of the experiences associated with individual quantum jumps reliable. Subjective memory associated with sensory mental images has duration of about .1 seconds from the temporal resolution of sensory experience: it is quite possible that our self has much longer duration. The subjectotemporal sequences of sub-selves make possible to remember the digits of a phonenumber.

Subsystem X possessing self behaves essentially as a separate sub-Universe with respect to NMP. An attractive hypothesis is that the experience of self is abstraction in the sense that the experiences of sub-selves X_{ij} of X_i are abstracted to average experience $\langle X_{ij} \rangle$. This implies that the experiences of sub-sub-...selves of X are effectively unconscious to X . This self hierarchy is infinite and has entire Universe, God at the top. Temporal binding with averaging implies that experiences of individual selves are reliable and abstraction brings in the possibility of quantum statistical determinism at the level of ensembles.

2.1.2 Psychological time and its arrow

Quantum classical correspondence requires that the flow of subjective time identified as a sequence of quantum jumps should have the flow of geometric time as a space-time correlate. The understanding of the detailed relationship between these two times has however remained a long standing problem, and I have proposed several models involving ad hoc assumptions. Only the emergence of zero energy ontology allows an ad hoc free model for how the experienced flow and arrow of geometric time emerge, and answers why the relationship between geometric past and future is so asymmetric and why sensory experience is about so narrow interval of geometric time. Also the notion of self reduces in well-defined sense to the notion of quantum jump with fractal structure [K6] .

The basic idea about the correspondence between subjective and geometric time is very simple. Configuration space spinor field represents a quantum superposition of space-time surfaces. Assume that the attention of self is directed to a fixed volume of the 8-D imbedding space. Quantum classical correspondence requires that this quantum superposition in the first approximation shifts towards geometric past of the imbedding space so that self experiences effective flow of the geometric time associated with the space-time surface. This explanation works only if macroscopic quantum coherence holds true so that one cannot regard the space-time surface as a fixed arena of dynamics. Also the representability of the space-time surfaces as sub-manifolds of 8-D imbedding space is essential. The identification of the fundamental volume of attention as a causal diamond inspired by zero energy ontology based formulation of quantum TGD provides answers to more detailed questions. This iden-

tification means also that causal diamond of imbedding space rather than space-time sheet becomes the space-time correlate of self.

2.1.3 Cosmology of consciousness

The idea about cosmology of consciousness is inspired by the prediction of the infinite self hierarchy and by quantum-classical correspondence principle [K46]. The expectation is that the fractal structure of the many-sheeted space-time should directly reflect the general structure for the cosmology of consciousness. For instance, the p-adic evolution of consciousness should have its counterpart at the space-time level. Indeed, there are good reasons to believe that 4-surfaces have decomposition into real regions and p-adic regions and that one can assign to each real region a finite prime p characterizing the effective p-adic topology of the real space-time region (or of light-like 3-surface or partonic 2-surface) and the p-adic topology which the real region is near criticality to transform to. In zero energy ontology this transformation indeed makes sense. Just like configuration space is conjectured to have a decomposition into regions D_P labelled by infinite p-adic primes P , the space-time surface decomposes into real regions labelled by finite primes appearing in the decomposition of P .

Fractality suggests that there are conscious universes within conscious universes and the nested structure of the topological condensate suggests that experiences of universes involve kind of abstractions about the experiences of the sub-universes they contain. The prediction of infinite hierarchy of selves and summation hypothesis for the experiences of selves is in accordance with this expectation.

Mind-like space-time sheets were introduced originally as space-time sheets of finite temporal duration or alternatively as space-time sheets for which the classical determinism in the standard sense of the word fails. In zero energy ontology all space-time sheets have finite temporal scale and zero energy states associated with them have mind-like aspects. For instance, the positive and negative energy parts of the fermionic state define a quantum representation for an abstraction for the Boolean statement $A \rightarrow B$ with various instances of a and b appearing in the superposition.

Since mind like space-time sheets have a bounded time duration, one cannot assign to a quantum jump a single value of the geometric time. Rather, our psychological time would be associated with one of the infinitely many irreducible sub-experiences associated with mind like space-time sheets and the values of the psychological time range from zero to infinity. Since selves contain sub-selves with various values of psychological time, experiences are actually multitime experiences with respect to both geometric and subjective time. The entire 4-dimensional space-time is a living system: both the geometric future and past are living and participate in each moment of consciousness. Selves have increasingly longer geometric and subjective memories and that at the limit of entire universe selves have infinitely long subjective memory.

2.1.4 Four-dimensional brain

The hypothesis that entire space-time surface is populated by mind like space-time sheets realized in concrete manner in zero energy ontology in terms of causal diamonds (CDs) representing systems participating in every moment of consciousness, means also dramatically new manner to understand brain. For instance, the problem of memory trivializes. Geometric memory provides simulations and expectations for what happened and will happen whereas subjective memory has interpretation as immediate short term memory. The most plausible interpretation of long term memories is as geometric memories represented by multitime snapshots. This hypothesis explains the practically unlimited capacity of autobiographical memory and also other basic aspects of long term memories and avoids the counter arguments against the neural net models of long term memory. The paradigm of four-dimensional brain (and body!) forces to reconsider the basic dogma of neuroscience stating that sensory consciousness is associated with brain only and explains nicely the results of Libet's experiments. A concrete model of the long term memory is based on quantum mirror mechanism: experience long term memory means looking at a quantum mirror at a distance of say light years. The attribute 'quantum' means that there is no need to code information to a classical signal, just time like entanglement made possible by the classical nondeterminism of Kähler action and by p-adic nondeterminism is enough.

2.1.5 Evidence for TGD based time concept

The new concept of time follows from the quantum jump between quantum histories concept so that tests for the latter are indirect tests for the former. Perhaps the strongest support for the new concept of time comes from the requirement of the internal consistency of the world view. The phenomenon of dissipation is paradoxical from the point of view of standard physics. It is generally accepted that fundamental laws of classical physics are reversible whereas everyday reality is manifestly irreversible. Thus the situation is rather schizophrenic. Two worlds, the reversible and extremely beautiful world of fundamental physics and the irreversible and mathematically rather ugly, irreversible "real" world, seem to exist simultaneously. Quantum jumps between quantum histories concept solves the paradox and one can understand dissipative world as an effective description forming "almost" envelope for the sequence of reversible worlds understood as entire time evolutions.

Quantum jumps between quantum histories concept explains the peculiar time delays of consciousness revealed in the experiments of Libet and Kornhuber relating to active and passive roles of consciousness [J48, J72] and the causal anomalies revealed by the experiments of Radin and Bierman [J25, J26, J88]. TGD predicts "tribar effect" as a general signature for the quantum jump between quantum histories concept.

A further implication is quantum theory of self-organization. Self-organization means the organization of selves leading to fixed point patterns analogous to those generated in Benard flow. This means that dissipation serves as a Darwinian selector of both genes and memes. Dissipation is present also at the elementary particle level and leads to the selection of the p-adic effective topologies of elementary particle space-time sheets. Black-hole elementary particle analogy suggests that the allowed p-adic primes are given the p-adic length scale hypothesis $p \simeq 2^k$, k power of prime.

2.2 TGD based concept of time

TGD based notion of time involves several new aspects. Quantum jump as occurring between entire quantum histories rather than time=constant snapshots of a single history is certainly the most decisive new element. The necessity to differentiate between subjective and geometric time is immediate implication of this identification. The classical non-determinism of Kähler action is second fundamental ingredient: without it time would be lost in the sense that the contents of our conscious experience would not be localized with respect to geometric time and one could not understand the emergence of psychological time and its arrow. The new view about time leads also to the notion of four-dimensional brain implying a new manner to see what long term memories are, and the vision about space-time as a four-dimensional organism. A further new element is related to the possibility of negative energy space-time sheets and classical communications also to the direction of geometric past. The final important ingredient is p-adic physics as physics of cognition and intention having rather exotic implications, such as replication of p-adic memes by time reflection, their instantaneous propagation by the same mechanism, and time reversed cognition. p-Adic physics as physics of intentionality is crucial for understanding of the psychological time as a front of p-adic-to-real phase transition transforming intentions to actions [K52].

2.2.1 'Holy trinity' of time developments

Quantum jump between quantum histories was originally believed to be something irreducible and structureless. Gradually the view about quantum jump has however become more and more structured and as a result a connection the quantum standard measurement theory follows as a prediction of quantum TGD. In what sense quantum jumps remains irreducible is that one cannot build any dynamical model for the non-deterministic steps appearing in quantum jump.

The general structure of quantum jump

It has gradually become clear that TGD involves "holy trinity" of dynamics.

1. The dynamics defined by the preferred extremals of Kähler action corresponds to the dynamics of material existence, with matter defined as "res extensa", three-surfaces. What preferred extremals really are has been a long standing open question. The recent formulation of the

quantum theory using modified Dirac action leads to the proposal that the preferred extremals are critical in the sense that they allow an infinite number of deformations for which the second variation vanishes. This serves as space-time counterpart for quantum criticality of TGD Universe fixing the fundamental variational principle uniquely.

2. The dynamics defined by the action of the unitary 'time development' operator U in the space of quantum histories, is the counterpart of the ordinary Schrödinger time evolution $U \equiv U(-t)$, $t \rightarrow \infty$ and can be regarded as "informational" time development occurring at the level of objective existence. It seems however unnecessary and in fact impossible to assign real Schrödinger time evolution with U . U defines the S-matrix of the theory.
3. The dynamics of quantum jumps between quantum histories corresponds to the dynamics of subjective existence.

Quantum jump was originally seen as something totally irreducible. Gradually the structure of quantum jump has revealed itself.

1. The first step in quantum jump is informational 'time development'

$$\Psi_i \rightarrow U\Psi_i \ ,$$

where U is the counterpart of the unitary process of Penrose. The resulting state is a completely entangled multiverse state, the entire universe being in a holistic state of 'oneness'.

2. Then follows the TGD counterpart of state function reduction realized as a localization in zero modes:

$$U\Psi_i \rightarrow \Psi_f^0 \ .$$

The assumption that localization occurs in zero modes of the configuration space would pose very important consistency condition on U : it must effectively correspond to a flow in zero modes such that there is one-one correlation between the quantum numbers in quantum fluctuating degrees of freedom in some state basis and the values of the zero modes. This together with the fact that zero modes are effectively classical variables, would imply that the localization in zero modes corresponds to a state function reduction. All p-adic configuration space degrees of freedom are zero modes so that in this sense cognition is classical. One must however be cautious: also wave functions in zero modes are possible as will be argued below.

3. The state function reduction is followed by a cascade of self measurements in quantum fluctuating degrees of freedom (zero modes do not change during this stage)

$$\Psi_f^0 \rightarrow \dots \rightarrow \Psi_f \ ,$$

whose dynamics is governed by the Negentropy Maximization Principle (NMP). For a generic entanglement probabilities his process leads to bound states or a completely unentangled state or bound states identifiable as prepared states for the next quantum jump. This process can be regarded as an analysis or even decay process. If entanglement probabilities are algebraic numbers, the state function reduction can lead to an entangled state with a positive entanglement entropy.

4. Measurement theory requires an entanglement between zero modes and quantum jumps of the physical state. The addition of a measurement interaction term to the modified Dirac action coupling to four-momentum and color quantum numbers of the state and also to more general conserved quantum numbers allows an explicit realization of this coupling and induces the addition of an analogous measurement interaction term to Kähler action [K30] . This term implies the entanglement of the quantum numbers of the physical states with zero modes.

A good metaphor for quantum jump is as Djinn leaving the bottle (informational time development), fulfilling the wish (quantum jump involving choice) and returning to, possibly new, bottle (localization in zero modes and subsequent state preparation process). One could formally regard each quantum jump as quantum computation lasting infinitely long time $t \rightarrow \infty$ followed by a state preparation of the initial state of the next quantum computation.

Is the complete localization in zero modes really necessary?

The detailed inspection of what happens in quantum jumps forces to consider the possibility that quantum jump involves always a complete localization in zero modes. This was indeed the original proposal. It however seems that a localization modulo finite measurement resolution might be a more realistic assumption. Certainly it is enough to explain why the perceived Universe looks classical.

1. QFT picture strongly suggests that sub-system must be defined as a tensor factor of the space of configuration space spinors at given point Y^3 of the configuration space. This suggests that subsystem should be defined as a function of Y^3 and should be a local concept. An important consequence of this definition is that entanglement entropy gives information about space-time geometry.
2. Configuration space spinor field can be formally expressed as superposition of quantum states localized into the reduced configuration space consisting of 3-surfaces belonging to light cone boundary. Hence configuration space spinor field can be formally written as

$$\sum_{Y^3} C(Y^3)(n, N)|n\rangle|N\rangle$$

for any subsystem-complement decomposition defined in Y^3 . Clearly, configuration space coordinates appear in the role of additional indices with respect to which entanglement coefficients are diagonal. The requirement that final state is pure state would suggest that quantum jump reducing entanglement must involve complete localization of the configuration space spinor field to some Y^3 plus further quantum jump reducing entanglement in Y^3 . Complete localization in the configuration space is however not physically acceptable option since the action of various gauge symmetries on quantum states does not commute with the complete localization operation. In particular, the requirement that physical states belong to the representations of Super Virasoro and super-symplectic algebras, is not consistent with this requirement.

3. Configuration space has fiber space structure. Configuration space metric is non-vanishing only in the fiber degrees of freedom and since the propagator for small fluctuations equals to the contravariant metric, fiber degrees of freedom correspond to genuine quantum fluctuations. Configuration space metric vanishes in zero modes, which can be identified as fundamental order parameters in the spirit of Haken's theory of self organization. The requirement that various local symmetries act as gauge symmetries, provides good reasons to expect that *entanglement coefficients in the fiber degrees of freedom are gauge invariants and depend on the zero modes parametrically*. The one-one correlation between quantum numbers of the state assignable to fiber degrees of freedom and classical variables identified as zero modes would encourage the assumption that a complete localization occurs in zero modes. A weaker condition is that localization occurs only modulo a finite measurement resolution.
4. The original argument was that the nonexistence of metric based volume element in zero modes forces the wave functions in zero modes to have a discrete locus. There however exists a symplectic measure defined by the symplectic form in zero modes. It does not however allow a complexification to Kähler form as it does in quantum fluctuating degrees of freedom. This symplectic form could define a hierarchy of integration measures coming as restrictions of $J \wedge J \dots \wedge J$ with n factors to $2n$ -dimensional sub-manifolds. Under some additional conditions- maybe the homological non-triviality of J and the orientability of the sub-manifold are enough, this measure would define a positive definite inner product and one would have a hierarchy finite-dimensional sub-spaces of zero modes. The maxima of Kähler function with respect to zero modes replace naturally the continuum with a discrete set of points and define the counterpart of the spin glass energy landscape consisting of the minima of free energy. Effective finite-dimensionality and even effective discreteness would be achieved.
5. The time development by quantum jumps in zero modes is effectively classical: Universe is apparently hopping around in the space of the zero modes. This looks very attractive physically since zero modes characterize the size, shape and classical Kähler fields associated with 3-surface.

Therefore each quantum jump gives very precise conscious geometric information about space-time geometry and about configuration space in zero modes. This also means that Haken's classical theory of self-organization generalizes almost as such to TGD context. The probability for localization to given point of zero mode space is given by the reduced probability density Q defined by the integral of the probability density R defined by configuration space spinor field over fiber degrees of freedom. The local maxima of Q with respect to zero modes appear as attractors for the time development by quantum jumps. Dissipative time development could be regarded as a sequence of quantum jumps leading to this kind of local maximum.

6. Effective localization in zero modes is completely analogous to spontaneous symmetry breaking in which scalar field attains vacuum expectation value with the difference that the number of degrees of freedom is infinite unlike in typical models of symmetry breaking. Thus the general structure of the configuration space spinor field together with TGD based quantum jump concept automatically implies spontaneous symmetry breaking in its TGD version (note however that particle massivation results from both p-adic thermodynamics and coupling to Higgs like field of purely geometric origin in TGD framework). TGD Universe is superposition of parallel classical universes (3-surfaces). Therefore quantum entangled state can be regarded as a superposition of parallel entangled states, one for each 3-surface. Formally entanglement coefficients can be regarded as coefficients containing the configuration space coordinates of 3-surfaces as additional index. The analogy with the spin glass also supports the localization in the zero modes.
7. Effective localization in the zero modes provides simple explanation for why the universe of conscious experience looks classical: moment of consciousness makes it classical. It also explains why the physics treating space-time as a fixed arena of dynamics has been so successful. As already found, a further important consequence is first principle description of the state function reduction.

2.2.2 Quantum jump as moment of consciousness and the notion of self

If quantum jump occurs between two different time evolutions of Schrödinger equation (understood here in very metaphorical sense) rather than interfering with single deterministic Schrödinger evolution, the basic problem of quantum measurement theory finds a resolution. The interpretation of quantum jump as a moment of consciousness means that volition and conscious experience are outside space-time and state space and that quantum states and space-time surfaces are "zombies". Quantum jump would have actually a complex anatomy corresponding to unitary process U , state function reduction and state preparation at least.

Quantum jump has a complex anatomy since it must include state preparation, state function reduction, and also unitary process characterized by U -matrix. Zero energy ontology means that one must distinguish between M -matrix and U -matrix. M -matrix characterizes the time like entanglement between positive and negative energy parts of zero energy state and is measured in particle scattering experiments. M -matrix need not be unitary and can be identified as a "complex" square root of density matrix representable as a product of its real and positive square root and of unitary S -matrix so that thermodynamics becomes part of quantum theory with thermodynamical ensemble being replaced with a zero energy state. The unitary U -matrix describes quantum transitions between zero energy states and is therefore something genuinely new. It is natural to assign the statistical description of intentional action with U -matrix.

Intuitively self corresponds to a sequence of quantum jumps which somehow integrates to a larger unit much like many-particle bound state is formed from more elementary building blocks. It also seems natural to assume that self stays conscious as long as it can avoid bound state entanglement with the environment: everything is conscious and consciousness can be only lost. This view predicts infinite self hierarchy with the entire Universe at the top.

If one accepts the hierarchy of Planck constants [K29], it might be unnecessary to distinguish between self and quantum jump. The hierarchy of Planck constants interpreted in terms of dark matter hierarchy predicts a hierarchy of quantum jumps such that the size of space-time region contributing to the contents of conscious experience scales like \hbar . Also the hierarchy of space-time sheets labeled by p-adic primes suggests the same. That sequence of sub-selves/sub-quantum jumps are experienced as separate mental images explains why we can distinguish between digits of phone number. The irreducible component of self (pure awareness) would correspond to the highest level in the "personal"

hierarchy of quantum jumps and the sequence of lower level quantum jumps would be responsible for the experience of time flow. Entire life cycle would correspond to single quantum jump at the highest(?) level of the personal self hierarchy and pure awareness would prevail during sleep: this would make it possible to experience directly that I existed yesterday. Whether these two definitions of self are in some sense equivalent will be discussed later.

Self is assumed to experience sub-selves as mental images identifiable as "averages" of their mental images. This implies the notion of ageing of mental images as being due to the growth of ensemble entropy as the ensemble consisting of quantum jumps (sub-sub-selves) increases.

There are thus two definitions of self. The first definition introduces self as a notion separate from quantum jump. Second definition reduces the notion of self to a fractal hierarchy of quantum jumps. The equivalence between two definitions of the notion of self will be proposed later.

2.2.3 Some aspects of classical non-determinism

The general view about the classical non-determinism of Kähler action and its role in TGD and TGD inspired theory of consciousness has developed gradually and still does so. The newest developments relate to the application of quantum gravitational hologram principle in TGD framework. What has been however clear for a long time is that TGD inspired theory of consciousness falls or stands with the classical non-determinism.

Vacuum extremals

Any 4-surface which belongs to $M_+^4 \times Y^2$, where Y^2 is so called Legendre manifold of CP_2 representable as

$$P_i = \nabla_i f(Q_1, Q_2), \quad i = 1, 2 \quad ,$$

where f is arbitrary function and (P_i, Q_i) are some canonical coordinates of CP_2 , is vacuum extremal of Kähler action. For these vacuum extremals the signature of the induced metric can be either Minkowskian or Euclidian. There are also vacuum extremals with Euclidian signature of the induced metric. The so called CP_2 type extremals are vacuum extremals having light like random curve as light cone projection. These extremals are isometric with CP_2 so that the signature of the induced metric is Euclidian. These extremals provide a model for elementary particle.

Only the non-vacuum deformations of the vacuum extremals are physical. The remnants of the huge vacuum non-determinism are expected to give rise to the non-determinism required by symbolic representations of conscious experience at the level of space-time dynamics giving rise to language as a special case. Of course, classical nondeterminism of the Kähler action might also relate to the nondeterminism of volition although it seems that p-adic-to-real phase transitions are responsible for the transformation of intentions to actions. It seems that the CP_2 type extremals representing cognitive neutrino pairs are crucial for our cognitive consciousness and its transformation to symbolic representations.

Mind-like space-time sheets as deformations of vacuum extremals

The original proposal that mind-like space-time sheets and matter-like space-time sheets differ in the sense that the first ones are non-deterministic and consist of a collection of 3-surfaces with time-like separations whereas the latter are deterministic or at least have infinite size in time direction by standard conservation laws. In zero energy ontology mind-likeness in this sense holds true quite generally.

Physical intuition suggests that the gluing vacuum extremals to a material space-time sheet $X^3(Y^3)$ by # (topological sum) contacts, an interaction results and deforms vacuum extremal slightly and that in some cases this leads to a new preferred extremal with a slightly larger value of Kähler function and hence a larger value of the vacuum functional making the 3-surface more probable. These deformed vacuum extremals are expected to be still non-deterministic although the non-determinism should be reduced considerably. Via their interactions with the environment, (mind-like) space-time sheets provide sensory and symbolic representations for some aspects of the surrounding world. Hence they are quite generally natural geometric counterparts of selves. For instance, the time evolution of our body would correspond to this kind of deformed vacuum space-time sheet with a finite time duration.

The space-time surfaces $X_i^4(Y^3)$ are expected to be very nearly identical outside the time-interval characterizing the size of the mind like space-time sheet: this in turn implies time localization for the non-determinism of quantum jump and therefore for the contents of conscious experiences associated with the mind like space-time sheet.

In zero energy ontology mind-like space-times sheets correspond to a collection of 3-surfaces belonging to boundaries of causal diamond (CD) and its sub- CD s corresponding to the classical correlate for radiative corrections. Generalized causality makes it possible to avoid paradoxical situation: assuming that space-time surface $X^4(Y^3)$ is preferred extremal of the Kähler action for Y^3 one might always find a new 4-surface giving rise to a smaller Kähler action by gluing suitable vacuum extremal to $X^4(Y^3)$.

Massless extremals as quantum gravitational holograms

Massless extremals (MEs) belong to the fundamental solutions of field equations. It has become also clear that they play the role of quantum gravitational holograms. The hologram principle of quantum gravitational theories roughly states that the quantum theory in space-time with boundary reduces to a conformal quantum field theory at the boundary. If Kähler action were deterministic, precisely this would happen. The construction of configuration space geometry relies crucially on the assumption that the complications due to the non-determinism of Kähler action does not radically modify the construction based on the assumption of a complete determinism.

It has indeed turned out that the basic construction in which everything reduces to the light like boundary of M_+^4 (moment of big bang) acting as a hologram in quantum gravitational sense and defining conformal quantum theory, generalizes. This construction survives as a template in a more general construction in which also the light like boundaries of MEs having always light like M_+^4 projection are taken into account besides δM_+^4 as surfaces at which initial values can be fixed arbitrarily. This brings in also time absent in a strictly deterministic theory. Thus the quantum gravitational hologram defined by δM_+^4 is replaced by a fractal structure formed by δM_+^4 and Russian doll hierarchy of the light like boundaries of MEs inside MEs. The super-canonical and super-conformal invariances of the light like boundaries indeed generalize in an elegant manner thanks to the basic properties of MEs.

There are good reasons to expect that the light like selves defined by the boundaries of MEs are fundamental in TGD inspired theory of consciousness. The super-canonical quantum states associated with these boundaries are genuine quantum gravitational states defined by configuration space functionals, whose dependence on the bosonic fiber degrees of freedom of the configuration space does not reduce to a mere vacuum functional given by the exponent of Kähler action. This means that these states do not possess any quantum field theoretic counterparts. They are state functionals in the world of worlds, so to say, and therefore should represent highest level in the hierarchy of quantum control in living systems. Thus it is the higher abstraction level of quantum gravitational states which connects conscious intelligence and quantum gravitation.

2.2.4 Two times

The notion of quantum jump implies a new view about time. Experienced/subjective time corresponds to a sequence of sub-quantum jumps and cannot be identified with the geometric time defined as the fourth space-time coordinate. This is of course obvious for anyone: consider only the reversibility of geometric time contra irreversibility of experienced time, and the fact that both geometric past and future exist whereas only subjective past exists. The fact that the contents of conscious experience is about 4-D rather than 3-D space-time region, motivates the notions of 4-D brain, body, and even society. In particular, conscious existence continues after biological death since 4-D body and brain continue to exist.

2.2.5 About the arrow of psychological time

Quantum classical correspondence predicts that the arrow of subjective time is somehow mapped to that for the geometric time. The detailed mechanism for how the arrow of psychological time emerges has however remained open. Also the notion of self is problematic.

Two earlier views about how the arrow of psychological time emerges

The basic question how the arrow of subjective time is mapped to that of geometric time. The common assumption of all models is that quantum jump sequence corresponds to evolution and that by quantum classical correspondence this evolution must have a correlate at space-time level so that each quantum jump replaces typical space-time surface with a more evolved one.

1. The earliest model assumes that the space-time sheet assignable to observer ("self") drifts along a larger space-time sheet towards geometric future quantum jump by quantum jump: this is like driving car in a landscape but in the direction of geometric time and seeing the changing landscape. There are several objections.
 - i) Why this drifting?
 - ii) If one has a large number of space-time sheets (the number is actually infinite) as one has in the hierarchy the drifting velocity of the smallest space-time sheet with respect to the largest one can be arbitrarily large (infinite).
 - iii) It is alarming that the evolution of the background space-time sheet by quantum jumps, which must be the quintessence of quantum classical correspondence, is not needed at all in the model.
2. Second model relies on the idea that intentional action -understood as p-adic-to-real phase transition for space-time sheets and generating zero energy states and corresponding real space-time sheets - proceeds as a kind of wave front towards geometric future quantum jump by quantum jump. Also sensory input would be concentrated on this kind of wave front. The difficult problem is to understand why the contents of sensory input and intentional action are localized so strongly to this wave front and rather than coming from entire life cycle.

There are also other models but these two are the ones which represent basic types for them.

The third option

The third explanation for the arrow of psychological time - which I have considered earlier but only half-seriously - looks to me the most elegant at this moment. This option is actually favored by Occam's razor since it uses only the assumption that space-time sheets are replaced by more evolved ones in each quantum jump. Also the model of tqc favors it.

1. In standard picture the attention would gradually shift towards geometric future and space-time in 4-D sense would remain fixed. Now however the fact that quantum state is quantum superposition of space-time surfaces allows to assume that the attention of the conscious observer is directed to a fixed volume of 8-D imbedding space. Quantum classical correspondence is achieved if the evolution in a reasonable approximation means shifting of the space-time sheets and corresponding field patterns backwards backwards in geometric time by some amount per quantum jump so that the perceiver finds the geometric future in 4-D sense to enter to the perceptive field. This makes sense since the shift with respect to M^4 time coordinate is an exact symmetry of extremals of Kähler action. It is also an excellent approximate symmetry for the preferred extremals of Kähler action and thus for maxima of Kähler function spoiled only by the presence of light-cone boundaries. This shift occurs for both the space-time sheet that perceiver identifies itself and perceived space-time sheet representing external world: both perceiver and percept change.
2. Both the landscape and observer space-time sheet remain in the same position in imbedding space but both are modified by this shift in each quantum jump. The perceiver experiences this as a motion in 4-D landscape. Perceiver (Mohammed) would not drift to the geometric future (the mountain) but geometric future (the mountain) would effectively come to the perceiver (Mohammed)!
3. There is an obvious analogy with Turing machine: what is however new is that the tape effectively comes from the geometric future and Turing machine can modify the entire incoming tape by intentional action. This analogy might be more than accidental and could provide a model for

quantum Turing machine operating in TGD Universe. This Turing machine would be able to change its own program as a whole by using the outcomes of the computation already performed.

4. The concentration of the sensory input and the effects of conscious motor action to a narrow interval of time (.1 seconds typically, secondary p-adic time scale associated with the largest Mersenne M_{127} defining p-adic length scale which is not completely super-astronomical) can be understood as a concentration of sensory/motor attention to an interval with this duration: the space-time sheet representing sensory "me" would have this temporal length and "me" definitely corresponds to a zero energy state.
5. The fractal view about topological quantum computation strongly suggests an ensemble of almost copies of sensory "me" scattered along my entire life cycle and each of them experiencing my life as a separate almost copy.
6. The model of geometric and subjective memories would not be modified in an essential manner: memories would result when "me" is connected with my almost copy in the geometric past by braid strands or massless extremals (MEs) or their combinations (ME parallel to magnetic flux tube is the analog of Alfvén wave in TGD).

This argument leaves many questions open. What is the precise definition for the volume of attention? Is the attention of self doomed to be directed to a fixed volume or can quantum jumps change the volume of attention? What distinguishes between geometric future and past as far as contents of conscious experience are considered? How this picture relates to p-adic and dark matter hierarchies? Does this framework allow to formulate more precisely the notion of self? Zero energy ontology allows to give tentative answers to these questions.

2.2.6 What really distinguishes between future and past?

Our knowledge about geometric future is very uncertain as compared to that about geometric past. Hence we usually use words like plan/hunch/hope/... in the case of geometric future and speak about memories in the case of geometric past. We also regard geometric past as something absolutely stable. Why we cannot remember geometric future as reliably as the geometric past? Is it that geometric future is highly unstable as compared to the geometric past? Why this should be the case? This provides a possible TGD based articulation for the basic puzzles relating to time experience. These questions have been already discussed in this chapter but I want to close the chapter with considerations inspired by the latest progress in the understanding of quantum TGD.

Is p-adic-to-real phase transition enough?

The basic idea is that the flow of subjective time corresponds to a phase transition front representing a transformation of intentions to actions and propagating towards the geometric future quantum jump by quantum jump. All quantum states have vanishing total quantum numbers in zero energy ontology which now forms the basis of quantum TGD [K19] and this ontology allows to imagine models for what could happen in this process.

This starting point is the interpretation of fermions as correlates for cognition bosons as correlates for intentions/actions [K79]. Fermions correspond to pairs of real and p-adic space-time sheets with opposite quantum numbers with p-adic space-time sheet providing a cognitive representation of the real space-time sheet. Bosonic space-time sheets would be either p-adic or real and thus represent intentions or actions. Fermionic world and its cognitive representations would be common to future and geometric past and the asymmetry would relate only to the intention-action dichotomy.

Geometric future contains a lot of p-adic space-time sheets representing intentions which transform to real space-time sheets allowing interpretation as desires inducing eventually neuronal activities. Time mirror mechanism for intentional action assumes that the phase transition gives rise to negative energy space-time sheets representing propagation of signals to geometric past where they induce neuronal activities. From Libet's experiments relating to neuronal correlates of volition the time scale involved is a fraction of second but an infinite hierarchy of time scales is implied by fractality.

Conservation of quantum numbers poses strong conditions on p-adic-to-real phase transition. Noether charges are in the real context given by integrals over partonic 2-surfaces. The problem is that these integrals do not make sense p-adically. There are two options.

1. Give up the notion of p-adic Noether charge so that it would not make sense to speak about four-momentum and other conserved quantum numbers in case of p-adic space-time sheet. This implies zero energy ontology in the real sector. All real space-time sheets would have vanishing conserved quantum numbers and p-adic-to-real transition generates real space-time sheet complex with vanishing total energy. Negative energy signal must be somehow compensated by a positive energy state.
2. It might be however possible to assign charges to p-adic space-time sheets. The equations characterizing p-adic space-time sheet representing intention and corresponding real space-time sheet representing action are assumed to be given in terms of same rational functions with coefficients which are algebraic numbers consistent with the extension of p-adic numbers used so that the points common to real and p-adic space-time sheets are in this extension. If real charges belong to the algebraic extension used, one could identify the p-adic charges as real charges. Zero energy ontology requires the presence of positive energy real space-time sheets whose charges compensate those of negative energy space-time sheets. One possibility is that real and corresponding p-adic space-time sheets appear in pairs with vanishing total quantum numbers just as fermionic space-time sheets are assumed to occur [K79]. In the case of fermions p-adic-to-real phase transition is impossible by Exclusion Principle so that a stable cognitive representation results.

The minimal option would be that p-adic space-time sheets possess negative energy and are transformed to negative energy signals inducing neuronal activities. The flow of subjective time would involve a transformation of the universe to zero energy universe in the sense that total conserved quantum numbers vanish in the real sense in bosonic sector but in fermionic sector real and p-adic charges compensate each other.

This picture is probably too simple. Robertson-Walker cosmology has vanishing density of inertial energy. Hence it would seem that real bosons and fermions should appear in both positive and negative energy states and the arrow of time defined by the direction of the propagation of the intention-to-action wave front would be local.

The transition of the geometric past back to intentional phase would involve transformation of real bosons to p-adic ones and is in principle possible for this option. For the first option the transition could occur only for real states with vanishing total quantum numbers which would make this transition highly improbable and thus imply irreversibility.

The basic criticism is that since intentions in the proposed sense do not involve any selection, one could argue that this picture is not enough to explain the instability of the geometric future unless the instability is due to the instability of p-adic space-time sheets in quantum jumps.

Does intentional action transform quantum critical phase to non-quantum critical phase?

It is far from clear whether the proposed model is not able to explain the uncertainty of the geometric future and relative stability of the geometric past related very intimately to the possibility to select between different options. TGD based view about dark matter as a hierarchy of phases characterized by M^4 and CP_2 Planck constants quantized in integer multiples of minimum value \hbar_0 of \hbar [K29] suggests a more refined view about what happens in the quantum jump transforming intention to action.

1. The geometric future of the living system corresponds to a quantum critical state which is a superposition of (at least) two phases. Quantum criticality means that future is very uncertain and universe can be in dramatically different macroscopic quantum states.
2. Experienced flow of time corresponds to a phase transition front proceeding towards the geometric future quantum jump by quantum jump. In this transition intentional action represented by negative energy bosonic signals transforms the quantum critical phase to either of the two phases present. This selection between different phases would be the basic element of actions involving choice. The geometric past is stabilized so that geometric memories about geometric past are relatively stable. This picture applies always in some time scale and there is an entire hierarchy of time and spatial scales corresponding to the hierarchies of p-adic length scales and of Planck constants. Note that Compton length and time are proportional to \hbar as is also the span of long term memories and time scale of planned actions.

The (at least) two phases present at quantum criticality would have different values of Planck constants. In the simplest case the values of M^4 and CP_2 Planck constants for the second phase would correspond to the minimal value \hbar_0 of Planck constants. For instance, cell could be in quantum superposition of ordinary and high T_c super-conducting phase, with high T_c superconductor characterized by a large M^4 Planck constant.

Intentional action would induce a transition to either of these two phases. Sub-system would chose either the lower or higher level in the hierarchy of consciousness with level characterized by the values of Planck constants. This unavoidably brings in mind a moral choice. Intentional actions involve often a choice between good and bad and this choice could reduce to a choice between values of Planck constant. Good deed would lead to higher value of Planck constant and bad deed to a lower one. This interpretation conforms with the earlier view about quantum ethics stating that good deeds are those which support evolution. The earlier proposal was however based on the assumption that evolution means a gradual increase of a typical p-adic length scale and seems to be too restricted in the recent framework.

For instance, in cell length scale the cells of the geometric future could be in quantum critical phase such that large \hbar phase corresponds to high T_c super-conductivity and low \hbar phase to its absence. In quantum jump cell would transform to either of these phases. The natural interpretation for the transition to low \hbar phase is as cell death since the communications of the cell to and quantum control by the magnetic body are lost. Ageing could be seen as a process in which the transitions to small \hbar phase begin to dominate or even the quantum criticality is lost. A model for the quantum criticality based on zeros of Riemann zeta developed in [K20, K79, K13] allows a more quantitative view about what could happen in the phase transition.

2.2.7 Memory and time

Do declarative memories and intentional action involve communications with geometric past?

Communications with geometric past using time mirror mechanism in which phase conjugate photons propagating to the geometric past are reflected back as ordinary photons (typically dark photons with energies above thermal threshold) make possible realization of declarative memories in the brain of the geometric past [K66] .

This mechanism makes also possible realization of intentional actions as a process proceeding from longer to shorter time scales and inducing the desired action already in geometric past. This kind of realization would make living systems extremely flexible and able to react instantaneously to the changes in the environment. This model explains Libet's puzzling finding that neural activity seems to precede volition [J72] .

Also a mechanism of remote metabolism ("quantum credit card") based on sending of negative energy signals to geometric past becomes possible [K38] : this signal could also serve as a mere control signal inducing much larger positive energy flow from the geometric past. For instance, population inverted system in the geometric past could allow this kind of mechanism. Remote metabolism could also have technological implications.

Episodal memories as time-like entanglement

Time-like entanglement explains episodal memories as sharing of mental images with the brain of geometric past [K66] . An essential element is the notion of magnetic body which serves as an intentional agent "looking" the brain of geometric past by allowing phase conjugate dark photons with negative energies to reflect from it as ordinary photons. The findings of Libet about time delays related to the passive aspects of consciousness [J48] support the view that the part of the magnetic body corresponding to EEG time scale has same size scale as Earth's magnetosphere. The unavoidable conclusion would be that our field/magnetic bodies contain layers with astrophysical sizes.

p-Adic length scale hierarchy and number theoretically preferred hierarchy of values of Planck constants, when combined with the condition that the frequencies f of photons involved with the communications in time scale T satisfy the condition $f \sim 1/T$ and have energies above thermal energy, lead to rather stringent predictions for the time scales of long term memory. The model for the hierarchy of EEGs relies on the assumption that these time scales come as powers $n = 2^{11k}$,

$k = 0, 1, 2,$, and predicts that the time scale corresponding to the duration of human life cycle is ~ 50 years and corresponds to $k = 7$ (amusingly, this corresponds to the highest level in chakra hierarchy).

2.2.8 Cosmology of consciousness

Cosmology of consciousness scenario is inspired by the notion of infinite self hierarchy and by the quantum-classical correspondence principle stating that the fractal structure of the many-sheeted space-time should directly reflect the general structure for the cosmology of consciousness. For instance, the p-adic evolution of consciousness should have its counterpart at space-time level: indeed, there are good reasons to believe that 4-surfaces have decomposition into regions obeying real or finite-p p-adic topology just like configuration space has decomposition into real regions and regions D_P labelled by infinite primes characterizing the appropriate functions space topology. Fractality suggests that there are conscious universes within conscious universes and that the experiences of universes involve kind of abstractions about the experiences of the sub-universes they contain. Summation hypothesis for the experiences of selves indeed states just this.

Each self corresponds geometrically to its own subset of mind like and matter like space-time sheets, separate conscious cosmology. Mind like space-time sheets are bounded in time direction: the sheet of 3-space is born when a tiny energy flows into the sheet from some larger sheet and dies when this energy flows back to the larger background sheet. p-Adic length scale L_p gives a first guess for the typical duration $T_p = L_p/c$ of the space-time sheet. Even human body could correspond to mind like space-time sheet: time duration would be of order of lifetime. Note however that the visible body might be only dip of iceberg, and it indeed seems that our magnetic body could have size for which light life is natural unit of size. Since selves contain sub-selves with various values of psychological time, the experiences are actually multi-time experiences with respect to both geometric and subjective time. The most natural identification of the psychological time is kind of center of mass coordinate associated with the sensory selves.

If quantum entanglement in the direction of time is a relatively rare phenomenon (it is completely absent in standard theories), entangled mind like space-time sheets correspond to nearly the same value of time so that our conscious experience gets dominant contribution from time values around the mean value of the time coordinate for our space-time sheet of finite duration. Entanglement in time direction gives rise to multi-snapshot experiences which would resemble vivid long term memories. The interpretation as genuine memories is however not correct. Rather, multi-time experiences with contents coming from geometric past and recent are in question.

The conclusion would be that the entire 4-dimensional space-time is a living system in TGD universe: both the geometric future and past are living and participate in each moment of consciousness. Each moment of consciousness decomposes into infinite number of sub-moments of consciousness of selves in the self hierarchy with the values of psychological time varying from zero to infinity. The value of our own psychological time of roughly 10^{11} years is just an accident. Entire civilizations can live in different geometric times without knowing anything about each other unless they happen to have entanglement in time direction. If they have, the resulting experiences could be interpreted as memories, dreams, religious or mystic experiences or simply as hallucinations. The inhabitants of sufficiently but not sufficiently advanced sub-cosmologies tend to believe that they are the only conscious beings in the Universe, construct their own cosmology and try desperately to understand why the value of cosmological time happens to be what it is and, to certain degree quite correctly, conclude that Anthropic Principle is the only explanation.

The civilizations of past could still exist and participate to each quantum jump. Also the civilizations of future coexist consciously with us. The hierarchy of selves implies that selves have increasingly longer geometric and subjective memories. The hypothesis about infinite primes implies a hierarchy of literally infinite values of psychological time and God like conscious beings with infinitely long geometric and subjective memories is possible if infinite primes. At the top of the hierarchy is the entire universe having infinitely long geometric and subjective memories and integrating all experiences at the lower levels of the hierarchy in single abstracted experience. Note that this picture gives hopes to understand how universe is able to construct theory about itself. Notice also that any theory of consciousness should be able to predict its own discovery and the infinite hierarchy of selves gives good hopes in this respect.

One can represent an objection against this picture. p-Adic-to-real phase-transition front should be common to the entire biosphere at our level of self hierarchy at least. It is not clear in what

time scale this is true and whether the geometric past can generate intentions which can effectively re-create the geometric past. If p-adic-to-real phase transition occurs in entire cosmology then one could say that there is universal psychological time. A concrete model for p-adic cognition at neuronal level however suggests that there is no deep reason to assume that psychological time would be more than local. The paradoxes related to the transformation of intentions to actions in the geometric past are avoided if the effects of this nondeterminism are bounded to a time scale not longer than p-adic length scale. This would also conform with the hypothesis that the second law of thermodynamics holds true only in time scales longer than the p-adic length scale characterizing the space-time sheet in question.

2.2.9 Communications in four-dimensional society

The idea about four-dimensional society makes sense only if communication between members of this society is possible. It would be even better if communication could occur in "real subjective time". This seems to be possible in principle as the following arguments show.

Communication method

A simple model for real time communication between societies of the geometric future and past is based on the possibility of space-time sheets of negative time orientation having negative energy density. It seems natural to assume that at least classical signals propagate from geometric future to geometric past along these space-time sheets. As suggested in [K15, K55] "massless extremals" could make possible coherent motion of living systems. It seems that they could make possible also "real subjective time" communications in four-dimensional society.

1. Signals to the geometric future propagate along space-time sheets of positive time orientation. These space-time sheets can correspond to ordinary material space-time sheets but also almost vacuum space-time sheets can be considered. In particular, so called "massless extremals" [K55] are possible.
2. Signals to the geometric past propagate along space-time sheets of negative time orientation. Negative energy massless extremals are the optimal choice as far as classical communication is involved. The reason is that signal propagates with maximal signal velocity and consists of Fourier components with same momentum direction so that the shape of pulse is preserved. Polarization direction at a given point of the massless extremal is constant and depends on the transversal coordinates only. Solution involves two arbitrary functions and linear superposition of parallel Fourier components with identical polarization directions is possible. Therefore all possible pulse shapes are possible.
3. What happens in the communication is following. Sender performs quantum jump in which massless extremal of positive/negative energy is generated representing signal propagating to geometric future/past. Some standardized alphabet formed by the pulse forms for massless extremals: two basic pulse shapes identifiable as binary digits is the simplest choice. Receiver interacts with the massless extremal purely classically to receive the message and generates a massless extremal propagating to geometric past/future as a reply. The difference between sender and receiver is that sender performs quantum jump whereas receiver just acts purely classically to receive the message.
4. The communication is on-line "real subjective time" communication. There is no need to wait for next billion years for reply and members of cultures separated by billions of light years can have real time chat about their family problems! Also communication with effective signal velocity larger than light velocity becomes possible by using a 'radio mast' in the geometric future able to send past-directed signals: the mast receives a signal from the geometric past and sends it to the second receiver in the geometric past.

Anomalies related to spinning astrophysical objects as empirical support for the idea

The proposed communication method could be regarded as mere wild science fiction unless there were some empirical support for the possibility of communication from geometric future to geometric past.

In the articles [H5, H6] various anomalies related to spinning objects are reviewed. These anomalies are discussed in [K83]. There are also anomalies related to spinning astrophysical objects. Kozyrev [H4] has conducted astronomical observations using a receiving system of a new type. These observations have been replicated later by other groups [H3]. These anomalies give also support for the possibility of the signal propagation backwards in time.

1. When a telescope was directed at a certain star, the detector positioned within the telescope registered the incoming signal even if the main mirror of the telescope was shielded by metal screens. This indicated that electromagnetic waves were accompanied by some waves not shielded by the metal screens.
2. When the telescope was directed to the true position, the signal became stronger. As if there had been almost instantaneous propagation of signal with velocity billions times greater than the velocity of light!
3. When the telescope was directed to a position symmetrical with respect to the visible position, again signal was detected: the imaginative interpretation was that the signal came from future position of the star!

Leaving aside the objections of a typical sceptic and the question whether the effect is real or not, one can ask whether the concepts of many-sheeted space-time concept and classical Z^0 field could somehow give rise to this kind of effect in strong conflict with the conventional wisdom.

1. Propagating photons (extremely tiny 3-surface glued to macroscopic space-time sheet) affect the space-time sheet and could generate propagating classical Z^0 field causing the effect in the detector. Of course, one cannot exclude the possibility of negative energy photons although the experimental arrangement eliminating the ordinary photons should eliminate also these.
2. The strong signal from the true position could have explanation in terms of a coherent classical Z^0 field of astronomical size. This kind of coherence is forced by the imbeddability requirement and was coined as topological field quantization in [K39]. One can intuitively understand it as follows. In TGD elementary particle is replaced with 3-surface, which can have arbitrarily large size and absolute minimization of Kähler action forces 3-surface to behave coherently like single particle (in case that it does not so, it decomposes into disjoint components!). The results of Kozyrev are not the only evidence for this kind of behavior. Total eclipses of the Sun by the Moon reach maximum eclipse about 40 seconds before Sun's and Moon's gravitational forces on Earth align [H13]. If gravity is a propagating force, this 3-body test implies that gravity propagates at least 20 times faster than light. The result is consistent with the assumption that the acceleration of Earth is towards the true instantaneous direction of the Sun now, rather than being parallel to the direction of the arriving solar photons now. The TGD based explanation is that the changes of the classical gravitational field are not propagating effects but that the classical gravitational field behaves like single coherent whole (it could of course contain also small propagating part).
3. The signal in the symmetric position could indeed come from geometric future. An attractive possibility is that classical Z^0 field propagated along space-time sheet with negative time orientation: for negative time orientation the propagation is expected to occur backwards in time.

There are also reports about the anomalies related to rotated magnetic systems in laboratory scale and these effects are under intensive study (for instance in Faraday Lab in Russia). The TGD based explanation of the anomalies reported in [H10] is developed in [K83]. The model involves in an essential manner the generation of both negative energy space-time sheets and many particle states with negative single particle energies residing at these sheets and some of the observed strange effects involved support the generation of the negative energy particles. The model allows to seriously consider the possibility that even ordinary ions and atoms could have negative energy counterparts.

2.3 Four-dimensional brain

The paradigm of 4-dimensional brain is the most important consequence of the Grand Scenario. The non-determinism of the Kähler action (non-determinism is understood here in the conventional sense of the word) is the quintessential, purely TGD based element of the Grand Scenario: without there would not be any evolution, the contents of conscious experience would be diffused around entire quantum histories and there would be no systems with strongly time-localized contents of consciousness. A second key element is p-adic nondeterminism making possible intentionality and cognition.

2.3.1 The paradigm of four-dimensional brain

The cosmology of consciousness implies that each conscious experience decomposes into separate sub-experiences with the values of the psychological time varying from zero to infinity. Furthermore, the experiences are in general multitime experiences both with respect to both geometric and subjective time. This picture forces the paradigm of 4-dimensional brain having profound consequences concerning the understanding of the brain functioning.

The difficult problems related to the understanding of conscious memory recall could trivialize. No separate mechanisms of memory storage or retrieval are needed and the difficult problems related to the interpretation of the stored memories are circumvented. There are two basic types of memories: geometric and subjective memories. Geometric memories provide as simulation for what happened and will happen provided no quantum jumps occur and has occurred and subjective memories tell what actually occurred. Actual memories are indeed known to be creative reconstructions of past and hence it seems that geometric memories are an essential part of construction. The comparison of expectations and actuality made possible by the two memory types gives rise to the emotions involving comparison aspect.

Subjective memory corresponds to immediate short term memory and the only possible identification of the *genuine* long term memories is as subjective memories at the higher level of self hierarchy, where the time span of subjective memory is longer. One possibility is periodic wake-up of sub-selves representing mental images and giving in this manner rise to long term memories: this requires some kind of periodic neural activity giving rise to the same sub-self periodically. Of course, it is not at all obvious whether long term memories are genuine! It is indeed known that long term memories are a result of a creative process and are not reliable. This would suggest that long term memories are actually geometric memories and are reasonably reliable because our geometric past is rather stable under quantum jumping. Of course, we do not usually test the reliability of our long term memories but take them as granted. The notion of mind like space-time sheet allows multitime experiences containing simultaneous contributions from both geometric present and past and the memories of, say, childhood could be genuine multitime experiences.

The "averaging" associated with the subjective memory implies that volition cannot correspond to the quantum jump occurring in the measurement of the density matrix. Rather, volitional activities must correspond to a localization in zero modes, most naturally selections between degenerate maxima of Kähler function. Besides volition associated with the motor activities, also the focusing of attention and even the selection of premises of logical thought very probably involve this kind of selection. The most probable function of the motor nerve pulses is the generation of multi-furcations in an initial value sensitive system between which the choice occurs. Various motor programs correspond to various branches of the multi-furcation. Just as sensory experience, motor activity is predicted to be a top-down self cascade of quantum jumps starting from the level of the entire body. Each selection of the space-time branch creates self inside which subsystems perform quantum jumps as long as self is awake and these quantum jumps in turn lead to even smaller sub-selves: in this manner a precise and flexible coordination and control of the movement involving volition at all length scales becomes possible whereas in the standard neuroscience picture body would act like a robot with fixed motor programs.

2.3.2 Geometric and subjective memories

TGD predicts two kinds of memories corresponding to two different time developments. There is deterministic (in generalized sense) geometric time development and the non-deterministic subjective

time development by quantum jumps. The memories with respect to subjective time are about previous conscious experiences and "real" whereas geometric "memories" are prophecies giving simulation of geometric past and future assuming that quantum jumps do not alter the macroscopic properties of the space-time surface.

A good visualization is following: each quantum jump represents particular geometric memory whereas the heap of these memories gives rise to subjective memory. The comparison between expectations and reality is obviously a central part of mentality and the heap structure of conscious experience implies that this comparison is a basic function of conscious mind not reducible to anything simpler. It is wellknown that our memories involve a lot of construction and are more like stories consistent with what we actually have experienced than actual documents of what happened. This suggests that geometric memories, possibly constrained by subjective memories, give rise to the "story" about past.

2.3.3 Memories with respect to geometric time as simulations

Geometric memories are about both future and past and are predictions/simulations for what would happen if no further quantum jumps would occur and what would have happened if no quantum jumps had occurred in past. Geometric memories are also about past: we continually make guesses about the sequences of events which could have led to some event and this is nothing but predicting the geometric past. Of course, geometric memories are simulations rather than real memories. Geometric "memories" are real in the classical limit, when the effect of quantum jumps becomes negligible. In classical physics geometric memory is all that is needed to make predictions of past and future. We can indeed predict rather reliably what will happen in the solar system during the next decade. Also the computational approach to mind assumes only geometric memories. p-Adic geometric memories about future give rise to intentionality often regarded as a basic characteristic of conscious mind: beliefs, expectations, plans, etc. can be understood in terms of the p-adic geometric memory of future.

Intentionality manifests itself in many ways: as expectations of future, planning, goals, desires, fears, imagination, disappointments, etc.. The basic element of mentality is the comparison between the expectations of future and what actually occurred. In TGD framework this tension between potential and actual can be understood. The temporal extension of the mind like space-time sheet makes possible expectations of what happens in the future assuming that no quantum jumps occur or at least that quantum jumps do not change the macroscopic space-time. Single quantum jump contains information about this kind of expectations. Subjective memory in turn tells what happened actually. Therefore it seems natural, and this is the only possibility given the fact that it is not possible to know anything about future quantum jumps, to assume that all aspects of intentionality are made possible the predictions of the expected geometric future and past provided by the mind like space-time sheet.

What is nice is that subjective memory makes it possible to compare the expectations with what really occurred since subjective memory is kind of heap of predictions of future arranged with respect to the value of the psychological time. The origin of at least some emotions, which often involve a comparison of what happened and what was expected to happen, is perhaps here. It is quite well possible that all comparisons must be realized as comparisons of the subjective and geometric time developments (it could be that self is also able to compare its sub-selves).

The possibility of this comparison perhaps provides a solution to the paradox raised by the innocent question "How do I know that the me of today is the same as the me of the yesterday? How do I even know that I existed yesterday?". The solution might be simple: mind like space-time sheets have extension which can be much longer than the duration of the subjective memory. Therefore subjective memories contain information about the geometric me of the yesterday and geometric me of today and since these me's resemble each other quite a lot, the conclusion is that also the yesterday's me was a conscious self living in this same body. It is however quite possible that temporal entanglement with higher selves still remembering my past wake-up states is also involved and realized as a formation of join along boundaries bonds between the mind like space-time sheets of my self and of higher level self. Higher level self could also communicate directly the subjective memories about my existence to me.

2.3.4 Are long term memories geometric or subjective memories?

The answer to the question whether long term memories are geometric memories and thus only simulations or genuine subjective memories of higher level self somehow communicated to us, is not obvious.

Long term memories as geometric memories?

Geometric memories realized as multitime experiences involving mind like space-time sheets located around several moments of the geometric time, provide the simplest realization for the long term memories.

1. The model solves the basic difficulties of the neural net models of long term memory. In the neural net models long term memories are represented by synaptic strengths. The problem is that the learning of new memories destroys old memories. In particular, the stability of the childhood memories is difficult to understand. It is also hard to understand how brain knows that the experience represents memory. One cannot avoid the difficulty by saying that novelty detection tells that experience occurs for the first time since the notion of novelty does not make sense if conscious experience contains only information from single moment of geometric time.
2. TGD model is consistent with neural net models and actually generalizes them. Neural net in the spirit of TGD corresponds to brain as system moving in spin glass energy landscape. Self-organization by quantum jumps leads the system to a bottom of an energy valley representing memory. This model is consistent with the fact that there is no upper bound for autobiographical memory. One can also understand how learning occurs. The repetition of an experience means that energy valley becomes a canyon in time direction so that mind like space-time sheets in the geometric past have a large probability to end up to the region representing memory. In particular, reverberating nerve pulse patterns are ideal for representing cognitive long term memories.
3. Highly emotional experiences generate deep valleys and increase the probability of the system of the geometric past to stay at the bottom of valley. This explains why childhood experiences are so stable. In fact, one could identify primitive emotions of pleasure and pain as related to the motion in the spin glass energy landscape. Pleasure and pain could even directly correlate with the sign of the increment of the Kähler function in the hopping motion in the spin glass energy landscape. Note that primitive pleasure and pain are very much like sensory experiences and one could regard them as sensory experiences of brain about its own motion in spin glass energy landscape. This leads to the generalization of the notions of sensory experience and motor action to include the motion in spin glass energy landscape and to a considerably new insight about the meaning of the brain architecture.

There are also perinatal experiences, memories about previous lives and transpersonal experiences having natural explanation in terms of geometric memory realized as multitime experiences associated with mind like space-time sheets located at different values of the geometric time.

Transpersonal experiences suggests that self is dynamical: if prenatal experiences, memories about previous lives and transpersonal experiences are really what they seem to be, the geometric time extension of self should dramatically increase during these experiences.

Long term memories as subjective memories of higher level self?

The natural identification of the immediate short term memory as subjective memory predicts that the life time of a human sensory self cannot be much longer than .1 seconds, the duration of psychological moment of time. Our long term memories correspond to much longer time interval and cannot thus correspond to our subjective memories. Entire hierarchy of subjective memories is however predicted and a possible model for *genuine* long term memories (whose existence is questionable) is as resulting from temporary entanglement with selves belonging to the higher level of the hierarchy. Also this identification is consistent with the fact that there seems to be no upper bound on autobiographical memory.

Quantum-classical correspondence principle suggests that entanglement could correspond geometrically to temporary join along boundaries bonds between the mind like space-time sheets of self and higher level self. Summation hypothesis implies that our genuine long term memories would be sums over a large number of wake-up periods of self in the subjective past of the self. Therefore one could perhaps understand how ageing self gains gradually wisdom from experience: also the identification of the long term memories as geometric memories explains this. It would seem that our self must be able to shift the hierarchy level in order to remember details on one hand and to form abstractions on the other hand and that the detailed memories about the wake-up periods of self are unavoidably lost.

There are however serious counter arguments against this identification.

1. It is not at all clear why the experiences of the higher level selves during entangled state could be ours! For instance, during sleep without dreams entanglement with some higher level self should occur and we do not remember anything about this. Trance is a second example of this: subject person does not remember anything about the trance state.
2. The averaging involved with the temporal binding means that the subjective memories of the higher level selves cannot possess the details of our long term memories.
3. It is not obvious how to understand learning and the role of emotions in learning.

The entanglement with the higher level self is not necessary to have genuine long term memories. One could consider also the possibility that higher level self could somehow communicate the long term memories to the lower level selves. One function of sleep might be the generation of the entanglement with higher selves making in turn possible the communication of genuine memories of subjective past to our mind. This communication could realize these memories as thoughts about the experiences of past realized as nerve pulse patterns regenerating these thoughts. The lack of a precise realization of this mechanism makes the realization of the long term memories as geometric memories much more attractive option.

Long term memories as a communication between now and geometric past

The basic challenge is to identify concrete mechanisms of long term memory recall. According to the idea of magnetic sensory canvas discussed in [K64], the positions of objects of perceptive field are coded by the frequency scale of the magnetic transitions occurring at the magnetic flux tube structures having size of wave lengths associated with EEG frequencies. The slowly varying thickness of the magnetic flux tube codes for the position of the object of the perceptive field.

This encourages to consider the possibility that also the temporal position of the object of perceptive field could be coded in this manner. There are however two difficulties involved:

1. Since the time scales are of order life time T , the needed frequency resolution is $\Delta f/f \sim \Delta T/T$, if the time resolution is ΔT . This requires frequency resolutions of order $\Delta f/f \sim 10^{-8}$ at least and this kind of resolution is certainly not achievable in the neuronal circuits.
2. If ELF MEs (massless extremals) are involved it is difficult to understand how one could circumvent the fact that the ME represents geometrically a light ray escaping from the system. This ray should be reflected somewhere. Kind of mirror would be required. Magnetic flux tubes could serve as this kind of mirror and allow the radiation to travel in zigzag curve in space-time to to geometric past.

There is however a much more elegant mechanism of long term memory recall based on MEs. First, of all what makes MEs so interesting from the point of view of long term memories, is that light like selves has a temporal extension, which can be arbitrary long in given rest system. Secondly, the pairs of MEs resulting when ME reflects from some structure such as magnetic flux tube structure serving as a mirror, provide a TGD based model of long term memories relying on the idea that long term memory recall involves a 'question' sent to the geometric past as a classical signal reflected back to brain in a magnetic mirror, and a subsequent quantum entanglement in which the selves of the geometric past and now as well as ME selves entangle to single self so that the self of the geometric now can share the experience of the self of the geometric past. What is so elegant in this mechanism is that

there is no necessity of sending the information as a classical signal, only the time like entanglement is needed. In this case the MEs would have a length of order lifetime so that long term memories would be astrophysical phenomena involving magnetic flux tube structures and MEs. The temporal location T of the memory (or rather, shared conscious event) of the geometric past would be coded by the length L of ME: $L = cT/2$. The TGD based notion of time indeed allows geometric time scales of order lifetime to be involved with subjective experiences in psychological time scale of a fraction of second. Certainly this mechanism is completely out of question in standard physics.

2.4 Time delays of consciousness and quantum jumps between histories

TGD based concept of time has rather dramatic implications and it would be important to show that the new time concept indeed solves conceptual problems and anomalies. One should also devise experiments to test the new time concept. Dissipation is the black sheep in the family of theoretical physics and quantum jump between quantum histories concept explains dissipation in elegant manner. Quantum jumps between quantum histories concept together with the notion of self explains also the peculiar time delays of consciousness revealed in the experiments relating to the active and passive roles of consciousness [J48, J72] and described by Penrose in his book [J82]. It is also possible to explain the causal anomalies revealed by the experiments of Radin and Bierman [J25, J26, J88]. TGD predicts "tribar effect" as a general signature for the quantum jump between quantum histories concept.

2.4.1 Dissipation as evidence for consciousness

TGD based picture about time relies crucially on the notion that quantum jumps occur between quantum histories, objective realities. This hypothesis obviously means giving up the materialistic idea about single objective reality behind our experiences. It took quite long time to realize that our everyday experiences reveals directly the occurrence of quantum jumps between quantum histories! The phenomenon of dissipation is paradoxical from the point of view of standard physics. It is generally believed that fundamental laws of classical physics are reversible whereas everyday reality is manifestly irreversible. This leads to a rather schizophrenic situation. Two worlds, the reversible and extremely beautiful world of fundamental physics and the irreversible and the mathematically horribly ugly "real" world, seem to exist simultaneously. Quantum jumps between quantum histories concept solves the paradox and one can understand dissipative world as an effective description forming "almost" envelope for the sequence of reversible worlds (understood as entire time evolutions).

Dissipation can be also regarded as a direct evidence for the presence of the self hierarchy. One can imagine quite spectacular tests for the idea. NMP predicts that self can be in two modes of consciousness: quantum jumps reduce either matter-mind like entanglement or reduced matter+mind-matter+mind type entanglement leading to an unentangled subsystem giving rise to two new self candidates (sub-system and its complement inside self). The first mode corresponds to "whole-body" consciousness and in this mode matter-mind like dissipation in short length scales should be completely absent. The lowered dissipation should reflect itself as lowered metabolism. The measurement of cell level dissipation occurred during meditative states could provide a test for this picture. TGD explanation for the phenomenon of synesthesia [J36] discussed in [K70] relies on the hypothesis that left brain or considerable parts of it get quantum entangled and spends part of time in "whole-body consciousness". Indeed, synesthesia can involve lowering of left brain metabolism by as much 18 per cent [J36]: this should lead to paralysis if standard wisdom about brain functioning would hold true!

2.4.2 Experiments related to the active role of consciousness

The first class of experiments [J72] is related to the active role of consciousness. For example, the human subject flexes his finger at free will. What happens is that neurophysiological processes (changes in EEG) start about one second before the conscious decision to flex the finger is made. Decision seems to be followed by the action rather than the action by decision! This is in apparent accordance with the point of view that consciousness is indeed a passive spectator and the act of free will is pure illusion.

Quantum jump between histories picture explains the time delays associated with the active aspect of consciousness nicely and also gives an example of two kinds of causalities.

1. The simplest assumption is that the subjective experience of the finger flexing corresponds to the moment, when subject person experiences finger flexing occurs.
2. The new quantum history differs in detectable manner from the old quantum history already before the moment of finger flexing since otherwise the new history would contain an instantaneous and discontinuous jump from non-flexed finger to flexed finger configuration, which is not allowed by field equations. ΔT of order one second seems to be the relevant time scale. It is important to notice that the difference is at the level of classical physics rather than, say, in the form of synchronous neural firing which might involve quantum jumps of lower level selves: in TGD framework EEG activity is indeed classical phenomenon.
3. The attempt of the experimenter to be objective means that in an ideal experiment the observations correspond to the new deterministic history in the associated quantum jump and hence experimenter sees neurophysiological processes as the (apparent) cause of the finger flexing with respect to geometric time. With respect to the subjective time the cause of the finger flexing is the decision of the subject person.
4. This explanation is based on the hypothesis that volitional actions are top-down actions starting from the level of the entire body. A less radical variant of this argument is that the time associated with the conscious decision to flex the finger corresponds to a discontinuous configurational change at the level of brain: the jump from non-flexed to flexed configuration would occur at the representational level and induce continuous flexing of finger. This does not however change the core of the argument.

2.4.3 Experiments related to the passive role of consciousness

Libet's experiments [J48] about the strange time delays related to the passive aspects of consciousness serve as a continual source of inspiration and headache. Every time one reads again about these experiments, one feels equally confused and must start explanations from scratch. The following explanation is based on the model of the sensory representations on the magnetic canvas outside the body and having size measured by typical EEG wave lengths [K64] .

The basic argument leading to this model is the observation that although our brain changes its position and orientation, the mental image of the external world is not experienced to move: as if we were looking some kind of sensory canvas inside cortex from outside so that the motion of canvas does not matter. Or equivalently: the ultimate sensory representation is outside brain at a fixed sensory canvas. In this model the objects of the perceptive field are represented on the magnetic canvas. The direction of the object is coded by the direction of ME located on brain whereas its distance is coded by the dominating frequency of ME which corresponds to a magnetic transition frequency which varies along the radial magnetic flux tubes slowly so that place coding by magnetic frequency results.

According to the summary of Penrose in his book 'Emperor's New Mind' these experiments tell the following.

1. With respect to the psychological time of the external observer subject person becomes conscious about the electric stimulation of skin in about .5 seconds. This leaves a considerable amount of time for the construction of the sensory representations.
2. What is important is that subject person feels no time delay. For instance she can tell the time clock shows when the stimulus starts. This can be understood if the sensory representation which is basically a geometric memory takes care that the clock of the memory shows correct time: this requires backwards referral of about .5 seconds. Visual and tactile sensory inputs enter into cortex essentially simultaneously so that this is possible. The projection to the magnetic canvas and the generation of the magnetic quantum phase transition might quite well explain the time lapse of .5 seconds.
3. One can combine an electric stimulation of skin with the stimulation of the cortex. The electric stimulation of the cortex requires a duration longer than .5 seconds to become conscious. This

suggests that the cortical mental image (sub-self) is created only after this critical period of stimulation. A possible explanation is that there stimulation generates quantum phase transition "waking up" the mental image so that threshold is involved.

4. If the stimulation of the cortex begins (with respect to the psychological time of the observer) for not more than .5 seconds *before* the stimulation of the skin starts, both the stimulation of the skin and cortex are experienced separately but their time ordering is experienced as being reversed!

A crucial question is whether the ordering is changed with respect to the subjective or geometric time of the subject person. If the ordering is with respect to the subjective time of the subject person, as it seems, the situation becomes puzzling. The only possibility seems to be that the cortical stimulus generates a sensory mental image about touch only after it has lasted for .5 seconds. In TGD framework sensory qualia are at the level of of sensory organs so that the sensation of touch requires back-projection from cortex to the skin. If the formation of back projection would takes about .5 seconds the observations can be understood. Genuine sensory stimulus creates cortical mental image almost immediately: this mental image is then communicated to magnetic body (time like entanglement).

5. If the stimulation of the cortex begins in the interval $T \in [25 - .5]$ seconds *after* the stimulation of the skin, the latter is not consciously perceived. This effect - known as backward masking - looks really mysterious. It would be interesting to know whether also in this case there is a lapse of .5 seconds before the cortical stimulation is felt.

According to the TGD based vision sensory mental images are at the level of sensory organs and brain constructs symbolic representations about them using intensive back-projections to the sensory organs. These representations give rise to a decomposition of the perceptive field to standardized sensory mental images. The most effective manner to achieve back-projection is by using negative energy signals propagating backwards in geometric time just like in the case of intentional action. Accepting this framework one can at least make questions.

i) Could the stimulation of the cortex induce a negative energy back-projection signal to the skin representing a stimulus effectively interfering to zero with the real stimulus? That the skin stimulus is perceived consciously for $T < .25$ seconds means that the compensating back projection is sent only if cortex has received information about skin stimulation. One can imagine that it takes .25 seconds to form a symbolic representation about the sensory mental images at sensory organ. Why the back-projection would compensate the skin stimulus?

It is known that brain acts like a highly selective gardener applying strong inhibition to certain sensory stimuli and strong excitation to others in order to build percepts. If this principle applies also in time domain - as it should if the paradigm of 4-D brain is accepted- the elimination of the sensory stimulus could be seen as a tendency to build sensory percepts which are sharply localized in time. A precise localization in time is indeed important in the case of sensory percepts.

Second explanation would be based on compensating back-projection. Everyone who has been swimming in windy sea, feels the waves for a long time after coming to the shore. This sensation would correspond to back-projection in TGD framework but it is not clear to me whether this back-projection tends to compensate the actual sensation in order to achieve metabolic economy.

ii) Could it be that the skin stimulus is actually consciously perceived but that this experience is not remembered? In TGD framework the memory about skin stimulus would be realized as a skin stimulus still continuing in the geometric past. If the cortical stimulation for some reason modifies the geometric past by destroying the skin stimulus using back-projection, there would be no memory about the skin stimulus.

1. Two options for the communications to the magnetic canvas

Consider now possible constraints from Libet's experiments on the model of sensory representations based on the notion of magnetic canvas. MEs induce magnetic quantum phase transitions via the classical magnetic field associated with them and oscillating with a multiple of the cyclotron frequency. There are two possibilities.

1) The classical signal is thought to propagate along an existing em ME to the magnetic canvas and induces the magnetic quantum phase transition.

2) MEs behave like topological field quanta. A passive Z^0 ME is replaced with a an active em ME in single quantum jump so that the signal propagates to the magnetic canvas effectively instantaneously.

2. Various time lapses involved

Let us first analyze various time lapses which can be involved in the process leading from the sensory stimulus to the sensory experience.

1. The propagation of the classical signal along ME to the magnetic sensory canvas takes some time. This gives upper bound for the possible sizes L of MEs. The lapse is however for $T_{cl} \sim L/c = 1/f$, which is about .1 seconds for earth-sized MEs and of same order as the time lapse $T_b \simeq .01$ seconds due to the conduction of the nerve pulses from skin to somatosensory cortex.
2. The time T_m for the magnetic quantum phase transition to occur should be $T_m \sim 1/\Gamma$, where Γ is the rate Γ for cyclotron transitions for ions in the harmonic perturbation defined by the classical magnetic field B associated with ME. If the magnetic quantum transitions occur incoherently, Golden Rule implies that the rate Γ should be of order

$$\Gamma \sim N \left(\frac{B}{B_e} \right)^2 f_c \ ,$$

where B is the amplitude of the oscillating magnetic field associated with ME, B_e is Earth's magnetic field, f_c is the corresponding cyclotron frequency, and N is the number of ions participating in the transition.

If T_m indeed represents a lapse of conscious experience then the magnetic field associated with the radial ME inducing the magnetic quantum phase transition should be very strong as compared with the typical intensities in MEG unless N is large. The relative intensity of the fluctuations of Earth's magnetic field is about $\Delta B/B_e \sim 10^{-8}$ and gives an estimate for the intensity of B . The lower bound for the number of ions participating to the quantum phase transition is $N = 10^{16}$. Since the magnetic flux tube has thickness of order cell size, and since there are not much more than about 10^2 ions per cellular volume, the required length of the magnetic flux tube participating in the quantum transition would be longer than 10^8 meters and is definitely too long.

Quantum coherence can however come in rescue here. If the magnetic transitions occur coherently, the rate is given by

$$\Gamma \sim N^2 \left(\frac{B}{B_e} \right)^2 f_c \ ,$$

where N is the number of the ions participating in the transitions. For $N > B_e/B$ ($\sim 10^8$ for $B \sim 10^{-8} B_e$) the rate is high enough if the length of the magnetic flux tube participating in which quantum phase transition occurs longer than 10^2 meters. Since the intensity of the magnetic field varies extremely slowly along the magnetic flux tube in the proposed model, the number of the ions participating the transition could indeed be large enough and T_m would become an unimportant factor.

3. The total lapse of time is $T = T_b + T_{cl} + T_m + T_p$, where $T_b \sim .01$ seconds is the time for the signal to propagate to the somatosensory area and T_p is the time used by cortex to estimate the position of the sensory stimulus and activate the MEs taking care of the sensory projection to the magnetic canvas. Since the coding of the position of skin is topographic, there is no need to compute the distance and orientation of the stimulus and one has T_p is minimal. This gives $T = T_b + T_{cl} + T_m + T_p$ for the classical option 1) and $T = T_b + T_m + T_p$ for the quantum option 2).

3. Constraints from Libet's experiments

It is interesting to look what Libet's experiments mean for various options about what precedes the magnetic quantum phase transition giving rise to the sensory experience. The basic observation is that the classical signal propagation time along ME, which is .1 seconds for magnetic flux tube at distance of order Earth circumference, is much shorter than the time .5 seconds between the sensory stimulus and conscious experience. Thus it does not strong constraints on the model based on option 1).

1. If one assumes that the formation of the sensory representations involves the propagation of a classical signals along MEs (option 1)), and that the sensory representation of the skin is at distance of, say, one fourth of Earth's radius corresponding to the frequency $f = 10$ Hz, the lapse is about $T \simeq T_b + T_{cl} + T_m + T_p = .1 + T_m$ seconds. This allows $T_m + T_p \simeq .4$ seconds. For $T_m \ll T_b$ $T_p \simeq .4$ seconds is allowed. In classical case there are however bounds on the distance of the magnetic canvas, five Earth circumferences is the upper bound.
2. Second option is that the process does not involve classical signalling in the proposed sense so that the distance of magnetic canvas does not matter at all. ME behaves as a single particle and is transformed from passive Z^0 ME to active em ME in single quantum jump. Suppose the arrival of the neuronal signal induced by the electrical stimulation of the skin to the somatosensory area induces this kind of quantum jump, which becomes thus capable of inducing magnetic quantum phase transition. If this is the case, then the sensory representation of the stimulus could result after $T \sim T_b + T_m + T_p$ after the arrival of the neural signal to the cortex. If T_m is negligible one has $T \simeq T_p \simeq .5$ seconds. The fact that the stimulation of cortex by .5 seconds is needed to produce artificially the sensory stimulus suggests that T_m is indeed negligible.
3. The third option is that there is a ME associated with the entire sensory pathway fused with the ME associated with the sensory projection to the magnetic canvas and that already the sensory stimulus at the skin initiates the magnetic quantum phase transition. In this case one has $T = T_m \simeq .5$ seconds.

2.4.4 The experiment of Radin and Bierman as evidence for quantum jump between quantum histories concept

The experiments of Radin [J88] and the later experiments by Radin and Bierman [J25, J26] gave evidence for anomalous unconscious emotional responses preceding their cause. Radin monitored the sympathetic and parasympathetic behavior of the autonomic nervous system with skin conductance, heart rate and fingertip blood volume measurements. Subjects were asked to look at a computer monitor and press a button to start a trial. Button press caused the display of a blank screen for five seconds, then a randomly selected calm or emotional picture was shown for three seconds, and this was followed by ten seconds of a blank screen. In three studies, Radin found significant differences in autonomic physiology, most notably skin conductance, *preceding* the exposure of emotional vs. calm pictures. Radin examined a number of possible normal explanations for the result and concluded that they did not apply.

Radin and Bierman interpreted the result of the experiment as evidence for a reversal of the arrow of time. The constancy of the arrow of psychological time is by no means obvious in TGD Universe and one of the basic challenges of TGD inspired theory of consciousness is to understand how the (probably statistical) arrow of psychological time emerges. Moment of consciousness as quantum jump between quantum histories concept provides however an elegant explanation of the effect without any need to assume the reversal of the arrow of psychological time. What is important that one can also avoid the poorly defined concept of effects propagating backwards in time, which is needed in explanations based on quantum state as time=constant snapshot concept.

Consider now the TGD based explanation. In quantum jump deterministic quantum history is replaced with a new one: this means that, not only the future, but also the *past* changes. Therefore, if the mean galvanic skin response of the subject person provides a faithful representation for some aspects of subject person's deterministic quantum history, the entire time record about skin response must change to a new one in any quantum jump. If subject person experiences a highly emotional stimulus, the moment of consciousness is expected to be more intensive than for calm stimulus in the sense that the non-determinism associated with the quantum jump is expected to cause observable effects in a larger space-time volume of the quantum history (represented to a good approximation as

quantum average space-time surface geometrically). Therefore also the change of the quantum past is expected to be more dramatic as it indeed seems to be according to the results of the experiment.

At first it might seem that there are no means to test whether the past has changed at the moment of consciousness. The experimental arrangement of Bierman and Radin, although certainly not originally planned to test quantum jumps between histories concept, circumvents in an ingenious manner this difficulty by comparing the skin responses associated with calm and emotional trials. Standard physics, which is based on assumption that there is no signal propagation backwards in time, predicts that the average skin responses before the stimulus should be identical for calm and emotional trials. This is not the case so that the results of the experiments indeed support TGD based world view.

One can in fact imagine even more dramatic test based on a modification of Radin-Bierman experiment. In quantum-mind discussion group Stan Klein [J70] suggested a modification of Radin-Bierman experiment [J25, J26, J88] providing a test for Stapp's and Sarfatti's theories of consciousness [J96, J1]. One could perhaps consider the following further modification of Radin-Bierman experiment so that it would simultaneously discriminate between Stapp's and Sarfatti's theories and TGD.

1. It might be possible for computer to perform a comparison of the preponse with average calm and emotional preponses *before* the subject person A sees the picture and, depending on whether the preponse is nearer to calm or emotional average preponse, to print C or E to a computer screen such that the printing result is seen by person B *before* A sees the picture.
2. The theories explaining phenomenon in terms of effects propagating backwards in time (say Sarfatti's theory [J1]) would predict that computer record and the sequence of letters remembered by B are identical and contain both C:s and E:s. According to [J70] Stapp's theory would predict that both computer record and B's memories contain only C:s.
3. TGD predicts that B would *see* only C:s. The concept of subjective memory implies that B also *remembers* of seing only C:s whereas computer records would contain both C:s and E:s. This would provide dramatic support for quantum jump between quantum histories concept and for the notion of subjective memory.

In TGD framework one can also consider an alternative explanation for the result of Radin-Bierman experiment. If this explanation is correct, the report of B is consistent with the computer record just as in Sarfatti's theory. The argument goes as follows.

1. Given moment of consciousness contains several irreducible subexperiences besides the experience corresponding to the "real I", which presumably corresponds to "I" able to communicate using language and possessing long term memories. These "I":s are usually collectively identified as subconscious mind. The phenomenon of blind sight and related phenomena [?] give support for the idea that there is second "I", most naturally at the same level of self hierarchy. One can even imagine entire population of selves at some lower level of self hirarchy giving rise to "Zombi within us" or shortly Z. In the latter case the response of Z is dictated by statistical determinism at the level of ensemble. Deterministic response has definite value in fight for survival.
2. The values of the psychological times associated with these various "I":s need not be same in given quantum jump. Suppose that Z has psychological time slightly larger than the psychological time of the ordinary "I" so that Z sees the state of the world at time $t + \Delta t$ whereas "the real I" sees it at time t in given quantum jump. The order of magnitude for Δt is roughly one second. Assume further that Z is able to assign emotional content to the picture. If the decision about what picture is shown is purely mechanical involving no quantum jump (and hence only effectively random) then Z can perceive the picture before the ordinary "I" perceives it with the result that galvanic preponse is created. Galvanic preponse is deterministic in case that Z is an entire population of "I":s.

Some remarks about the model are in order.

1. The criticism against this kind of model is that Z is perhaps not able to assign any emotional content to the pictures. The experiments supporting the existence of Z mildly suggest that Z sees the things "as they are" (for instance Z cannot be fooled by visual illusions) which in turn suggests that emotional response is perhaps not involved.

2. Z could also receive the information about the picture by precognition in principle made possible by the diffuse contribution to the contents of conscious experience coming from entire initial and final quantum histories. If this is the mechanism, one can however wonder why the "real" I is not capable to same so that also "real" "I" would have *conscious experience* about the nature of the picture before seeing it.
3. In case of Kornhuber experiments similar explanation would lead to the veto model: the conscious decision to raise index finger is preceded by the conscious decision of Z to raise it and the "real I" can decide whether to allow various neural processes to continue or not.
4. In principle (probably only in principle) one could test the model by allowing the selection of the figure to be shown to A be determined by a quantum jump rather than by deterministic process. If this quantum jump occurs only very short time before A sees the picture, response should disappear.

An effect resembling Radin-Bierman effect might occur in much more concrete situation. There is a legend about the ability of the short distance runners to anticipate the shot of the starting pistol and start already before the gun shot. Perhaps this really occurs but in the following sense. When short distance runners hear the shot they perform a quantum jump to a new history. For obvious reasons they might have developed a skill to jump to a quantum history at which they started before the gun shot. Whether this effect occurs could be tested by using video camera or some more sophisticated arrangement (gun shot can be accompanied or even replaced by light signal to make the timing precise). What could happen is that the man with the gun honestly claims that the runner started after the shot whereas videocamera tells that runner started before the shot. This effect deserves the nickname "tribar effect" (tribar is the famous nonexisting triangle like structure formed from three bars): in its various forms the effect could provide very general hard evidence for TGD based view about space-time.

Notice that the paradox of ping pong game described in the book of Penrose [J82] can be resolved in quantum jumps between quantum histories picture. The problem is that the time delays of consciousness are so long that no conscious action seems to be possible in ping pong game. The resolution is simple. The players can quite well miss the ball time on the old history but perform a jump to a new history: on this history they do not miss the ball thanks to the rapid deterministic reflex action.

2.5 Good and Evil, Life and Death

In principle the proposed conceptual framework allows already now a consideration of the basic questions relating to concepts like Good and Evil and Life and Death. Of course, too many uncertainties are involved to allow any definite conclusions and one could also regard the speculations as outputs of the babbling period necessarily accompanying the development of the linguistic and conceptual apparatus making ultimately possible to discuss these questions more seriously.

Even the most hard boiled materialistic sceptic mentions ethics and moral when suffering personal injustice. Is there actual justification for moral laws? Are they only social conventions or is there some hard core involved? Is there some basic ethical principle telling what deeds are good and what deeds are bad?

Second group of questions relates to the biological death. What happens in the biological death? Is self preserved in the biological death in some form? Is there something deserving to be called soul? Are reincarnations possible? Are we perhaps responsible for our deeds even after our biological death? Could the law of Karma be consistent with physics? Is liberation from the cycle of Karma possible?

In the sequel these questions are discussed from the point of view of TGD inspired theory of consciousness. It must be emphasized that the discussion represents various points of view rather than being a final summary. Also mutually conflicting points of view are considered. The cosmology of consciousness, the concept of self having mind like space-time sheet and causal diamond as its correlates, and the vision about the fundamental role of negentropic entanglement provide the building blocks needed to make guesses about what biological death could mean from subjective point of view.

2.5.1 Life and Death

One can interpret ageing in two senses. The ageing with respect to geometric time and the ageing with respect to the subjective time. Before discussing ageing in the sense of geometric time one must specify what one means with geometric time and what one believes its relationship to subjective time to be.

1. There are two geometric times corresponding to the times assignable to space-time surface and imbedding space.
 - (a) The recent argument for the arrow of psychological time allows to understand the flow of geometric time assignable to space-time surface in manner rather different from the standard one. The causal diamond CD representing self is actually stationary and space-time surface effectively flows into it from geometric future. A generalized form of NMP implying that selves are curious and want to know what is in the space-time future outside the CD implies that selves perform quantum jumps drawing the space-time surface inside CD . The argument explains also why mental images tend to be located near the future boundary of CD and thus why sensory input is mostly about a rather narrow time interval. The arrow of time emerges spontaneously but the CP breaking of quantum TGD might help to establish global choice of the arrow of time.
 - (b) One can speak also about the arrow of cosmic time identified as a gradual growth of the size of CD quantum jump by quantum jump so that the past boundary of CD recedes. There are reasons to believe that this cosmic time is discontinuous and its values come as powers of two.
2. Subjective ageing could correlate closely with the entropy growth due to the randomness of state function reduction leading to thermalization or the ensemble of mental images. This would correspond also to second law. Also entropic mental images are generated by bound state entanglement. On the other hand, life as something in the intersection of real and p-adic worlds with negentropic entanglement carrying conscious information might change the situation. Both the growth of negentropy of conscious experience reflecting itself as evolution and the growth of entropy as physicist identifies it and reflecting itself as biological again would be involved. NMP suggests that negentropy of conscious experience tends to increase and the biological death is only a transformation to some new form of existence. The dark matter hierarchy with levels labeled by the values of Planck constants has become a key element of TGD inspired theory of consciousness and one can imagine that during ageing these levels of existence begin gradually dominate consciousness.

What interests us mostly is obviously the subjective ageing and biological death. What dying person might experience? Is there a continuity of subjective experience or does suffering end with a loss of consciousness. What follows after biological death? How our deeds affect what happens in biological death and to the experiences after the biological death? Here are some possible answers.

1. Perhaps the only thing that happens in biological death is that the contribution of biological body to the contents of consciousness disappears so that other contributions usually masked to a high degree by sensory input and motor activities become into full light of consciousness. In fact biological body and magnetic body are 4-dimensional and there are good reasons to expect that it continues to contribute to the consciousness of some self- not necessarily the self which possessed the body. The question is however about what this particular self that I have experiences in biological death and after it.
2. The notion of negentropic entanglement suggests allows to consider an answer to what might happen in biological death from the point of subjective time. Depending on the choices of self which has the dying person as sub-self, dying person generates bound state entropic entanglement with a loss of consciousness or negentropic entanglement accompanied by an expansion of consciousness. What option the higher level self chooses depends on the probability of the size of the contribution of the state with negentropic entanglement.

3. If the dying person has a strong negentropic entanglement with external world, it tends to be preserved in quantum jumps and only a small entropic contribution is present and there is only a small probability to lose consciousness. Another manner to see this is that a subself having very entropic subselves (mental images) is experienced by self as something unpleasant and by generalized NMP self might want to get rid of this kind of mental image. This would reduce the chances of experiencing an expansion of consciousness. Perhaps death could be seen as the price for sins.
4. One could also argue that although consciousness might be lost it might be not be in any manner different from sleep. It could be gained back in wake-up but as something different from ordinary wake-up consciousness and determined by the 4-D biological and magnetic bodies and the deceased could remember his former life by still existing 4-D body. The notion of electromagnetic body, when combined with the view about psychological time, allows to consider a general answer to these questions. Magnetic body probably survives the biological death, and since it serves as the sensory canvas, there are all reasons to expect that subjective consciousness continues after the biological death. The contents of consciousness would be determined by the 4-dimensional physical and electromagnetic bodies and the dominating contribution creating the illusion about reality as a time=constant snapshot would be absent. Kind of timeless consciousness would be in question in accordance with the life review experiences associated with NDEs.
5. One can also ask what might be the physical correlate of self after the biological death. The 4-D space-time sheet representing self very probably does not disappear in biological death and the 4-D character of the perceptive field suggests that this 4-D body continues to exist as a conscious entity and the sub-*CD*s of the geometric past representing mental images still exist. Only at the future boundary of *CD* the flow of 4-D biological body ceases but the sub-*CD*s representing existing mental images float to the direction of geometric past in the river of time and remain consciousness.

Ageing as a price for having self

In standard quantum theory framework not allowing negentropic entanglement self can be regarded as a statistical ensemble of mental images defined by the unentangled final states of the quantum jumps. Since the size of this ensemble increases quantum jump by quantum jump, the approach of this ensemble to thermal equilibrium is unavoidable although living matter has probably invented manners to fight against the second law of thermodynamics. Thus ageing of self means dissipation.

The hierarchy of Planck constants and negentropic entanglement mean deviations from this picture.

1. For higher levels of dark matter hierarchy the dissipation rate is expected to be slower: the naive expectation is that the rate is inversely proportional to Planck constant.
2. Negentropic entanglement means second exception to the rule and for given *CD* second law can be broken in time scales shorter than the time scale characterizing *CD* [K46] .

Each p-adic length scale defines its characteristic dissipation rates. In case of a self decomposing into sub-selves the rate of dissipation is sum over the real dissipation rates associated with the nested system formed by the self, its sub-selves, their sub-selves, etc.... The dissipation associated with states of whole-body consciousness can be anomalously small since only negentropic mental images are absent and if there is only one such mental image (or no mental images at all) there is no generation of ensemble entropy. A possible test for this is the study of total rate of metabolism during meditation.

Dissipation causes the ageing of self: getting old at least at the level of biological body would be the price for having self. More concretely, the entropies associated with various distributions of quantum number and zero mode increments increase during ageing so that mental images are gradually blurred. Note that also our self which defines a mental image of a higher level self is blurred. Also biological death, or at least death experience, seems to be unavoidable fate of self.

Ageing and death from the point of view entanglement generation

The possibility of negentropic entanglement allows to see ageing from different point of view. Sub-selves generate either entropic or negentropic entanglement and also the generation of entropic entanglement

should contribute besides the generation of ensemble entropy of mental images to ageing of the biological body. The generation of negentropic entanglement—perhaps with higher levels of self hierarchy—would be also an aspect of again. This is suggested if NMP is taken analog of second law holding in the realm of subjective existence.

1. Ageing as an entropic process could be seen also as a process analogous to the process of getting drowsy and falling asleep but in much longer time scales. Bodily sub-self would not remember anything about these periods in the case that the entanglement was entropic. Also sleep could represent a similar conscious state without bodily mental image and the impossibility to remember anything about this period of consciousness might be simply due to the fact that one can remember something about sleep state only in sleep state. The periods during which negentropic entanglement prevails would be experienced as enlightenment like experiences. During ageing bodily sub-self would spend more and more time near the critical line at which this kind of phase transition occurs.
2. Ageing could be seen as a process of personal growth generating negentropic entanglement. The negentropic entanglements generated with larger selves would give rise to larger selves and the metaphor 'awakening' would thus be much more than a metaphor. Time-like negentropic entanglement would mean longer time span of attention. Person would spend more and more time in extended state of consciousness and in death finally leave the confines of the biological body. Note that person need not, and probably doesn't, remember anything about the periods of entanglement in which the local topology of self changes. This would make possible the evolution of selves continuing after death to higher levels of conscious existence.

This picture is rather optimistic: one must also consider the possibility that the evolution of self is not always a continuous personal growth! The fact that the individual development of most people seems to be a process of continual abstraction suggests that biological death is only one step in the process of abstractions and that our self consciously experiences the final transition to higher level of existence in biological death.

Why childhood memories are recalled so intensely?

The first manner to see ageing is as a subjective experience: as ageing with respect to subjective time. Our self contains sub-selves representing our memories, sensory input from the geometric now and future plans. At the old age it often happens that childhood memories begin to dominate whereas the recall of more recent memories is gradually lost. Of course, the contribution of future plans becomes also gradually negligible. This suggests that the contents of consciousness for our self can suffer a gradual transformation such that the childhood begins to dominate: of course, this need not happen always. That the childhood dominates is not easy to understand if the memories of the past are stored in the geometric now as assumed in the standard brain science. In TGD framework the very fact that the childhood consciousness is very intense and un-conceptual, explains the dominance of the episodal memories of childhood.

Who is the subjective experiencer in this kind of situation? Is it the old person with vivid memories or a child with some very diffuse ideas about future? The view about psychological time would suggest that the general experience gradually becomes some kind of a 4-dimensional life review such that the very intense childhood memories dominate but that the person in the psychological now is still the only one who can transform intentions to actions effectively whereas the 4-D body of the past is more or less frozen.

Death as disappearance of the mental image representing the biological body?

If one takes seriously the following two assumptions behind the TGD based model of quantum control and coordinate based on the symbiosis of MEs, magnetic flux tube structures, and matter at the atomic space-time sheets, one ends up with rather concrete view about what happens after the biological death. The ultimate sensory representations are realized on the sensory canvas provided by magnetic flux tube structures of similar size, so that we have magnetic body providing sensory representation of the biological body and external world [K64]. Our magnetic self very probably survives in the biological death by the conservation of the magnetic flux.

In this picture the body of after-life body would consist of the magnetic body plus MEs possibly surviving the death of the biological body. The only difference as compared to the life before death would be that the sensory and cognitive mental images representing the biological body (sub-selves) would disappear and the attention of our self would be directed to something else. Possibly to the entire time span of 4-D biological body since sensory input and motor actions at the upper boundary of personal CD are absent. Near death experiences indeed support this view [K15]. In this picture re-incarnation is possible and even plausible and means only that the magnetic flux tube structure representing our bodily self turns its attention to some other biological body and uses it as a sensory and motor organ. This new biological body could be plant, animal, human, or perhaps something else. In this picture the metaphor about biological body as a cloth becomes very concrete.

Since self has an extension with respect to geometric time, it has memories about its earlier history and one could perhaps identify the continuation of self after the death as that self which has the memories of self with respect to geometric time before death. In this extended state of consciousness self could experience the subjective past of the space-time sheet of self and associate it with self's recent mindlike space-time sheet.

Near death experiences

Near death experiences provide a testing ground for the general ideas about what might happen in the physical death. Experiences resembling near death experiences can be produced now in controlled manner in laboratory circumstances for people well and alive and irrespective of their belief structure subject persons tell about light tunnels and meeting of deceased relatives [J29]. These experiences have been found to be therapeutic and are indeed used as therapy to cure severe psychic traumas. Therefore the materialistic explanation as a hallucination associated with dying brain seems to be excluded. Near death experiences involve experiences like being in light tunnel, seeing beautiful and rich landscapes and meeting dead relatives. Also out-of-body experiences are involved. The model of NDEs are discussed in detail in [K63] and here only some brief comments are represented.

The proposed picture about physical death allows a lot of room to interpret these experiences. For instance, OBEs allow two explanations.

1. The first explanation is based on the fact that in TGD based model of sensory representations the magnetic sensory canvas far outside body basically sees the brain in ELF light. This light usually comes from brain and provides a sensory representation for the external world. TGD predicts also a mechanism producing background ELF radiation from the entire body at magnetic transition frequencies and this background would make possible to see the body 3-dimensionally from outside when the sensory input is absent and does not mask this weak contribution. NDE OBEs might correspond to this kind of vision reported also by yogis.
2. The experience looking one's body from outside could mean that some higher level self corresponding to slow EEG waves and higher em selves formed physically by the personnel of hospital in the hospital room begins to dominate. This self could perhaps see patient's body with the combined eyes of the hospital personnel. Indeed, since the sensory input from the biological body ceases, the illusory identification of 'me' with the biological body ceases and attention can be directed to this higher level sensory input.

Geometrically the em bodies of our dead relatives would exist in the geometric past and now, perhaps already in a re-incarnated form. This allows several explanation for the experience of meeting dead or living relatives. A very concrete model would be based on electromagnetic bridges formed by magnetic mirrors and connecting us with our relatives and friends. This would make possible for us to see them in ELF light just like we would see ourselves.

The experience about meeting deceased relatives could be also understood as a special kind of geometric memory. Generation of the long term memory means classically looking to a magnetic mirror at classical level and seeing the me of the past in the mirror. It is however possible to see someone else in the mirror since the magnetic fluxtube from the mirror could continue to the body of the deceased relative of friend instead of my body. In the usual states of consciousness the sensory input from the psychological now dominates and this contribution is masked. In near death experiences sensory input from the geometric now is diminished and the transpersonal background contribution becomes unmasked.

What after biological death?

Biological death could mean the loss of sub-self representing body image and involve extension of the physical self: this would explain out of body experiences and near death experiences (person near death looking his body from outside). In fact, an attractive hypothesis, motivated by the quantum model of brain, is that the topological field quanta associated with photons generated by EEG currents having size of order Earth by Uncertainty Principle, could correspond to selves in our personal self hierarchy. Also magnetic flux tube structures associated with body and brain could have similar sizes and serve as a magnetic body [K64]. In biological death these ELF selves could continue to oscillate as Schumann resonances in the wave cavity between Earth's surface and ionosphere interacting with magnetic flux tube structures!

Neutrinos which are proposed to play important role in living matter would correspond to CD with time scale of order 10^4 years for the standard value of Planck constant and just this fact suggest that they could indeed be important. If one believes that even cell sized structures have their own CD s then the primary p-adic length scale defined by the size scale of a large neuron (10^{-4} meters) would correspond to a time scale of the order of the age of the Universe! It seems implausible that these CD s could disappear totally although zero energy ontology in principle allows it.

Biological body is accompanied by magnetic body and radiation body which provide representation for the physical (or better to say, material) body. The latter consists of radiation selves (massless extremals representing topologically rays of light) representing classically the ELF radiation fields generated by EEG currents, one is led to ask what happens for these em selves in biological death. Some of them correspond to resonant frequencies of the em fields in the 80 km thick wave cavity between Earth surface and ionosphere known as Schumann frequencies and one can consider the possibility that that something which might be called soul remains after the biological death and is represented as Schumann resonances.

The most plausible hypothesis is that both ULF MEs and magnetic flux tube structures remaining after physical death together with the 4-dimensional body of geometric past define our self after the biological death. This leads to the following speculative vision about consciousness after the biological death.

1. The transformation of intentions to actions as p-adic-to-real transitions ceases in the biological death so that the dominating contribution of the psychological now to the experience disappears and conscious experience becomes kind of four-dimensional life review in which also the contributions from other bodies (say deceased relatives) appear as unmasked.
2. The geometric past, or rather experiences about it, can be gradually refined but no big changes are possible, so that a totally new life based on different decisions does not seem to be possible. The assumption about totally new life would also lead to paradoxes. On the other hand, the instability of the long term memories suggests that the memories about the past life could be edited. The conscious experience contains also the contribution of the magnetic body continuing to exist.
3. The surviving magnetic body could attach to some new organism which it begins to use as a sensory and motor organ. The re-incarnation would have the memories of the past life as an unconscious background masked strongly by the sensory input and coming clearly conscious only in some altered states of consciousness. The reports about children remembering they previous life could be understood in this conceptual framework. This of course makes one wonder whether young children could remember their past lives. Perhaps someone should ask!

Does soul exist in some sense?

An open question is what happens for the space-time sheet (or CD) assignable to self after biological death.

1. Could this space-time sheet or CD be called soul? Does this soul continue drift in lightcone and get attached to some new material system. Or can it disappear in quantum jump? This would not be a reincarnation in the usual sense of the word. The re-incarnation in the usual sense if the word would mean that one has memories about the life of someone whose has lived in past. In TGD Universe this is quite possible since the mechanisms of remote mental interactions

are basically the same as the interaction mechanisms making possible for the magnetic body to control the biological body receive information from it.

2. "Ontogeny recapitulates phylogeny" principle suggests that the evolution of an individual is image for the evolution of the entire universe. Biological death would be only a metamorphosis to some new form of existence, perhaps as topologically quantized classical fields associated with the biological body. Magnetic flux tube structures having sizes measured in scale of light lifetime are especially promising candidates for the components of electromagnetic body surviving in the death of what is usually identified as the biological body. Some experimental facts lead to rather precise ideas about the geometric representation of our selves and also suggest that our existence continues in electromagnetic form after death [K15] .

Indirect support for the survival of mindlike space-time sheets after death comes from rather unexpected direction.

1. The phenomenon of phantom DNA suggesting that mindlike space-time sheets associated with DNA remain in the chamber which contained DNA: in the experiments of Poponin [I114] the signature of phantom DNA is its interaction with laser light at visible frequencies. Phantom DNA would be represented by mindlike space-time sheets with size of at least the wavelength of visible light (10^{-7} meters). The em selves remaining after our death would have consirably larger size! One can however consider the possibility that some detectable interaction between EFL frequency em fields and 'phantom brain' ('em soul') could be possible and make it possible to prove experimentally the presence of em soul!
2. The claimed successes of homeopathy (for phantom DNA and homeopathy see [K93] and [K36]). could also have explanation in terms of the mindlike space-time sheets. Homeopathic drugs are fabricated by a repeated dilution of the active drug so that the concentration of the drug in solution becomes extremely low. The method of fabrication could however imply that final product contains quite many mindlike space-time sheets of the drug molecules. These mindlike space-time sheets might be able to affect the sickness since the mindlike space-time sheets provide a cognitive representation for drug and this mimicry could 'cheat' the patient to cure. The law of similarities could have something to do with the mechanism involved.

More concretely, a given quantum transition frequency characterizing the medicine would be represented as ME with length equal to the wavelength associated with the transition frequency. The electromagnetic body of the molecule could be mimicked by liquid crystal water blobs producing similar transition frequencies and thus containing similar MEs in their electromagnetic bodies. The effect of the medicine would be mediated by the electromagnetic body so that the 'fake' medicine could indeed cure.

Some support for the extension of self in death is provided by near death experiences. For instance, looking one's body from outside could mean that self is entangled with a larger self formed by the personnel of hospital in the hospital room and sees patient's body with the eyes of the personnel. This experience could be understood as experience of, say self representing hospital room: in this experience the visual experiences of persons in the hospital room would fuse to the experience experienced by patient entangled with the hospital room. Meeting one's relatives and elders could mean entanglement with a larger self formed by the selves of dead and living relatives. This larger self could experience the abstracted experiences of dead and living relatives. Also the ability of subjects of surgical operations to occasionally remember about events occurred during unconscious state, supports this view. Magnetic flux tube structures are the most plausible candidates for the 'body' remaining in physical death: this point is discussed in more detail in [K15] .

Is it possible to get into contact with deceased?

There is a lot of subjective evidence consistent with life after death. Near-death experiences are not the only manner to get convinced for life after death. So called eye-movement desensitization and reprocessing (EMDR) discovered by Francine Shapiro [J29, J92] induces what could be interpreted as after-death communications.

1. The experiences of subject persons can be induced by this therapy in highly reliable manner: according to [J29] 98 per cent of patients willing to participate the therapy had after death communication experience. It does not matter what the religious convictions of the subject person are and the experiences are actually rather easy to induce. It does not matter if the loss is traumatic or not or whether it is recent or occurred for decades in past.
2. The experiences resemble near death experiences (light tunnels, beautiful landscapes) and involve spiritual contact with the deceased. The EMDR technique involves getting the patient to move his or her eyes in a particular rhythmic fashion while at the same time attending to a particular aspect of the traumatic memory.
3. How EMDR works is poorly understood as yet: possibly the fact that the shifting of eyes leads to increased brain processing is of importance. Notice that rapid eye movements REM are also involved with dreams. A possible explanation is that EMDR experiences could involve communication with the recent selves of the deceased ones located possibly in the geometric recent or past and represented by magnetic flux tube structure and MEs interacting with them.

2.5.2 Good and Evil

The vision about life as something in the intersection of real and p-adic worlds together with the notion of negentropic entanglement gives hopes for understanding the quantum correlates of evolution and even ethics. The basic principle would be that good deeds generate negentropic entanglement and Negentropy Maximization Principles- perhaps suitably generalized from its original form- would define the basic principle of ethics.

Quantum ethics very briefly

There are many manners to interpret evolution in TGD Universe.

1. p-Adic evolution would mean a gradual increase of the p-adic primes characterizing individual partonic 2-surfaces and therefore their size. The identification of p-adic space-time sheets as representations for intentions and the identification of p-adic-to-real phase transitions as transformations of intentions to real actions gives additional concreteness to this vision.
2. The hierarchy of Planck constants suggests evolution as the gradual increase of the Planck constant characterizing p-adic space-time sheet (or partonic 2-surface for the minimal option). This evolution could be seen as a migration to the pages of the book like structure defined by the generalized imbedding space and has therefore quite concrete geometric meaning. It implies longer time scales of long term memory and planned action and macroscopic quantum coherence in longer scales.

The singular coverings of CDs and CP_2 are characterized by an Abelian group Z_n permuting the sheets of the covering and corresponds naturally to powers of the (quantum) phase $q = \exp(i2\pi/n)$ allowing to define the notion of angle in p-adic context but only with a finite resolution since only finite number of angles are represented as phases for a given value of n . The increase of the integers n could be interpreted as the emergence of higher algebraic extensions of p-adic numbers in the intersection of the real and p-adic worlds. These observations suggest that all three views about evolution are closely related.

3. The vision about life as something in the intersection of real and p-adic worlds allows to see evolution information theoretically as the increase of number entanglement negentropy implying entanglement in increasing length scales. This option is consistent with the first one if the effective p-adic topology characterizes the real partonic 2-surfaces in the intersection of p-adic and real worlds.

The third kind of evolution would mean also the evolution of spiritual consciousness if the proposed interpretation is correct. In each quantum jump U -process generates a superposition of states in which any sub-system can have both real and algebraic entanglement with the external world. If state function reduction process involves also the choice of the type of entanglement it could be interpreted as a choice between good and evil. The hedonistic complete freedom resulting as the entanglement

entropy is reduced to zero on one hand, and the algebraic bound state entanglement implying correlations with the external world and meaning giving up the maximal freedom on the other hand. The selfish option has the risk of leading to non-algebraic bound state entanglement implying a loss of consciousness: death as the prize of sin. The second option means expansion of consciousness - a fusion to the ocean of consciousness as described by spiritual practices.

In this framework one could therefore understand the physics correlates of ethics and moral. The ethics is simple: evolution of consciousness to higher levels is a good thing. Anything which tends to reduce consciousness represents violence and is a bad thing. Moral rules are related to the relationship between individual and society and presumably develop via self-organization process and are by no means unique. Moral rules however tend to optimize evolution. As blind normative rules they can however become a source of violence identified as any action which reduces the level of consciousness.

There is an entire hierarchy of selves and every self has the selfish desire to survive and moral rules develop as a kind of compromise and evolve all the time. The newest progress in this evolution is brought by the cosmology of consciousness, which forces to extend the concept of society to four-dimensional society! The decisions of "me now" affect both my past and future and time like quantum entanglement makes possible conscious communication in time direction by sharing conscious experiences. One can therefore speak of genuinely four-dimensional society. Besides my next-door neighbors I had better to take into account also my nearest neighbors in past and future (the nearest ones being perhaps copies of me!). If I make wrong decisions those copies of me in future and past will suffer the most. Perhaps my personal hell and paradise are here and are created mostly by me.

How the law of Karma could be realized?

The existence of self hierarchy means that our deeds are remembered also after our death at higher level of self hierarchy although only as an abstracted summary. One can therefore ask whether the law of Karma or something akin to it might be implied by basic principles of consciousness theory.

First of all, self has two life strategies: be a sinner or saint.

1. Self can fight for the metabolic energy feed giving rise to the self organization of self. This strategy works as long as self is a young, brisk and arrogant sinner. Sinners are not desirable mental images from the point of view of higher level self since they induce a lot of entropic mental images (pain). This strategy is also in conflict with the possible goal of the higher level self to achieve fusion of its own mental images.
2. Self can attempt to share mental images by quantum entangling its sub-selves with the sub-selves of other, possibly, higher level selves. This mechanism gives rise to quantum metabolism and expanded states of consciousness, favors the generation of social structures, and means fusion of mental images from the point of view of higher level self. The cognitive mental images of the saintlike self are highly negentropic and favored by p-adic NMP.

On basis of these findings the policy for higher level selves looks obvious: try to get rid of the unpleasant mental images represented by sinners. Higher level self could apply this policy for purely selfish reasons: too bad sinners might affect like a poison to the moral level of the higher level self and, since the law of Karma is universal, could eventually lead to the decline of the higher level self to a lower level of the hierarchy: the world would seem to be a tough place also after death!

What 'liberation' might mean?

The strong analogies with eastern spirituality encourage to ask whether the TGD inspired quantum counterpart for the concept of liberation might make sense.

1. Quantum-classical correspondence principle suggests that the endless evolution at the level of the entire universe corresponds to endless evolution at the level of individual so that the notion of liberation would make sense only as kind of transformation to a higher level of consciousness.
2. In the real context selves having only single mental image or no mental images at all are in state of 'oneness' and experience no divisions and separations since the analysis process represented by state function reductions and self measurements is absent. This kind of state realized at the level of field body is a possible candidate for enlightened state. Certainly it cannot last forever.

3. Liberation experience might also relate to the experience of "cosmic consciousness". Most naturally a generation of negentropic entanglement fusing self to a self at higher level of self hierarchy. The fear about the loss of consciousness is what gives self an ego, since ego is something which can be lost. This can happen via the generation of entropic bound state entanglement with some other system. This can happen for any subsystem of Universe but not for the entire Universe enjoying an eternal state of consciousness. The state of cosmic consciousness thus means being a self without ego. The counterpart for this would be negentropic entanglement. Leaving aside the question whether we are able to experience ideal cosmic consciousness, one can consider the possibility that even human beings could achieve a state of consciousness in which the loss of consciousness is highly un-probable and that this loss of ego is synonymous with the experience of liberation.

The term "cosmic consciousness" looks somewhat pompous notion to anyone identifying himself with his suffering biological body and it would be certainly very difficult to sell this concept to a neuroscientist. This notion might however have a rather literal meaning in the intersection of real and p-adic worlds representing life. If p-adic- and real-rational imbedding space points are related via the identification of common rational points, p-adic space-time sheets typically have an infinite size with respect to the real topology since p-adically infinitesimally small distances necessarily correspond to infinite real distances. In this cognitive sense cosmic consciousness would have surprisingly concrete meaning.

Chapter 3

Time, Space-Time, and Consciousness

3.1 Introduction

In this chapter I will discuss TGD based view about time and space-time. The discussion of the many-sheeted space-time concept explaining the basic notions once again is included because I feel that this is in order since the understanding of "topological light rays" (massless extremals, briefly MEs), and of magnetic and electric flux quanta has developed vigorously since the articles published in the last issue of JNLRMI [L3] . I have not even attempted to include all essential aspects since this would simply lead both me and the reader to despair. I consider those aspect that I feel especially relevant just now. To be honest, the act of writing the article generated a lot of new insights and ideas so that the boring duty to summarize something already done transformed once again to an active process of thinking and identifying weak points in the existing scenario and trying to see the idea landscape from a more general perspective. The eight online books [K82, K12, K60, K10, K34, K41, K44, K74] at my home page provide a comprehensive unavoidably out of date summary TGD inspired theory of consciousness.

A brief summary of what might be called basic principles is in order to facilitate the reader to assimilate the basic tools and rules of intuitive thinking involved.

3.1.1 Quantum-classical correspondence

The fundamental metalevel guiding principle is quantum-classical correspondence (classical physics is an exact part of quantum TGD). The principle states that all quantum aspects of the theory, which means also various aspects of consciousness such as volition, cognition, and intentionality, should have space-time correlates. Real space-time sheets provide kind of symbolic representations whereas p-adic space-time sheets provide correlates for cognition and intentions. All that we can symbolically communicate about conscious experience relies on quantal space-time engineering to build these representations.

3.1.2 Classical physics as exact part of quantum theory

Classical physics corresponds to the dynamics of space-time surfaces determined by the absolute minimization of so called Kähler action. This dynamics have several unconventional features basically due to the possibility to interpret the Kähler action as a Maxwell action expressible in terms of the induced metric defining classical gravitational field and induced Kähler form defining a non-linear Maxwell field not as such identifiable as electromagnetic field however.

Classical electroweak and color fields as signature for a fractal hierarchy of copies standard model physics

The geometrization of classical fields means that various classical fields are expressible in terms of imbedding space-coordinates and are thus not primary dynamical variables. This predicts the presence

of long range weak fields, in particular Z^0 fields, and color (gluon) fields not possible in standard physics context. It took 26 years to end up with a convincing interpretation for this puzzling prediction.

What seems to be the correct interpretation is in terms of an infinite fractal hierarchy of copies of standard models physics with appropriately scaled down mass spectra for quarks, leptons, and gauge bosons. Both p-adic length scales and the values of Planck constant predicted by TGD [K92] label various physics in this hierarchy. Also other quantum numbers are predicted as labels. This means that universe would be analogous to an inverted Mandelbrot fractal with each bird's eye of view revealing new long length scale structures serving also as correlates for higher levels of self hierarchy.

Exotic dark weak forces and their dark variants are consistent with the experimental widths for ordinary weak gauge bosons since the particles belonging to different levels of the hierarchy do not have direct couplings at Feynman diagram level although they have indirect classical interactions and also the de-coherence reducing the value of \hbar is possible. Classical long ranged weak fields play a key role in quantum control and communications in living matter [K31, K26]. Long ranged classical color force in turn is the backbone in the model of color vision [K32]: colors correspond to the increments of color quantum numbers in this model. The increments of weak isospin in turn could define the basic color like quale associated with hearing (black-white \leftrightarrow to silence-sound [K32, K61, K65]).

Topological field quantization and the notion of many-sheeted space-time

The compactness of CP_2 implies the notions of many-sheeted space-time and field quantization. Topological field quantization means that various classical field configurations decompose into topological field quanta. One can see space-time as a gigantic Feynman diagram with lines thickened to 4-surfaces. Only preferred extremals of Kähler action with the property that there exists infinite number of deformations with a vanishing second variation of Kähler action allows to assign to give 3-surface a unique space-time surface. This implies that only selected field configurations analogous to Bohr's orbits are realized physically so that quantum-classical correspondence becomes very predictive. An interpretation as a 4-D quantum hologram is a further very useful picture [K37] but will not be discussed in this chapter in any detail.

Topological field quantization implies that the field patterns associated with material objects form extremely complex topological structures which can be said to belong to the material objects. The notion of field body, in particular magnetic body, typically much larger than the material system, differentiates between TGD and Maxwell's electrodynamics, and has turned out to be of fundamental importance in the TGD inspired theory of consciousness. One can say that field body provides an abstract representation of the material body.

One implication of many-sheetedness is the possibility of macroscopic quantum coherence. By quantum classical correspondence large space-time sheets as quantum coherence regions are macroscopic quantum systems and therefore ideal sites of the quantum control in living matter.

1. The original argument was that each space-time sheet carrying matter has a temperature determined by its size and the mass of the particles residing at it via de Broglie wave length $\lambda_{dB} = \sqrt{2mE}$ assumed to define the p-adic length scale by the condition $L(k) < \lambda_{dB} < L(k_>)$. This would give very low temperatures when the size of the space-time sheet becomes large enough. The original belief indeed was that the large space-time sheets can be very cold because they are not in thermal equilibrium with the smaller space-time sheets at higher temperature.
2. The assumption about thermal isolation is not needed if one accepts the possibility that Planck constant is dynamical and quantized and that dark matter corresponds to a hierarchy of phases characterized by increasing values of Planck constant [K92, K25]. From $E = hf$ relationship it is clear that arbitrarily low frequency dark photons (say EEG photons) can have energies above thermal energy which would explain the correlation of EEG with consciousness. This vision allows to formulate more precisely the basic notions of TGD inspired theory of consciousness and leads to a model of living matter giving precise quantitative predictions. Also the ability of this vision to generate new insights to quantum biology provides strong support for it [K26].

Many-sheeted space-time predicts also fundamental mechanisms of metabolism based on the dropping of particles between space-time sheets with an ensuing liberation of the quantized zero point kinetic energy. Also the notion of many-sheeted laser follows naturally and population inverted many-sheeted lasers serve as storages of metabolic energy [K38].

Space-time sheets topologically condense to larger space-time sheets by wormhole contacts which have Euclidian signature of metric. This implies causal horizon at which the signature of the induced metric changes from Minkowskian to Euclidian. This forces to modify the notion of subsystem. What is new is that two systems represented by space-time sheets can be unentangled although their subsystems bound state entangle with the mediation of the join along boundaries bonds connecting the boundaries of sub-system space-time sheets. This is not allowed by the notion of subsystem in ordinary quantum mechanics. This notion in turn implies the central concept of fusion and sharing of mental images by entanglement.

The possibility of negative energies

A further prediction derives from the fact that space-time is 4-surface rather than an abstract manifold. Energy momentum tensor of general relativity is replaced by a collection of conserved energy and momentum currents, which are 4-vector fields. This makes the notions of energy and momentum precisely defined but also implies that the sign of energy and momentum depend on the time-orientation of the space-time sheet. Negative energies become therefore possible somewhat like in the lines of a Feynman diagram. Negative energy topological light rays have phase conjugate laser waves [D33] as the most plausible standard physics counterparts, and play a fundamental role in quantum metabolism as a kind of quantum credit card [K38]. They generate also time like entanglement which corresponds to a formation of new kind of bound states.

Negative energies might be possible even for ordinary particles and could mean dramatic deviation from the standard quantum theory. The roles of annihilation and creation operators have changed for negative energy space-time sheets. This would mean that operator combinations involving both annihilation and creation operators would generate states involving positive and negative energy space-time sheets. One can even imagine that a intentional action could create states with vanishing net quantum numbers and that positive and negative energy particles could be separated from each other.

In the framework of zero energy ontology this somewhat non-rigorous sounding original vision finds a precise formulation. In zero energy ontology all quantum states have vanishing net energy since positive and negative energy parts of the state have opposite quantum numbers. Therefore the problems related to the conservation of quantum numbers are automatically resolved automatically.

TGD Universe is quantum spin glass

Since Kähler action is Maxwell action with Maxwell field and induced metric expressed in terms of $M_+^4 \times CP_2$ coordinates, the gauge invariance of Maxwell action as a symmetry of the vacuum extremals (this implies is a gigantic vacuum degeneracy) but not of non-vacuum extremals. Gauge symmetry related space-time surfaces are not physically equivalent and gauge degeneracy transforms to a huge spin glass degeneracy. Spin glass degeneracy provides a universal mechanism of macro-temporal quantum coherence and predicts degrees of freedom called zero modes not possible in quantum field theories describing particles as point-like objects. Zero modes are identifiable as effectively classical variables characterizing the size and shape of the 3-surface as well as the induced Kähler field.

Classical and p-adic non-determinism

The vacuum degeneracy of Kähler action implies classical non-determinism, which means that space-like 3-surface is not enough to fix the space-time surface associated with it uniquely as an absolute minimum of action, and one must generalize the notion of 3-surface by allowing sequences of 3-surfaces with time like separations to achieve determinism in a generalized sense. These "association sequences" can be seen as symbolic representations for the sequences of quantum jumps defining selves and thus for contents of consciousness. Not only speech and written language define symbolic representations but all real space-time sheets of the space-time surfaces can be seen in a very general sense as symbolic representations of not only quantum states but also of quantum jump sequences. An important implication of the non-determinism is the possibility to have conscious experiences with contents localized with respect to geometric time. Without this non-determinism conscious experience would have no correlates localized at space-time surface, and there would be no psychological time.

p-Adic non-determinism follows from inherent non-determinism of p-adic differential equations for any action principle and is due to the fact that integration constants, which by definition are functions with vanishing derivatives, are not constants but functions of the pinary cutoffs x_N defined

as $x = \sum_k x_k p^k \rightarrow x_N = \sum_{k < N} x_k p^k$ of the arguments of the function (see Fig. 3.6.4). In p-adic topology one can therefore fix the behavior of the space-time surface at discrete set of space-time points *above* some length scale defined by p-adic concept of nearness by fixing the integration constants. In the real context this corresponds to the fixing the behavior *below* some time/length scales since points p-adically near to each other are in real sense faraway. This is a natural correlate for the possibility to plan the behavior and p-adic non-determinism is assumed to be a classical correlate for the non-determinism of intentionality, and perhaps also imagination and cognition.

These two non-determinisms allow to understand the self-referentiality of consciousness at a very general level. In a given quantum jump a space-time surface can be created with the property that it represents symbolically or cognitively something about the contents of consciousness before the quantum jump. Thus it becomes possible to become conscious about being conscious of something. This is very much like mathematician expressing her thoughts as symbol sequences which provides feedback to go the next abstraction level.

Classical and p-adic non-determinisms force also the generalization of the notion of entanglement. Time-like entanglement, crucial for understanding long term memory and precognition becomes possible. The notion of many-sheeted space-time forces also to modify the notion of subsystem, which implies that unentangled systems can have entangled subsystems. One can partially understand this in terms of length scale dependent notion of entanglement (the entanglement of subsystems is not seen in the length scale resolution defined by the size of unentangled systems) but only partially. The formation of join along boundaries bonds between subsystem space-time sheets and the fact that topologically condensed space-time sheets are separated by "elementary particle horizons" from larger space-time sheets, provide the deeper topological motivation for the generalization of subsystem concept.

p-Adic fractality of life and consciousness

p-Adic fractality of biology and consciousness has become an increasingly important guide line in the construction of the theory. This notion allows to relate phenomena occurring in the molecular level to phenomena like remote viewing and psychokinesis and it leads also to the view that topological field quanta of various fields of astrophysical size are crucial for the functioning of bio-systems. If one accepts p-adic fractality, the theory can be tested in unexpected manners, in particular in molecular and cellular length scales where the systems are much simpler. Sensory perception, long term memory, remote mental interactions, metabolism: all these phenomena rely on the same basic mechanisms. p-Adic length scale hypothesis allows to quantify the hypothesis with testable quantitative predictions.

Double slit experiment and classical non-determinism

Bohr's complementarity principle is the basic element of Copenhagen interpretation and at the same time one of the most poorly defined aspects of this interpretation. If the possibility of macroscopic quantum entanglement between measurement instrument and quantum system is accepted, complementary principle becomes un-necessary. This is however not all that is needed. If classical non-determinism makes it possible to represent quantum jump sequences at space-time level, a revision of space-time description of quantum measurement is necessary. This sounds very logical but to be honest, I write these lines only after having learned about the remarkable experiment done by Shahriar Afshar [D12].

The variant of double slit experiment by Shahriar Afshar seems to contradict the Copenhagen interpretation which states that the particle and field aspects are complementary and thus mutually exclusive. In the case of double slit experiment complementarity predicts that the measurement of whether the photon came to the detector through slit 1 or 2 should destroy the interference pattern of electromagnetic fields in the region behind the screen.

The experimental arrangement of Afshar differs from the standard double slit experiment in that a lens was added behind the screen. The lens transmitted the photons coming from slits 1 and 2 via mirrors to detectors A and B so that in particle picture a photon detected by A (B) could be regarded as coming from slit 1 (2). In the first step both slits were open and the detectors represented interference patterns representing diffraction through single slit. The other slit was then closed and metal wires at the positions of dark interference rings were added. These wires degraded somewhat the

image in the second detector. After this the second slit was opened again. Surprisingly, the resulting interference pattern was the original one.

The measurement certainly measures the particle aspect of photons. On the other hand, the preservation of the detected patterns means that no photons did enter in the regions containing the wires so that also interference pattern is there. Hence wave and particle aspects seem to be mutually consistent.

This finding is difficult to understand in Copenhagen interpretation and also in the many-worlds interpretation of quantum mechanics. Afshar himself suggest that the very notion of photon must be questioned. It is however difficult to accept this view since the photon absorption quite concretely corresponds to a click in the detector and also because the mathematical formalism of second quantization works so fantastically.

The conclusion can be criticized. What is primarily measured is not basically through which slit the photons came but whether the direction of the momentum of the photon emerging from the lens was in the angle range characterizing the detector or not. One can however argue that in deterministic physics for fields the two measurements are equivalent so that the problem remains.

In TGD framework the classical physics is not completely deterministic (in the standard sense of the word) and this has led to a generalization of the notion of quantum classical correspondence. Space-time surface provides a classical (unfaithful) representation not only for quantum states but for quantum jump sequences or equivalently, for sequences of quantum states. The most obvious identification for the quantum states is as the maximal non-deterministic regions of a given space-time sheet.

One can of course generalize the notion of determinism by allowing unions of 3-surfaces with time-like separations as causal determinants. I used the term association sequence in the original formulation identifying them as space-time correlates for thoughts. This led eventually to the notion of zero energy ontology in which a key role is played by causal diamonds identified as intersections of future and past directed lightcones containing space-time surfaces and carrying positive and negative energy parts of zero energy states at the intersections of space-time surfaces with the opposite light-like boundaries of the causal diamond.

In the recent context this would mean that the fields in the region between the screen and lens represent the state before the state function reduction and thus the interference pattern, whereas the fields in the region between lens and detectors represent the situation after the state function reduction. The interaction with lens involves classical non-determinism.

This picture conforms also with the notion of topological field quantization. The space-time decomposes into space-time sheets interpreted, topological field quanta (topological light rays containing photons, flux quanta of magnetic field, etc.). Topological field quanta correspond to the coherence regions for classical fields with spinor fields included. De-coherence corresponds to the splitting of space-time sheet to smaller, possibly parallel space-time sheets. Topological field quantum carries classical fields inside it but behaves as a whole like particle. Hence particle and wave aspects are consistent in the sense that below the size scale L of the topological field quantum (say the thickness of a magnetic flux tube or topological light ray) the description as a wave applies and above L particle description makes sense. In the recent case the coherence is lost at the lens space-time sheet where the space-time sheet representing interference pattern decomposes to two sheets representing photon beams going to the two detectors.

3.1.3 Some basic ideas of TGD inspired theory of consciousness and quantum biology

The following ideas of TGD inspired theory of consciousness and of quantum biology are the most relevant ones for what will follow.

1. "Everything is conscious and consciousness can be only lost" is the briefest manner to summarize TGD inspired theory of consciousness. Quantum jump as moment of consciousness and the notion of self are key concepts of the theory. Self is a system able to avoid bound state entanglement with environment and can be formally seen as an ensemble of quantum jumps. The contents of consciousness of self are defined by the averaged increments of quantum numbers and zero modes (sensory and geometric qualia). Moments of consciousness can be said to be the counterparts of elementary particles and selves the counterparts of many-particle states,

both bound and free. The selves formed by macro-temporal quantum coherence are in turn the counterparts of atoms, molecules and larger structures. Macro-temporal quantum coherence effectively binds a sequence of quantum jumps to a single quantum jump as far as conscious experience is considered. The idea that conscious experience is about changes amplified to macroscopic quantum phase transitions, is the key philosophical guideline in the construction of various models, such as the model of qualia, the capacitor model of sensory receptor, the model of cognitive representations, and declarative memories.

2. Macro-temporal quantum coherence is a second consequence of the spin glass degeneracy [K37]. It is essentially due to the formation of bound states and has as a topological correlate the formation of join along boundaries bonds connecting the boundaries of the component systems. During macro-temporal coherence quantum jumps integrate effectively to single long-lasting quantum jump and one can say that system is in a state of oneness, eternal now, outside time. Macro-temporal quantum coherence makes possible stable non-entropic mental images. Negative energy MEs are one particular mechanism making possible macro-temporal quantum coherence via the formation of bound states, and remote metabolism and sharing of mental images are other facets of this mechanism. The real understanding of the origin of macroscopic quantum coherence requires the generalization of quantum theory allowing dynamical and quantized Planck constant [K25, K26].
3. p-Adic physics as physics of intentionality and possibly also of cognition is a further key idea of TGD inspired theory of consciousness. p-Adic space-time sheets as correlates for intentions and p-adic-to-real transformations of them as correlates for the transformation of intentions to actions allow deeper understanding of also psychological time as a front of p-adic-to-real transition propagating to the direction of the geometric future. Negative energy MEs are absolutely essential for the understanding of how precisely targeted intentionality is realized.

In this chapter various aspects related TGD based notion of time are discussed. The original motivation for writing this chapter was to have a chapter completely free of mammoth bones. I would be happy to tell that the treatment is completely logical top-down discussion starting from the basic postulates but I must confess that there are internal inconsistencies. I have not had time to make all necessary updates and I hope that reader could forgive this. The last section of the chapter represents the latest (June 2008) vision about the relationship between geometric time and subjective time and also about the notion of self relying on the notion of zero energy ontology, hierarchy of Planck constants, and the improved understanding of p-adic length scale hypothesis not available when I wrote this chapter for the first time.

3.2 Many-sheeted space-time, magnetic flux quanta, electrets and MEs

TGD inspired theory of consciousness and of living matter relies on space-time sheets carrying ordinary matter, topological light rays (massless extremals, MEs), and magnetic and electric flux quanta. There are some new results which motivate a separate discussion of them.

3.2.1 Dynamical quantized Planck constant and dark matter hierarchy

By quantum classical correspondence space-time sheets can be identified as quantum coherence regions. Hence the fact that they have all possible size scales more or less unavoidably implies that Planck constant must be quantized and have arbitrarily large values. If one accepts this then also the idea about dark matter as a macroscopic quantum phase characterized by an arbitrarily large value of Planck constant emerges naturally as does also the interpretation for the long ranged classical electro-weak and color fields predicted by TGD. Rather seldom the evolution of ideas follows simple linear logic, and this was the case also now. In any case, this vision represents the fifth, relatively new thread in the evolution of TGD and the ideas involved are still evolving.

Dark matter as large \hbar phase

D. Da Rocha and Laurent Nottale have proposed that Schrödinger equation with Planck constant \hbar replaced with what might be called gravitational Planck constant $\hbar_{gr} = \frac{GmM}{v_0}$ ($\hbar = c = 1$). v_0 is a velocity parameter having the value $v_0 = 144.7 \pm .7$ km/s giving $v_0/c = 4.6 \times 10^{-4}$. This is rather near to the peak orbital velocity of stars in galactic halos. Also subharmonics and harmonics of v_0 seem to appear. The support for the hypothesis coming from empirical data is impressive.

Nottale and Da Rocha believe that their Schrödinger equation results from a fractal hydrodynamics. Many-sheeted space-time however suggests astrophysical systems are not only quantum systems at larger space-time sheets but correspond to a gigantic value of gravitational Planck constant. The gravitational (ordinary) Schrödinger equation would provide a solution of the black hole collapse (IR catastrophe) problem encountered at the classical level. The resolution of the problem inspired by TGD inspired theory of living matter is that it is the dark matter at larger space-time sheets which is quantum coherent in the required time scale [K72].

Dark matter hierarchy and generalization of the imbedding space

In the appendix of [K14] the mathematical description of dark matter hierarchy in terms of the book like structure of the generalized imbedding space is briefly summarized. Some comments are however in order.

The pages of the "Big Book" are characterized by two numbers x_a and x_b assignable to M^4 and CP_2 degrees of freedom. The values of these numbers are either integers or their inverses depending on whether the page of the book is a singular covering or factor space defined by a discrete subgroup of $SU(2)$. For a given CD the sectors characterized by different integers are glued together along $M^2 \subset M^4$ defining quantization axis of energy and spin. In CP_2 degrees of freedom the gluing is along a homologically trivial geodesic sphere of CP_2 and also now a fixing of the quantization axes is involved. The positions of the tips of CD and preferred points of CP_2 at the two light-like boundaries of CD fix the quantization axis and moduli space for CD s. An attractive hypothesis is that the relative positions of tips and corresponding preferred points of CP_2 form discrete spaces. The quantization of the temporal distance between tips in powers of two implies p-adic length scale hypothesis.

The arguments related to a model of anyons lead to the proposal that Planck constant equals to the product $x_a x_b$ and the value spectrum consists of rationals. One can expect that certain values are preferred ones for number theoretic reasons. For instance, ruler-and-compass integers expressible as product of a power of two with a product of different Fermat primes define an extension of p-adic numbers involving only square root operation applied to rationals. Only four Fermat primes are known and they are given by $F_k = 2^{2^k} + 1$, $k = 1, 2, 3, 4$. Primes and their inverses are also favored values for x_a and x_b . Since large values of Planck constant are favored in living matter, coverings of both M^4 and CP_2 are favored. The finite discrete symmetries of biomolecules (such as 5- and 6-fold rotational symmetries of aromatic molecules) might correspond to singular factor spaces of CD and therefore to $x_a = 1/n_a$.

The original working hypothesis was motivated by the model for planetary orbits with gigantic Planck constant $\hbar_{gr} = GMm/v_0$, $v_0/c \simeq 2^{-11}$. [K72]. v_0 has an interpretation as a velocity like parameter. This motivated the working hypothesis that preferred values of Planck constant come as powers of $\lambda = 2^{11}$ and living matter provides some support for this hypothesis consistent also with ruler-and-compass hypothesis. This hierarchy means for a given particle a hierarchy of zoomed up Compton lengths and times making possible macroscopic quantum coherence by the overlap criterion of space-time sheets having sizes of order Compton length. It must be however emphasized that much more general spectrum for the preferred values of Planck constant is expected.

A possible criterion for the phase transition to larger \hbar phase at the lowest level is that the interaction strength αQ^2 for particles of charge Q and gauge coupling strength α satisfies $\alpha Q^2 \geq 1$ and implies the increase of \hbar by $\hbar \rightarrow Q^2 \alpha \hbar / v_0$ implying the reduction of the interaction strength as $Q^2 \alpha \rightarrow v_0$. Another such criterion could be energy minimization.

Dark matter as a source of long ranged weak and color fields

Long ranged classical electro-weak and color gauge fields are unavoidable in TGD framework. The smallness of the parity breaking effects in hadronic, nuclear, and atomic length scales does not however

seem to allow long ranged electro-weak gauge fields. The problem disappears if long range classical electro-weak gauge fields are identified as space-time correlates for massless gauge fields created by dark matter. Also scaled up variants of ordinary electro-weak particle spectra are possible. The identification explains chiral selection in living matter and unbroken $U(2)_{ew}$ invariance and free color in bio length scales become characteristics of living matter and of bio-chemistry and bio-nuclear physics. An attractive solution of the matter antimatter asymmetry is based on the identification of also antimatter as dark matter.

Dark matter hierarchy and consciousness

The emergence of the vision about dark matter hierarchy has meant a revolution in TGD inspired theory of consciousness. Dark matter hierarchy means also a hierarchy of long term memories with the span of the memory identifiable as a typical geometric duration of moment of consciousness at the highest level of dark matter hierarchy associated with given self so that even human life cycle represents at this highest level single moment of consciousness.

Dark matter hierarchy leads to detailed quantitative view about quantum biology with several testable predictions [K26] . The hierarchy of dark matter levels is labeled by the values of Planck constant having quantized but arbitrarily large values. For the most general option the values of \hbar are products and ratios of two integers. The products of distinct Fermat primes and power of two are number theoretically favored values for these integers. p-Adic length scale hypothesis favors powers of two.

The general prediction is that Universe is a kind of inverted Mandelbrot fractal for which each bird's eye of view reveals new structures in long length and time scales representing scaled down copies of standard physics and their dark variants. These structures would correspond to higher levels in self hierarchy. This prediction is consistent with the belief that 75 per cent of matter in the universe is dark.

1. *Living matter and dark matter*

Living matter as ordinary matter quantum controlled by the dark matter hierarchy has turned out to be a particularly successful idea. The hypothesis has led to models for EEG predicting correctly the band structure and even individual resonance bands and also generalizing the notion of [J17] [K26] . Also a generalization of the notion of genetic code emerges resolving the paradoxes related to the standard dogma [K43, K26] . A particularly fascinating implication is the possibility to identify great leaps in evolution as phase transitions in which new higher level of dark matter emerges [K26] .

It seems safe to conclude that the dark matter hierarchy with levels labelled by the values of Planck constants explains the macroscopic and macro-temporal quantum coherence naturally. That this explanation is consistent with the explanation based on spin glass degeneracy is suggested by following observations. First, the argument supporting spin glass degeneracy as an explanation of the macro-temporal quantum coherence does not involve the value of \hbar at all. Secondly, the failure of the perturbation theory assumed to lead to the increase of Planck constant and formation of macroscopic quantum phases could be precisely due to the emergence of a large number of new degrees of freedom due to spin glass degeneracy. Thirdly, the phase transition increasing Planck constant has concrete topological interpretation in terms of many-sheeted space-time consistent with the spin glass degeneracy.

2. *Dark matter hierarchy and the notion of self*

The vision about dark matter hierarchy leads to a more refined view about self hierarchy and hierarchy of moments of consciousness [K25, K26] . The larger the value of Planck constant, the longer the subjectively experienced duration and the average geometric duration $T(k) \propto \lambda^k$ of the quantum jump.

Dark matter hierarchy suggests also a slight modification of the notion of self. Each self involves a hierarchy of dark matter levels, and one is led to ask whether the highest level in this hierarchy corresponds to single quantum jump rather than a sequence of quantum jumps. The averaging of conscious experience over quantum jumps would occur only for sub-selves at lower levels of dark matter hierarchy and these mental images would be ordered, and single moment of consciousness would be experienced as a history of events. One can ask whether even entire life cycle could be regarded as a single quantum jump at the highest level so that consciousness would not be completely

lost even during deep sleep. This would allow to understand why we seem to know directly that this biological body of mine existed yesterday.

The fact that we can remember phone numbers with 5 to 9 digits supports the view that self corresponds at the highest dark matter level to single moment of consciousness. Self would experience the average over the sequence of moments of consciousness associated with each sub-self but there would be no averaging over the separate mental images of this kind, be their parallel or serial. These mental images correspond to sub-selves having shorter wake-up periods than self and would be experienced as being time ordered. Hence the digits in the phone number are experienced as separate mental images and ordered with respect to experienced time.

3.2.2 p-Adic length scale hypothesis and the connection between thermal de Broglie wave length and size of the space-time sheet

Also real space-time sheets are assumed to be characterized by p-adic prime p and assumed to have a size determined by primary p-adic length scale L_p or possibly n-ary p-adic length scale $L_p(n)$. More generally, each space-time dimension could correspond to its own p-adic length scale and even several p-adic primes could be associated with single dimension.

The possibility to assign a p-adic prime to the real space-time sheets is required by the success of the elementary particle mass calculations and various applications of the p-adic length scale hypothesis. Rationals are common to reals and all p-adic number fields. The p-adic-to-real transition transforming intentions to actions is made possible by a large number of common rational points between p-adic and real space-time surfaces, which supports the view that real space-time sheets obeys effective p-adic topology as an approximate topology in some resolution and below some length scale. p-Adic prime thus characterizes the classical non-determinism of the Kähler action.

Parallel space-time sheets with distance about 10^4 Planck lengths form a hierarchy. Each material object (...atom, molecule, ..., cell,...) corresponds to this kind of space-time sheet. The p-adic primes $p \simeq 2^k$, k prime or power of prime, characterize the size scales of the space-time sheets in the hierarchy. The p-adic length scale $L(k)$ can be expressed in terms of cell membrane thickness as

$$L(k) = 2^{(k-151)/2} \times L(151) \quad , \quad (3.2.1)$$

$L(151) \simeq 10$ nm. These are so called primary p-adic length scales but there are also n-ary p-adic length scales related by a scaling of power of \sqrt{p} to the primary p-adic length scale. Quite recent model for photosynthesis [K38] gives additional support for the importance of also n-ary p-adic length scales so that the relevant p-adic length scales would come as half-octaves in a good approximation but prime and power of prime values of k would be especially important.

3.2.3 Topological light rays (massless extremals, MEs)

I have described MEs, or "topological light rays", in previous articles of JNLRMI [L4] and in [K55, K8] , and describe here only very briefly the basic characteristics of MEs and concentrate on new idea about their possible role for consciousness and life.

What MEs are?

MEs can be regarded as topological field quanta of classical radiation fields [K55, K8] . They are typically tubular space-time sheets inside which radiation fields propagate with light velocity in single direction without dispersion. The simplest case corresponds to a straight cylindrical ME but also curved MEs, kind of curved light rays, are possible. The initial values for a given moment of time are arbitrary by light likeness. Therefore MEs are ideal for precisely targeted communications. What distinguishes MEs from Maxwellian radiation fields in empty space is that light like vacuum 4-current is possible: ordinary Maxwell's equations would state that this current vanishes. Quite generally, purely geometric vacuum charge densities and 3-currents are purely TGD based prediction and could be seen as a classical correlate of the vacuum polarization predicted by quantum field theories.

MEs are fractal structures containing MEs within MEs. The so called scaling law of homeopathy predicts that the high frequency MEs inside low frequency MEs are in a ratio having discrete values [K36] . One can indeed justify this relationship. As ions drop from smaller space-time sheets to

magnetic flux tubes, zero point kinetic energy is liberated as high frequency MEs, and the ions dropped to magnetic flux tubes generate cyclotron radiation, and the ratio of the fundamental frequencies is constant not depending on particle mass and being determined solely by p-adic length scale hypothesis. The model for the radio waves induced by the irradiation of DNA by laser light [I75] gives support for this picture [K37].

Two basic types of MEs

MEs have 2-dimensional CP_2 projection which means that electro-weak holonomy group is Abelian (color holonomy is always Abelian which suggests that physical states in TGD Universe correspond to states of color multiplets with vanishing color hypercharge and isospin rather than color singlets). If CP_2 projection belongs to a homologically non-trivial geodesic sphere, only em and Z^0 fields and Abelian color gauge fields are present. In the homologically trivial case only classical W fields are non-vanishing.

1. Neutral MEs can be assigned to various kinds of communications from biological body to the magnetic body and fractal hierarchy of EEGs and ZEGs represent the basic example in this respect [K26].
2. Dark W MEs serving as correlate for dark W exchanges induce an exotic ionization of atomic nuclei [K76, K27, K26]. This induces charge entanglement between magnetic body and biological body generating dark plasma oscillation patterns inducing nerve pulse patterns and ion waves at the space-time sheets occupied by the ordinary matter. The mechanism is based on many-sheeted Faraday law inducing electromagnetic fields at ordinary space-time sheet in turn giving rise to ohmic currents. State function reduction selects one of the exotically ionized configurations. This mechanism is the most plausible candidate for how magnetic body as an intentional agent controls biological body.

Negative energy MEs

MEs can have either positive or negative energy. The understanding of negative energy MEs has increased considerably. Phase conjugate laser waves [D33] are the most plausible standard physics counterparts of negative energy MEs since they can be interpreted as time reversed laser beams and do not possess direct Maxwellian analog. By quantum-classical correspondence one can interpret the frequencies associated with negative energy MEs as energies. One can also assume that the Bose-Einstein condensed photons associated with negative energy MEs and with the coherent light generated by the light like vacuum current have negative energies.

For frequencies which are above thermal energy there is no system which could interact with negative energy MEs or absorb negative energy photons. Therefore negative energy MEs and corresponding photons should propagate through matter practically without any interaction. Feinberg has demonstrated that phase conjugate laser beams behave similarly: for instance, one can see through chickens using these laser beams [D4]. This means that negative energy MEs do not respect Faraday cages and thus represent an attractive candidate for the hypothetical Psi field. Note that MEs are not a mere classical correlate for photons, as is clear from the fact that in the case of Z^0 MEs there are no Z^0 photons.

Negative energy MEs have many applications.

1. Negative energy MEs ideal for generating time like entanglement. Since negative energies are involved, this entanglement can be seen as a correlate for the bound state entanglement leading to a macro-temporal quantum coherence. Negative energy MEs make thus possible telepathic sharing of mental images. Negative energy MEs are involved with both sensory perception, long term memory, and motor action.
2. Negative energy MEs are ideal for a precisely targeted realization of intentions. p-Adic ME having a large number of common rational points with negative energy ME is generated and transformed to a real ME in quantum jump. The system receives positive energy and momentum as a recoil effect and the transition is not masked by ordinary spontaneously occurring quantum transitions since the energy of the system increases. One can say that negative energy ME

represents the desires communicated to the geometric past and inducing as a reaction the desired action realized as say neuronal activity and generation of positive energy MEs.

3. The generation of negative energy MEs is also in a key role in remote metabolism and MEs serve as quantum credit cards implying an extreme flexibility of the metabolism. During the writing of this article one new and important aspect of remote metabolism became obvious. If the system receiving negative energy MEs is a population inverted laser or its many-sheeted counterpart, then quite a small field intensity associated with negative energy MEs (intensity of negative energy photons) can lead to the amplification of the time reflected positive energy signal. The reason is that the rate for the induced emission is proportional to the number of particles dropped to the ground state from the excited state. Therefore even negative energy bio-photons might serve as quantum controllers of metabolism and induce much more intense beams of positive energy photons, say when interacting with mitochondria.

How MEs propagate in matter

MEs can propagate in matter in two different manners: along interior or along boundaries (this is new).

1. The interaction analogous to the ordinary interaction of electromagnetic fields with matter is based on the formation of wormhole contacts between ME and the interior of the material space-time sheet. As a consequence, MEs tend to be stuck to the interior of the space-time sheets while interacting with matter. This leads to the lowering of the phase velocity from light velocity. Since the sizes of the wormhole contacts are extremely small, about 10^4 Planck lengths, the effect is usually small. At the quantum level the reduction of the phase velocity could be interpreted in terms of the shifting of the positive energy ME in each quantum jump relative to the background space-time sheet to the direction of the geometric future so that the phase associated with a ME would be observed to change more slowly. For negative energy MEs would be opposite if they shift to the direction of geometric past and apparent super-luminal light velocity would result. This mechanism is proposed as an explanation for the observed super-luminal light velocities [D11] in photon tunnelling [H12] .
2. MEs can also propagate along boundaries of the material space-time sheets. What can happen that ME joins partially along its boundaries to two space-time sheets, which can be characterized by different p-adic primes. Particles can flow between space-time sheets and charged particles experience the transversal electric field of ME as an external electric potential forcing the particles to flow in a particular direction (note that all nuclei are complete Z^0 ions). The sizes of the join along boundaries contacts are gigantic as compared to the sizes of wormhole contacts and one expects that the reduction of the phase velocity is dramatic. The quantum mechanism for the reduction is same as in the previous case. EEG phase velocity could be interpreted as a reduced effective phase velocity of Z^0 and em boundary MEs [K62, K65] . One can assign also to boundary MEs dielectric constant allowing to model their interaction with matter.

An open question is whether also negative energy MEs can propagate along boundaries or whether topological considerations related to the notion of time orientations forbid this. For negative energy MEs the propagation along boundaries would predict highly super-luminal effective phase velocities.

3.2.4 Magnetic flux quanta and electrets

Magnetic flux tubes and electrets are extremals of Kähler action dual to each other. Also layer like magnetic flux quanta and their electric counterparts are possible. The magnetic/electric field is in a good approximation of constant magnitude but has varying direction.

Magnetic fields and life

The magnetic field associated with any material system is topologically quantized, and one can speak about magnetic body. An attractive idea is that the relationship of the magnetic body to the material system is to some degree that of the manual to an electronic instrument. Magnetic body would thus allow to realize both sensory and abstract symbolic representations about the material body. Magnetic

body would in this case serve as a kind of computer screen at which the data items processes in say brain are communicated either classically (positive energy MEs) or by sharing of mental images (negative energy MEs).

Magnetic body is also an active intentional agent: motor actions are controlled from magnetic body and proceed as cascade like processes from long to short length and time scales as quantum communications of desires at various levels of hierarchy of magnetic bodies. Communication occurs backwards in geometric time by negative energy MEs. Motor action as a response to these desires occurs by classical communications by positive energy MEs and as neural activities. This explains the coherence and synchrony of motor actions difficult to understand in neuroscience framework. The sizes of flux tubes are astrophysical: for instance, EEG frequency of 7.8 Hz corresponds to a wave length defined by Earth's circumference. The non-locality in the length scale of magnetosphere, and even in length scales up to light life, is forced by Uncertainty Principle alone, if taken seriously in macroscopic length scales. Magnetic

The leakage of supra currents of ions and their Cooper pairs from magnetic flux tubes of the Earth's magnetic field to smaller space-time sheets and their dropping back involving liberation of the zero point kinetic energy defines one particular metabolic "Karma's cycle". The dropping of protons from $k = 137$ atomic space-time sheet involved with the utilization of ATP molecules is only a special instance of the general mechanism involving an entire hierarchy of zero point kinetic energies defining universal metabolic currencies. This leads to the idea that the topologically quantized magnetic field of Earth defines the analog of central nervous system and blood circulation present already during the pre-biotic evolution and making possible primitive metabolism. This has far reaching implications for the understanding of how pre-biotic evolution led to living matter as we understand it [K31] .

For instance, it has recently become clear that the dropping of atoms and molecules from $k = 131$ space-time sheets creates photons at visible and near infrared wave lengths. The hot $k = 131$ space-time sheets (with temperatures above 1000 K) could have served as a source of metabolic energy for life-forms at cool $k = 137$ sheets. Photosynthesis could have developed in the circumstances where solar radiation was replaced with these photons. The correct prediction is that chlorophylls should be especially sensitive to these wave lengths. In particular, it is predicted that also IR wave lengths 700-1000 nm should have been utilized. There indeed are bacteria using only this portion of solar radiation. This leads to a scenario making sense only in TGD universe. Pre-biotic life could have developed at the cool space-time sheets in the hot interior of Earth below crust, where $k = 131$ space-time sheets are possible and this life could still be there [K31] . Also the life as we know it, could involve hot spots generated by the cavitation of water inside cell. The classical repulsive Z^0 force could cause a strong acceleration during final stages of bubble collapse creating high temperatures, and could explain also sono-luminescence [D14] , [D14] as suggested in [K27] .

Magnetic Mother Gaia could also form sensory and other representations receiving input from several brains via negative energy EEG MEs entangling magnetosphere with brains. The multi-brained magnetospheric selves could be responsible for the third person aspect of consciousness and for the evolution of social structures. Some aspects of remote viewing very difficult to understand if remote viewing involves only the target and viewer [J75] , the successful healing by prayer and meditation groups [J24] , and the experiments of Mark Germaine [J59] support the view that multi-brained possibly magnetospheric selves are involved. Magnetic flux tubes could function as wave guides for MEs and this aspect is crucial in the model of long term memory.

Electrets and bio-systems

Bio-systems are known to be full of electrets and liquid crystals [I93] . Perhaps the most fundamental electret structure is cell membrane. In particular, the water inside cells tends to be in gel phase which is liquid crystal phase. There are many good reasons for why water should be in ordered phase. One very fundamental reason is that bio-polymers are stable in liquid crystal/ordered water phase since there are no free water molecules available for the depolymerization by hydration. In fact, only a couple of years ago it was experimentally discovered that bio-polymers can be stabilized around ice.

The capacitor model for sensory receptor is one very important application of the electret concept (see the article "Quantum model of sensory receptor" in [L5] and [K32]). Sensory qualia result in the flow of particles with given quantum numbers from the plate to another one in quantum discharge. This kind of amplification of quantum number *resp.* zero mode increments would give rise to both geometric *resp.* non-geometric qualia [K32] .

Also micro-tubuli are electrets. Sol-gel transition, as any phase transition, is an good candidate for the representation of a conscious bit and controlled local sol-gel transitions between ordinary and liquid crystal water could be a basic control tool making possible cellular locomotion, changes of protein conformations, etc... The tubulin dimers of micro-tubuli could induce sol-gel transformations by generating negative energy MEs, and micro-tubular surface could provide bit maps of their environment somewhat like sensory areas of brain provide maps of body. If gel→sol transition around tubulin inducing conformational change induces sol→gel transformation in some point of environment as would be the case for the seesaw mechanism to be discussed below, a one-one correspondence would result. By this one-one correspondence micro-tubules would automatically generate kind of conscious log files about the control activities which could have evolved to micro-tubular declarative memory representations about what happens inside cell [K38] .

3.3 Some applications of the many-sheeted space-time concept

In this section some applications of the many-sheeted space-time concept are represented in the hope that they might give idea about how the basic concepts and rules can be applied in practice.

3.3.1 A general model for energy storage and energy utilization by remote metabolism

The general model for energy storage and utilization based on remote metabolism is surprisingly simple [K38] .

1. Metabolic energy can be stored as a zero point kinetic energy to various space-time sheets. Typically there are two space-time sheets involve/Users/mattipitkanen/Desktop/tgd/ the larger space-time sheet characterized by p-adic prime k_{gr} defines the ground sate of the many-sheeted laser and the smaller space-tiome sheet characterized by k_{ex} defines the excited state serving as the energy storage. At least the particles at $k = k_{gr}$ space-time sheet form Bose-Einstein condensate. The energy storage involves the kicking of particles to $k = k_{ex}$ space-time sheet and is analogous to a population inversion in laser. Bose-Einstein condensates of electronic Cooper pairs, H atoms, H₂ atoms and protonic Cooper pairs, O and O₂ atoms,... are possible. The dropping of a particle to a larger space-time sheet liberates a standardized energy quantum. Since Bose-Einstein condensate is in question, this process can occur coherently which allows high metabolic power. The power is especially high if both space-time sheets carry Bose-Einstein condensates.
2. Remote metabolism provides and elegant manner to utilize the stored energy. The user must only send negative energy ME at energy sufficiently near to the energy currency. This implies a highly economical use of the metabolic energy. For instance, when an enzyme needs energy, it generates negative energy ME activating ADP to ATP by kicking proton to the atomic $k = 137$ space-time sheet. In this case .5 eV plus possibly an additional energy .34 eV to kick phosphate ion to $k = 131$ space-time sheet is needed [K38] . .
3. "Seesaw" mechanism minimizes the waste of metabolic energy since the same energy can be used repeatedly [K38] . In the simplest situation two users send alternately negative energy MEs to each other so that dissipative losses are minimized. Negative energy MEs and seesaw mechanism are not restricted to transitions involving the dropping of particles between space-time sheets: any transitions will do but it would seem that Bose-Einstein condensates must be in question. For instance, the model applies also to cyclotron transitions.
4. The fact that proton mass is with 6 percent accuracy 2^{11} times the mass of electron implies approximate symmetry. Proton or hydrogen atom at space-time sheets k corresponds to electronic Cooper pair at space-time sheet $k + 10$ as far as zero point kinetic energies are considered so that one has an approximate $(proton, k) \rightarrow (2e, k + 10)$ symmetry. This means that the protonic and electronic energy currencies are consistent with each other. Concerning the construction of the models, this implies certain degree of non-uniqueness.

3.3.2 Capacitor model of sensory qualia

The assumption that sensory qualia are realized at the level of sensory receptors, when combined with the requirement that the average increments are non-vanishing, and perhaps even same from quantum jump to quantum jump and amplified to a quantum phase transition, poses strong constraints on the model of the sensory receptor. The recent version of the model is discussed in [K32, K61]. This model has led to a breakthrough in understanding of seemingly unrelated topics such as the mysterious large parity breaking in living matter, EEG, biophotons, and even biological evolution as it could occur in TGD Universe so that a more detailed discussion is in order.

Basic model

These constraints motivate what might be called the capacitor model of the sensory receptor.

1. There are two reservoirs of quantum charges having total charges of equal magnitude but of opposite sign (quantum charges refer to any quantum numbers, not only electric charge). The net charges are macroscopic in order to guarantee robustness. These reservoirs are analogous to capacitor plates, and only the second one corresponds to the sensory experienced quale unless both the quale and its conjugate are experienced simultaneously. Capacitor plates can carry several charges simultaneously.
2. When the sensory quale is generated, there is a flow of charge quanta between the quantum capacitor plates. The charge quanta are more or less constant. This requirement could be relaxed to the condition that only the average increment is constant.

The notion of capacitor is understood in a rather abstract sense in the recent model.

Cell membrane as quantum capacitor

Cell membrane, or rather the pair formed by cell interior and exterior, and synaptic junction are excellent candidates for quantum capacitors.

1. During nerve pulse various ions flow between cell interior and exterior, which suggests that sub-neuronal sensory qualia are generated in a time scale of millisecond. Also membrane oscillations might give rise to some kind of sensory qualia. In particular, super-conducting Cooper pairs and bosonic ions enter or leave the Bose-Einstein condensates at the magnetic flux tubes and this should give rise to a chemical experience defined by the quantum numbers of the carrier particle. Not only the increment of electric charge but increments of magnetic quantum numbers characterize the qualia in question. Various information molecules transferred through the cell membrane could also give rise to sensory qualia.
2. In the synaptic contact the vesicles containing neurotransmitter are transmitted, and the net quantum numbers for the vesicles should determine the neuronal chemical qualia associated with the process.
3. One realization of the capacitor plates as parallel space-time sheets with different values of p-adic prime. A population reversed many-sheeted laser might perhaps describe what is involved. The generation of population reversal for Bose-Einstein condensed bosons followed by the dropping of the bosons to the larger space-time sheet would correspond to a generation of quale. Quale and its conjugate quale could correspond to generation of population reversal and its decay. Population reversal would also provide a storage of metabolic energy and remote metabolism sending negative energy MEs to the system inducing dropping of bosons to a larger space-time sheet would thus perhaps induce a sensory quale. Photosynthesis and $\text{ADP} \rightarrow \text{ATP}$ transformation would be typical examples about this kind of remote metabolism involving "metabolic" qualia.

Qualia of magnetic body

Qualia might accompany also quantum phase transitions at magnetic flux quanta. A typical example is a coherently occurring cyclotron transition for a macroscopic phase of Cooper pairs of ions of bosonic ions. It would seem that quantum phase transitions at the magnetic flux quanta and particle flows between the quantum electrodes associated with electret type structures could define two basic types of qualia. Note that electret structures are dual to magnetic flux quanta as solutions of field equations. Vision and hearing would be basic examples of these two types of qualia.

Cell membrane as a sensory receptor

The model for cell membrane as sensory receptor [K32, K61, K62, K26] leads to a detailed identification of the qualia assignable to the cell membrane. The ensuing general model of how cell membrane acts as a sensory receptor has unexpected implications for the entire TGD inspired view about biology.

1. The most important implication concerning the model of sensory receptors relates to the vacuum degeneracy of Kähler action. It has been clear from the beginning that the nearly vacuum extremals of Kähler action could play key role in living systems. The reason is their criticality making them ideal systems for sensory perception. These extremals carry classical em and Z^0 fields related to each other by a constant factor and this could explain the large parity breaking effects characterizing living matter. The assumption that cell membranes are nearly vacuum extremals and that nuclei can feed their Z^0 charges to this kind of space-time sheets (not true for atomic electrons) in living matter leads to a modification of the model for the cell membrane as Josephson junction. Also a model of photoreceptors explaining the frequencies of peak sensitivity as ionic Josephson frequencies and allowing the dual identifications Josephson radiation as biophotons (energies) and EEG radiation (frequencies) emerge since the values of Planck constant can be very large. The value of the Weinberg angle in this phase is fixed to $\sin^2(\theta_W) = .0295$, whereas in standard phase the value is given by $\sin^2(\theta_W) = .23$. The significance of this quantitative success for TGD and TGD inspired quantum biology cannot be over-estimated.
2. DNA as topological quantum computer model [K28] plus certain simplifying assumption leads to the conclusion that the spectrum of net quantum numbers of quark antiquark pair define the primary qualia assignable to a nucleotide-lipid pair connected by a magnetic flux tube. The most general prediction is that the net quantum numbers of two quark pairs characterize the qualia. In the latter case the qualia would be assigned to a pair of receptor cells.
3. Composite qualia result when one allows the nucleotide-lipid pairs of the membrane to be characterized by a distribution of quark-antiquark pairs. Cell membrane -or at least the axonal parts of neurons- would define a sensory representation in which a pair of this kind defines a pixel characterized by primary qualia. Cells would be sensory homunculi and DNA defines a sensory hologram of body of or of part of it. Among other things this would give a precise content to the notion of grandma cell.
4. Josephson frequencies of biologically important ions are in one-one correspondence with the qualia and Josephson radiation could re-generate the qualia or map them to different qualia in a one-one and synesthetic manner in the neurons of the sensory pathway. For large values of Planck constant Josephson frequencies are in EEG range so that a direct connection with EEG emerges and Josephson radiation indeed corresponds to both biophotons and EEG. This would realize the notion of sensory pathway which originally seemed to me a highly non-realistic notion and led to the vision that sensory qualia can be realized only at the level of sensory organs in TGD framework.
5. At the level of brain motor action and sensory perception look like reversals of each other. In zero energy ontology motor action can be indeed seen as a time reversed sensory perception so that the model of sensory representations implies also a model for motor action. Magnetic body serves as a sensory canvas where cyclotron transitions induced by Josephson frequencies induce conscious sensory map entangling the points of the magnetic body with brain and body.

Sensation of pitch as a magnetic quale

The model for hearing follows as a special case from the general model for sensory receptor and representations [K61]. In this model the sensation of pitch is identified as a quale assignable to magnetic body rather than cell membrane.

1. Concerning hearing, the basic questions relate to the precise identification of the hearing quale, to the representation of pitch of the sound at the magnetic body, and to the representation of various geometric data about sound. The electromagnetic charge of the quark pair (or equivalently electroweak isospin) looks like an excellent candidate in this respect so that charge increment would define one fundamental hearing quale.

This quale need not correspond to pitch. The vision about hearing as a frequency quale suggests that cyclotron transition frequency corresponds to the pitch. Sound frequency would be coded to an increment of cyclotron frequency and pitch would be a quale assignable to magnetic body rather than biological body. Hearing would in a well-defined sense represent a higher level sensory modality not understandable without the notion of magnetic body. The strength of the magnetic field would code for cyclotron frequency and therefore for the pitch. One of the mysteries related to hearing is the ability to hear frequencies much higher than the maximum rate of nerve pulses which is below kHz. The coding by Josephson frequencies and representation of them as quale of the magnetic body resolves this mystery.

2. At the quantitative level the first challenge is to understand the typical hearing ranges (humans, mice, bats, sea mammals) and here the time scales of CDs associated with quarks and leptons give intriguing hints. Also their cyclotron frequencies are involved and large values of Planck constant are unavoidable. Josephson frequencies are given by the effective membrane potential (Z^0 potential must be included) divided by Planck constant and it is possible to represent arbitrarily low frequencies in terms of membrane potential by allowing Planck constant to have high enough values.
3. The extreme rapidity of signalling from hair cells to brain is one of the mysteries of hearing and here Josephson radiation (biophotons) provides a direct neuronal window with practically instantaneous communication. Microtubules could be associated with the flux tubes along which Josephson radiation propagates and also microtubular conformational waves could be involved.
4. Hearing represent in many respects an exceptional quale: consider only music experience, language, internal speech, the understanding and production of speech, and right brain sings- left brain talks metaphor. This conforms with the assumption that magnetic body is involved in essential manner with hearing. Zero energy ontology leads to a vision explaining basic aspects of music experience and the notion of memetic code plus possible realization of genetic code as temporal patterns could provide first principle understanding of language.

The role of exotic variants weak gauge bosons in biology

This basic framework basically inspired by the model of sensory receptor leads to a further developments about the role of EEG [K26]. In key role is the hypothesis that Mersenne primes and Gaussian Mersennes (the number theoretical miracle is that there are four of them in the length scale range between cell membrane thickness and size of nucleus!) correspond to length scales allowing exotic variants of weak bosons and their dark variants. This not only leads to general model for EEG and its generalization but also to a detailed quantitative vision about evolution in TGD Universe. The vision means that weak gauge bosons and gluons play a key role in biology in macroscopic length and time scales.

Charge entanglement induce by classical means and non-local charges transfer by the exchange of W boson would induce non-local capacitor discharges which can be regarded also as exchanges of virtual W bosons inducing exotic ionization leading to dark plasma oscillation patterns inducing various kinds of physiological activity such as Ca^{2+} waves. .1 seconds could be seen as a period of recurring plasma oscillations as also the time scale assignale to the causal diamond of electron.

Sensory perceptions and motor actions could result in capacitor discharges induced by entanglement by W MEs and color charged gluonic MEs. Even sensory organs would cognize and feel to

some extent. The temporal coherence of cognitive and emotional would be spoiled by nerve pulses. Sensory receptors do not fire so that this is not a problem. At the level of cortex however glial cells would remain viable candidates for carrying higher level sensory, cognitive, and emotional qualia. Neural activity would be responsible for the carving of the sensory percepts: sensory back projections to sensory organs would be in crucial role in this process. This picture is discussed in detail in [K32, K61, K62, K26] .

3.3.3 Support for the notion of remote metabolism

The list of applications of negative energy MEs is now quite long. Below some examples providing support for the notion of remote metabolism are discussed.

Remote metabolism, photosynthesis, and ionic pumps

Photosynthesis is a fundamental metabolic function and a many-sheeted model allows to concretize the general ideas about quantum metabolism. What happens in photosynthesis at the level of energy balance seems to be relatively well-understood [I100, I35] but the detailed molecular mechanisms remain obscure. Several strange features, such as the appearance of electron pairs, suggest that super-conductivity and atomic and molecular Bose-Einstein condensates are involved.

p-Adic length scale hypothesis gives stringent quantitative guidelines in the attempt to understand photosynthesis in many-sheeted space-time, and one ends up to a general view about how Bose-Einstein condensates store metabolic energy as zero point kinetic energy and how this energy is utilized by remote metabolism by generating negative energy MEs sent to population inverted many-sheeted lasers. Electronic Cooper pairs kicked to $k_{ex} = 155$ space-time sheet from $k_{gr} = 149$ lipid layer of cell membrane space-time sheets are involved with the photo-system II. Electrons kicked to $k_{ex} = 157$ space-time sheet from $k_{gr} = 151$ cell membrane space-time sheets are involved with photo-system I. The resulting simple model of photosynthesis is successful both at qualitative and quantitative level. In particular, the energy 1 eV/electron for the excitations of the reaction center is predicted correctly from p-adic length scale hypothesis. The model also explains why the electrons from photo-system II producing oxygen from water and generating ATP molecules end up to the photo-system I [K38] .

TGD provides also a new view about ionic pumps and channels whose behavior is found to be in a dramatic conflict with what one expects [I112] . At theoretical level the idea that every possible biologically interesting ion needs a separate pump leads to absurd conclusions. Furthermore, it is found that the ionic flows continue even under metabolic deprivation. Finally, the ionic currents seem to be quantal and universal (same for cell membrane and an artificial membrane!) which is not consistent with the idea of ionic channels.

In TGD framework ionic pumps and channels would be actually sensors which measure chemical concentration gradients and voltages [K38] . The dominating part of the ionic currents would flow along cell membrane space-time sheets (perhaps as dark ion currents) and dissipate minimally. Most of the metabolic energy would be used to build up the hierarchy of EEGs making possible communications to the magnetic bodies and to provide energy for negative energy W MEs responsible for the generation of generalized motor actions of magnetic body at biological body.

The model for how brain constructs sensory, cognitive, and emotional representations leads to the view that non-firing astrocytes are responsible for higher level cognitive and emotional representations at magnetic bodies. Glial cells would not serve as energy reservoirs but be the main users of the metabolic energy and neurons would be specialized to communications and processing of information [K65] .

Memory feats of synesthetes

Synesthesia involve also exceptional episodal memory feats with simultaneous lowering of metabolic rate in left brain with as much as 18 per cent [J37] (for TGD inspired model of synesthesia see [K64]). This should be lethal according to the standard wisdom. The simplest explanation is that the starving neurons in the left cortex generate negative energy MEs which entangle left brain with the geometric past. This allows left cortex to get energy from the brain of the geometric past and as a by-product induces episodal memories.

The explanation of various findings of Libet about the time delays of sensory consciousness discussed in the article "Time, space-time, and consciousness" in [L5] suggests a more complex model. Starving neurons draw energy from sensory organs so that the magnetic body, usually drawing energy from the sensory organs, is forced to draw energy from the geometric past. Thus sensory experience with an input coming from the geometric past results, and could give rise to episodal long term memories. This model applies also to the experiences generated by an artificial electric or magnetic stimulation of neurons. Also the life review of NDE experiences could be a by-product of neuronal starvation. Philosophizing a little bit, one might perhaps see the purpose of suffering as generating bound state entanglement and thus making possible the macroscopic and macro-temporal quantum coherence.

Insect-plant communications

Callahan has made very important discoveries related to the olfaction of insects and insect-plant interaction. Callahan's work [I57, I42] demonstrates that the insect olfaction is based on infrared light generated by the odorant molecules interacting with the antennae of the insects. Also the olfaction of higher organisms could rely on IR light generated by odorant molecules. Callahan has also shown plants communicate with insects utilizing infrared light [I42]. This conforms with the findings of Albrecht-Buehler [I47] showing that all cells contain micro-tubular structures acting as receiving antennae for infrared light. Furthermore, plants suffering from de-nutrition are found more easily by insects than healthy plants.

These findings encourage to consider the following mechanism for insect-plant communications. This mechanism could apply also to the plant-human interactions [K35].

1. Insects generate infrared MEs propagating like massless particles inside low frequency negative energy MEs acting as bridges quantum entangling the plant and the insect. Both classical communications by positive energy IR MEs and quantum communications by negative energy IR MEs are in principle possible.
2. In the case that plant suffers from de-nutrition, it can gain metabolic energy by sending negative energy MEs received by insect. This gives for plant metabolic energy and at the same time generates the quantum entanglement bridge making it possible for the insect to find the plant.

Dogs and their masters

Dogs are also claimed to be able to anticipate that their masters are arriving home. Some dogs are able to anticipate the epileptic attacks of their master. The highly developed sense of smell of dogs is usually represented as an explanation of this ability. This might be a correct conclusion but in different sense as usually believed. If IR MEs represent a crucial element of olfaction, one can consider the possibility that dog precognizes its master's epileptic attack by receiving the negative energy MEs generated by the starving neurons in the master's brain in the geometric future. This explanation requires that epileptic attacks occur in the master's brain also in the geometric future where intentions are not yet realized. Similar mechanism might be involved with the ability to anticipate the arrival of the master to home. It is possible to test this hypothesis: are dogs more able to precognize the activities of their master if master is tired or sick.

The proposed model is also consistent with the hypothesis that olfaction corresponds to a "skin sense" in the sense that the back projection from brain is based on classical communications and sensory organs entangle with external world. The hypothesis is motivated by the observations about the development of embryo [K32] and is discussed in the article "Quantum model of sensory receptor" in [L5].

3.4 Time and intentionality

The highly non-trivial question is how psychological time emerges in TGD framework, where moments of consciousness correspond to quantum jump between quantum histories (histories in the sense that configuration space spinor fields have space-time surfaces as classical correlates). I have proposed several mechanisms to achieve this. For all options the time-asymmetry of the future light cone is the fundamental inducer of the arrow of psychological time.

1. The contents of conscious experience come from finite-sized space-time sheet and since there is more room in the geometric future than in past of lightcone, the average locus of space-time sheet must drift to the geometric future during quantum jump sequence.
2. Space-time sheets having finite geometro-temporal duration drift to the direction of the geometric future. The direction of drifting is forced by the breaking of time reflection symmetry implied by the geometry of the future light cone. This option will not be discussed in this article.
3. Psychological time defines the front of p-adic-to-real phase transition transformation intentions to actions. This option seems to be more plausible. It does not however exclude the possibility that also mind like space-time sheets indeed drift to the direction of geometric future.
4. The latest proposal relies on recent formulation of quantum TGD in terms of zero energy ontology and the identification of the space-time correlate of self as the causal diamond defined by a pair of future and past directed lightcones, which is a subspace of imbedding space rather than space-time sheet. Configuration space spinor field represents a quantum superposition of space-time surfaces. Assume that the attention of self is directed to a fixed volume of the 8-D imbedding space. Quantum classical correspondence requires that this quantum superposition in the first approximation shifts towards geometric past of the imbedding space so that self experiences effective flow of the geometric time associated with the space-time surface. This explanation works only if macroscopic quantum coherence holds true so that one cannot regard the space-time surface as a fixed arena of dynamics. Also the representability of the space-time surfaces as sub-manifolds of 8-D imbedding space is essential. The identification of the fundamental volume of attention as a causal diamond inspired by zero energy ontology based formulation of quantum TGD provides answers to more detailed questions.

There are also other questions about time and intentionality.

1. How consensus time emerges and is there a universal time in some sense?
2. Are there also doers besides the deeds? That is: are there also causal agents and how they could be defined;
3. Can one distinguish between quantum randomness and the non-determinism of intentionality? Is it possible to measure whether the system is intentional?

3.4.1 The notions of psychological time and self in zero energy ontology

Zero energy ontology provides an explanation for the arrow of psychological time - which I have considered earlier but only half-seriously - looks to me the most elegant at this moment. The explanation also unifies the original notion of self based on the identification of self as a sequence of quantum jumps the notion of reducing self hierarchy to a fractal hierarchy of quantum jumps within quantum jumps. This option is also favored by Occam's razor since it uses only the assumption that space-time sheets are replaced by more evolved ones in each quantum jump. Also the model of DNA as topological quantum computer favors it [K28].

How the arrow of psychological time emerges in zero energy ontology?

1. In standard picture the attention would gradually shift towards geometric future and space-time in 4-D sense would remain fixed. Now however the fact that quantum state is quantum superposition of space-time surfaces allows to assume that the attention of the conscious observer is directed to a fixed volume of 8-D imbedding space. Quantum classical correspondence is achieved if the evolution in a reasonable approximation means shifting of the space-time sheets and corresponding field patterns backwards backwards in geometric time by some amount per quantum jump so that the perceiver finds the geometric future in 4-D sense to enter to the perceptive field. This makes sense since the shift with respect to M^4 time coordinate is an exact symmetry of extremals of Kähler action. It is also an excellent approximate symmetry for the preferred extremals of Kähler action and thus for maxima of Kähler function spoiled only by the presence of light-cone boundaries. This shift occurs for both the space-time sheet that perceiver

identifies itself and perceived space-time sheet representing external world both perceiver and percept change.

2. Both the landscape and observer space-time sheet remain in the same position in imbedding space but both are modified by this shift in each quantum jump. The perceiver experiences this as a motion in 4-D landscape. Perceiver (Mohammed) would not drift to the geometric future (the mountain) but geometric future (the mountain) would effectively come to the perceiver (Mohammed)!
3. There is an obvious analogy with Turing machine: what is however new is that the tape effectively comes from the geometric future and Turing machine can modify the entire incoming tape by intentional action. This analogy might be more than accidental and could provide a model for quantum Turing machine operating in TGD Universe. This Turing machine would be able to change its own program as a whole by using the outcomes of the computation already performed.
4. The concentration of the sensory input and the effects of conscious motor action to a narrow interval of time (.1 seconds typically, secondary p-adic time scale associated with the largest Mersenne M_{127} defining p-adic length scale which is not completely super-astronomical) can be understood as a concentration of sensory/motor attention to an interval with this duration: the space-time sheet representing sensory "me" would have this temporal length and "me" definitely corresponds to a zero energy state.
5. The fractal view about topological quantum computation strongly suggests an ensemble of almost copies of sensory "me" scattered along my entire life cycle and each of them experiencing my life as a separate almost copy.
6. The model of geometric and subjective memories would not be modified in an essential manner: memories would result when "me" is connected with my almost copy in the geometric past by braid strands or massless extremals (MEs) or their combinations (ME parallel to magnetic flux tube is the analog of Alfven wave in TGD).

This argument leaves many questions open. What is the precise definition for the volume of attention? Is the attention of self doomed to be directed to a fixed volume or can quantum jumps change the volume of attention? What distinguishes between geometric future and past as far as contents of conscious experience are considered? How this picture relates to p-adic and dark matter hierarchies? Does this framework allow to formulate more precisely the notion of self? Zero energy ontology allows to give tentative answers to these questions.

Can one choose between the two variants for the notion of self or are they equivalent?

I have considered two different notions of "self" and it is interesting to see whether the new view about time might allow to choose between them or to show that they are actually equivalent.

1. In the original variant of the theory "self" corresponds to a sequence of quantum jumps. "Self" would result through a binding of quantum jumps to single "string" in close analogy and actually in a concrete correspondence with the formation of bound states. Each quantum jump has a fractal structure: unitary process is followed by a sequence of state function reductions and preparations proceeding from long to short scales. Selves can have sub-selves and one has self hierarchy. The questionable assumption is that self remains conscious only as long as it is able to avoid entanglement with environment.

Even slightest entanglement would destroy self unless one introduces the notion of finite measurement resolution applying also to entanglement. This notion is indeed central for entire quantum TGD also leads to the notion of sharing of mental images: selves unentangled in the given measurement resolution can experience shared mental images resulting as fusion of sub-selves by entanglement not visible in the resolution used.

2. According to the newer variant of theory, quantum jump has a fractal structure so that there are quantum jumps within quantum jumps: this hierarchy of quantum jumps within quantum jumps would correspond to the hierarchy of dark matters labeled by the values of Planck constant.

Each fractal structure of this kind would have highest level (largest Planck constant) and this level would correspond to the self. What might be called irreducible self would correspond to a quantum jump without any sub-quantum jumps (no mental images). The quantum jump sequence for lower levels of dark matter hierarchy would create the experience of flow of subjective time.

It would be nice to reduce the original notion of self hierarchy to the hierarchy defined by quantum jumps. There are some objections against this idea. One can argue that fractality is a purely geometric notion and since subjective experience does not reduce to the geometry it might be that the notion of fractal quantum jump does not make sense. It is also not quite clear whether the reasonable looking idea about the role of entanglement as destroyer of self can be kept in the fractal picture.

These objections fail if one can construct a well-defined mathematical scheme allowing to understand what fractality of quantum jump at the level of space-time correlates means and showing that the two views about self are equivalent. The following argument represents such a proposal. Let us start from the causal diamond model as a lowest approximation for a model of zero energy states and for the space-time region defining the contents of sensory experience.

Let us make the following assumptions.

1. Assume the hierarchy of causal diamonds within causal diamonds in a sense to be specified more precisely below. Causal diamonds would represent the volumes of attention. Assume that the highest level in this hierarchy defines the quantum jump containing sequences of lower level quantum jumps in some sense to be specified. Assume that these quantum jumps integrate to single continuous stream of consciousness as long as the sub...-sub-self in question remains unentangled and that entangling means loss of consciousness or at least that it is not possible to remember anything about contents of consciousness during entangled state.
2. Assume that the contents of conscious experience come from the interior of the causal diamond. A stronger condition would be that the contents come from the boundaries of the two light-cones involved since physical states are defined at these in the simplest picture. In this case one could identify the lower light-cone boundary as giving rise to memory.
3. The time span characterizing the contents of conscious experience associated with a given quantum jump would correspond to the temporal distance T between the tips of the causal diamond. T would also characterize the average and approximate shift of the superposition of space-time surfaces backwards in geometric time in single quantum jump at a given level of hierarchy. This time scale naturally scales as $T_n = 2^n T_{CP_2}$ so that p-adic length scale hypothesis follows as a consequence. T would be essentially the secondary p-adic time scale $T_{2,p} = \sqrt{p} T_p$ for $p \simeq 2^k$. This assumption - absolutely essential for the hierarchy of quantum jumps within quantum jumps - would differentiate the model from the model in which T corresponds to either CP_2 time scale or p-adic time scale T_p . One would have hierarchy of quantum jumps with increasingly longer time span for memory and with increasing duration of geometric chronon at the highest level of fractal quantum jump. Without additional restrictions, the quantum jump at n^{th} level would contain 2^n quantum jumps at the lowest level of hierarchy. Note that in the case of sub-self - and without further assumptions which will be discussed next - one would have just two quantum jumps: mental image appears, disappears or exists all the time. At the level of sub-sub-selves 4 quantum jumps and so on. Maybe this kind of simple predictions might be testable.
4. We know that that the contents of sensory experience comes from a rather narrow time interval of duration about .1 seconds, which corresponds to the time scale T_{127} associated with electron. We also know that there is asymmetry between positive and negative energy parts of zero energy states both physically and at the level of conscious experience. This asymmetry must have some space-time correlate. The simplest correlate for the asymmetry between positive and negative energy states would be that the upper light-like boundaries in the structure formed by light-cones within light-cones intersect along light-like radial geodesic. No condition of this kind would be posed on lower light-cone boundaries. The scaling invariance of this condition makes it attractive mathematically and would mean that arbitrarily long time scales T_n can be present in the fractal hierarchy of light cones. At all levels of the hierarchy all contribution from upper boundary of the causal diamond to the conscious experience would come from boundary of same

past directed light-cone so that the conscious experience would be sharply localized in time in the manner as we know it to be. The new element would be that content of conscious experience would come from arbitrarily large region of Universe and seeing Milky Way would mean direct sensory contact with it.

5. These assumptions relate the hierarchy of quantum jumps to p-adic hierarchy. One can also include also dark matter hierarchy into the picture. For dark matter hierarchy the time scale hierarchy $\{T_n\}$ is scaled by the factor $r = \hbar/\hbar_0$ which can be also rational number. For $r = 2^k$ the hierarchy of causal diamonds generalizes without difficulty and there is a kind of resonance involved which might relate to the fact that the model of EEG favors the values of $k = 11n$, where $k = 11$ also corresponds in good approximation to proton-electron mass ratio. For more general values of \hbar/\hbar_0 the generalization is possible assuming that the position of the upper tip of causal diamond is chosen in such a manner that their positions are always the same whereas the position of the lower light-cone boundary would correspond to $\{rT_n\}$ for given value of Planck constant. Geometrically this picture generalizes the original idea about fractal hierarchy of quantum jumps so that it contains both p-adic hierarchy and hierarchy of Planck constants.

The contributions from lower the boundaries identifiable in terms of memories would correspond to different time scales and for a given value of time scale T the net contribution to conscious experience would be much weaker than the sensory input in general. The asymmetry between geometric now and geometric past would be present for all contributions to conscious experience, not only sensory ones. What is nice that the contents of conscious experience would rather literally come from the boundary of the past directed light-cone along which the classical signals arrive. Hence the mystic feeling about telepathic connection with a distant object at distance of billions of light years expressed by an astrophysicist, whose name I have unfortunately forgotten, would not be romantic self deception.

This framework explains also the sharp distinction between geometric future and past (not surprisingly since energy and time are dual): this distinction has also been a long standing problem of TGD inspired theory of consciousness. Precognition is not possible unless one assumes that communications and sharing of mental images between selves inside disjoint causal diamonds is possible. Physically there seems to be no good reason to exclude the interaction between zero energy states associated with disjoint causal diamonds.

The mathematical formulation of this intuition is however a non-trivial challenge and can be used to articulate more precisely the views about what configuration space and configurations space spinor fields actually are mathematically.

1. Suppose that the causal diamonds with tips at different points of $H = M^4 \times CP_2$ and characterized by distance between tips T define sectors CH_i of the full configuration space CH ("world of classical worlds"). Precognition would represent an interaction between zero energy states associated with different sectors CH_i in this scheme and tensor factor description is required.
2. Inside given sector CH_i it is not possible to speak about second quantization since every quantum state correspond to a single mode of a classical spinor field defined in that sector.
3. The question is thus whether the Clifford algebras and zero energy states associated with different sectors CH_i combine to form a tensor product so that these zero energy states can interact. Tensor product is required by the vision about zero energy insertions assignable to CH_i which correspond to causal diamonds inside causal diamonds. Also the assumption that zero energy states form an ensemble in 4-D sense - crucial for the deduction of scattering rates from M -matrix - requires tensor product.
4. The argument unifying the two definitions of self requires that the tensor product is restricted when CH_i correspond to causal diamonds inside each other. The tensor factors in shorter time scales are restricted to the causal diamonds hanging from a light-like radial ray at the upper end of the common past directed light-cone. If the causal diamonds are disjoint there is no obvious restriction to be posed, and this would mean the possibility of also precognition and sharing of mental images.

This scenario allows also to answers the questions related to a more precise definition of volume of attention. Causal diamond - or rather - the associated light-like boundaries containing positive and

negative energy states define the primitive volume of attention. The obvious question whether the attention of a given self is doomed to be fixed to a fixed volume can be also answered. This is not the case. Selves can delocalize in the sense that there is a wave function associated with the position of the causal diamond and quantum jumps changing this position are possible. Also many-particle states assignable to a union of several causal diamonds are possible. Note that the identification of magnetic flux tubes as space-time correlates of directed attention in TGD inspired quantum biology makes sense if these flux tubes connect different causal diamonds. The directedness of attention in this sense should be also understood it could be induced from the ordering of p-adic primes and Planck constant: directed attention would be always from longer to shorter scale.

3.4.2 Psychological time and intentionality

In materialism's world one might have experience of free will but non-determinism would be replaced with non-computability or something akin to that. In theories of quantum consciousness based on standard QM one has only state function collapse and it is difficult to understand where the intentionality comes from and how quantum non-determinism differs from randomness. In TGD framework one has both the experience of free will and genuine non-determinism. p-Adicity and the new view about space-time allow precisely targeted intentionality, and one can characterize the long range temporal correlations and the failure of the statistics based on real topology as signatures of intentionality.

The basic vision would be that volitional act is realized as a phase transition of a p-adic space-time sheet to a real space-time sheet. These phase transitions are 4-dimensional and induced in quantum jumps. The natural guess was that the propagation of phase transition front to the direction of future could give rise to the flow of the psychological time.

This is a rather nice looking idea but it turns out that the recent form of quantum TGD (I am writing this June 2008) leads to a much simpler view about flow and arrow of psychological time and also explains sharp asymmetry between geometric future and past and why sensory experience is about so narrow time interval.

What causality means in TGD framework?

In order to minimize confusion it is in order to clarify the various meanings that one can give to causality in TGD framework.

1. At the level of space-time surfaces the absolute minimization of Kähler action defines dynamics of the space-time surfaces and defines the causality of passive events at classical level. Induced spinors (spinors of the 8-D imbedding space restricted to the space-time surface) obey the super-symmetric variant of field equations for the space-time surface and single particle Schrödinger equation can be identified as the non-relativistic limit for the dynamics of the induced spinor fields. The finite size of the space-time sheet defines naturally the notions of coherence length and time for both classical fields and spinor fields. In both cases classical determinism is broken in its naive form. For p-adic space-time sheets p-adic variants of field equations hold true and have the inherent p-adic non-determinism.
2. At configuration space level general coordinate invariance together with huge super-conformal invariance related symmetries can be said to dictate the behavior configuration space spinor fields playing a role analogous to quantum states of quantum field theories. If the naive classical determinism of Kähler were not broken, the physics would reduce to the boundary of the future light cone, the moment of big bang and time would be lost as in the canonical quantization of General Relativity. Fortunately this does not happen.
3. Quantum jumps can be said to realize the causality with respect to the subjective time, the causality of deeds. Selves can be seen as self-organization patterns acting as causal agents. At this level system's behavior is based on rules analogous to those governing the behavior of statistical cellular automata and are a result of self-organization. The laws are not absolute but analogous to traffic rules obeyed or possibly disobeyed by intentional agents.

A further question concerns causal agents: everyday thinking suggests that deeds indeed have doers. In quantum consciousness theories based on standard quantum measurement theory doers are

"observers" somewhere outside. In TGD causal agents are rather abstract: ensembles of quantum jumps deciding to some degree what kind of quantum jump they want to add to the ensemble defining them.

Materialization of intentions

Em fields, in particular ELF em fields, are crucial for the TGD inspired model of brain and a natural assumption is that p-adic-real phase transitions occur also for massless extremals (MEs).

A concrete picture about the materialization of intentions emerges, when one asks how a precisely targeted intention could be realized at the atomic or molecular level. The basic point is that molecules can only intend to make simple quantum transitions.

1. If the transition occurs to a lower energy state it can occur spontaneously whereas the transitions to a higher energy states cannot. Spontaneous transitions mask the possibly occurring intended transitions so that only the transitions which cannot occur spontaneously allow precisely targeted intention.
2. What would happen is that first a p-adic ME representing the intention to perform the transition is generated. Then the transition occurs and conservation laws require that the p-adic ME is transformed to a negative energy ME in the transition. Physical intuition suggests that the p-adic ME and the corresponding real ME resemble each other maximally in the sense that they go through the same rational imbedding space points in some p-adic resolution and with respect to the p-adic topology which is effective topology. In the case of the real ME.
3. Quite generally, it seems that intention can be realized in a precisely targeted manner only for the transitions which cannot occur spontaneously, and thus involve the emission of negative energy MEs.
4. The generation of negative energy MEs utilizes the buy now-let others pay mechanism of metabolism, which implies extreme flexibility. Of course, there must exist an unselfish self, which is able to pay and this puts severe constraints on the mechanism.

Psychological time as a front of volition identified as p-adic-to-real phase transition?

A possible resolution of the problems related to the preferred role of single moment of time for conscious experience could be based on the idea that biological growth and self-organization is a phase transition front proceeding in the direction of the geometric future quantum jump by quantum jump. And, in particular, that the dominating contribution to the conscious experience comes from the front of the phase transition where the volition is realized. The phase transition in question would be nothing but transformation of intentions to action and thus p-adic-to-real phase transition proceeding quantum jump by quantum jump towards geometric future.

This proposal forces to make ad hoc assumptions in order to avoid paradoxical conclusions and at this moment I cannot take it seriously although it is clear that intentional actions are certainly associated with the brief interval of geometric time about which also sensory experience is about. Despite this I will discuss this option.

It seems that our geometric past is relatively stable and that quantum transitions affecting geometric future in long time scales occur rarely. If this were not the case, miraculous events would occur. Physicist would transform in single quantum jump to a musician when the young student in the geometric past of subjective now would change his future plans. There are however anecdotal reports about miraculous healings in which the entire physical appearance of the person suddenly changes so that one must be cautious here. Certainly our long term memories, which in TGD framework are interpreted as mental images of the geometric past shared by quantum entanglement with geometric now, are unstable. This means that the geometric past is probably unstable in sufficiently short length and time scales. Hence it seems reasonable to assume that geometric past does not involve intentional action in length/time scales much longer than neuronal length/time scale responsible for mental images.

One of course ask what is the time scale in which geometric past p-adicizes in long time scales and our four-dimensional body can be lived again. It is quite conceivable that there is this kind of refractory period. Certainly this period must be longer than the time scale in which the intentions

affect the geometric future. One fascinating question is what in the geometric future is p-adic: are only MEs p-adic?; are p-adic magnetic flux tubes there?; could the developing organism have a rough p-adic body plan; could cognitive mental images be represented in terms of p-adic neutrino-antineutrino pairs? Be as it may, the conservation of energy and various other quantum numbers forces to conclude that the material world exists also in the geometric future and the question is how wide is the range of intentional action. A good guess is that intentional action selects between the almost degenerate absolute minima of Kähler action implied by the spin glass degeneracy and thus having same induced Kähler field.

A natural guess for the average increment of the geometric time in quantum jump is as CP_2 time so that there would be about 10^{39} quantum jumps per second. This assumption is motivated by the quantum jump as the elementary particle of consciousness metaphor and by the fact that CP_2 time represents naturally a fundamental unit of time. If the rate of increase for psychological time could be different for selves able to communicate and observe each other, rather counter intuitive conclusions would follow.

Note that macro-temporal quantum coherence effectively increases the duration of the quantum jump to the duration of the bound state responsible for the coherence. During these experiences ordinary categories of time and space do not apply. These experiences can be also interpreted as experiences about what it is to be in quantum superposition. Sensory qualia like colors seem to correspond to this kind of mental images having no reduction to the level of classical space-time dynamics.

How consensus geometric time emerges for p-adic option?

The assumption that the dominating contributions to the contents of our everyday consciousness correspond to roughly same value of time seems to be an intuitively obvious fact. In TGD framework this assumption translates to the hypothesis that there is collective higher level self having us as sub-selves and that there is a phase transition front in which intentions represented by p-adic space-time sheets transform to real space-time sheets representing actions.

To get convinced that this assumption is necessary, one can imagine a situation in which the intention-to-action phase transition occurs at different values of geometric time so that Bob would be transforming his intentions to actions in the geometric future of Alice or vice versa. If Bob would live in the geometric future of Alice, Alice would see Bob's geometric past. Bob would behave like an almost robot like entity without expressing intentions and free will. If Bob would live in the geometric past of Alice, then Alice would experience Bob's behavior as utterly unpredictable.

The presence of collective levels of consciousness in astrophysical length scale is thus necessary for a consensus time. This requires macro-temporal quantum coherence in astrophysical length scales made possible by the spin glass degeneracy of TGD universe. Bound state formation in astrophysical length scales is crucial for this coherence and gravitational interaction becomes a key player here although TGD suggests strongly that also classical Z^0 forces are important: in fact, classical em and Z^0 fields are unavoidably accompanied by gravitational fields. For instance, negative energy MEs inducing time like entanglement carry both classical gravitational and em/ Z^0 fields so that it is a matter of taste whether one speaks about gravitational/em or Z^0 MEs.

It is interesting to notice that there is a close connection with the basic difficulty of quantum field theories. In QFT framework it has not been really possible to appropriately describe bound states. Even the model of hydrogen atom based on Bethe-Salpeter equation has dramatic failures whereas non-relativistic models work very satisfactorily [A6]. The basic difference between relativistic and non-relativistic treatments is that non-relativistic treatment assumes common time for particles forming the bound state. In Poincare invariant quantum field theory this kind of assumption cannot be made so that each particle has its own time. In TGD framework particles are 3-surfaces and bound states of them involve the generation of join along boundaries bonds so that the common time emerges automatically. This does not break Poincare invariance since it is realized in the 8-dimensional imbedding space rather than at space-time surfaces.

The subjective and geometric times are universal in a well-defined sense whereas the correspondence between subjective and geometric time depends on which corner of 4-dimensional space-time surface the self lives. Subjective time is universal by definition since quantum jumps are performed by the entire universe. Macro-temporal quantum coherence leads to the integration of a large number of quantum jumps to single effective quantum jump, whose duration serves as a unit of subjective time.

p-Adic time scales are highly suggestive as universal chronons. There is an infinite number of manners of selecting a geometric time coordinate for space-time surface but under rather general conditions one can use the light cone proper time defining cosmic time as a unique universal geometric time coordinate. In general relativity this kind of universal time does not exist.

3.4.3 Why p-adic intentionality does not reduce to quantum randomness?

The basic argument against quantal free will is that quantum non-determinism is basically randomness of a particular kind so that one can apply statistical determinism to predict the behavior for an ensemble of systems. The crucial question is whether also p-adic intentionality reduces to randomness so that statistical determinism applies. One can imagine two mutually consistent approaches to the problem.

1. The notion of randomness is based on the notion of probability, and it could happen that the notion of probability simply does not make sense at all for a system exhibiting an intentional behavior or that the probabilities do not exist in the real sense but only as p-adic probabilities. Thus abnormal statistics might serve as a signature of an intentional system.
2. Intentionality involves free will and unpredictability in short time scales but predictability in long time scales. This could serve as a signature of an intentional system. Quantum-classical correspondence states that the dynamics of space-time surface mimics quantum dynamics and therefore also the dynamics of consciousness and intentionality. If so the behavioral patterns of an intentional system characterized by p-adic prime p should obey p-adic topology, which is a strong and testable prediction.

p-Adic topology for time series as a signature of intentionality

Intentional behavior means that there is unpredictability in short time scales but predictability in long time scales because system can realize its long term plans and use its partially free will to cope with the changing challenges of the everyday life.

p-Adic topology could realize this idea.

1. The rational values of real and p-adic imbedding space coordinates correspond to the same points of the generalized imbedding space (essentially union of real and p-adic imbedding spaces for various values of p with common rational points identified).
2. The points, which are p-adically close to each other can have arbitrarily long real distance since the points x and $x + kp^n$, $k \in \{0, p-1\}$, become arbitrarily near to each other p-adically and arbitrarily far way in real sense as n increases for the p-adic topology characterized by prime p .

Thus p-adic long range fractal correlations could simply result from p-adic continuity. The local unpredictability would be mimicked by a discontinuous behavior in the real topology resulting from the fact that time values close to each other in the real sense are far from each other in p-adic sense.

p-Adic non-determinism means that integration constants of p-adic differential equations having by definition vanishing derivatives, are functions of the pinary cutoffs x_N defined as $x = \sum_k x_k p^k \rightarrow x_N = \sum_{k < N} x_k p^k$ of the arguments of the function. Since the rational values of real and p-adic coordinates correspond to same points of imbedding space, this means that p-adic non-determinism realizes intentionality by fixing the solution of field equations at a finite number of points below some real time (length) scale defined by N . The choice of these pseudo constants would characterize p-adic intentionality, the future plan of the system relatively stable against quantum jumps and the range of intentional action would be finite, which could explain why the young person in the geometry youth now cannot make choices affecting dramatically the geometric now decades later.

There is an analogous non-determinism also in the real sector due to the dramatic failure of the complete non-determinism of the basic action principle determining the dynamics of space-time surfaces. This non-determinism makes it possible to transform intentions to actions by p-adic-to-real transitions occurring in quantum jumps. It also justifies the characterization of the real space-time sheets by a p-adic primes.

Consider now a situation in which some observables of might -be intentional system are measured as a function of time. Suppose that measurements are carried out at moments $t_n = n\Delta T$, $\Delta T = T/N_m$, where T is the duration of the experiment and N_m is the number of measurements.

1. With respect to the real topology the behavior of the system would look random in short time scales with violent discontinuities independently how precise the time resolution is made: fluctuations would actually become more violent with the improving time resolution.
2. p-Adic fractality would predict long range correlations over arbitrarily long time scales p^n in this kind of situation. Time values t and $t+rp^k \Delta T$ would be near to each other p-adically so that the values of the observables measured at these time values would be near to each other. Long range temporal correlations would thus quantify the ideas that will is not completely free and that intentionality implies an approximate predictability in long time scales. The fact that p-adic pseudo constants allow intentional free will only below some time and length scales, justifies the idea that our life is in long time scales determined by what might be called fate although we can make freely decisions in short time scales. The stability of the p-adic pseudo constants and binary cutoff N in quantum jumps would also mean that the realization of p-adic intentions occurring subjectively now in my geometric childhood would not have dramatic implications in the geometric now.
3. p-Adic fractality would also mean that similar behavioral time patterns could repeat themselves as temporally scaled-up versions. Person would react in a similar manner in different time scales, say in stressing situation lasting for few minutes or many years. What is used to call as personality might have something to do with these fractal behavioral patterns. There is indeed statistical evidence for the possibility to predict much about the life cycle of a person from the behavioral patterns in childhood. The child who wants all now tends to become an adult who does the same. Some aspects of personality would perhaps represent something not invariant under time translations but under p-adic time scalings.

How statistical behavior could exhibit intentionality?

Consider an ensemble of consisting of N_m measurements of some observables of a system during a fixed time interval T occurring at equally spaced moments of time $t_n = n \times \Delta T$, $\Delta T = T/N_m$. Classify the measurements by some equivalence relation so that there are I possible outcomes and estimate the probabilities for the outcomes as rational numbers $p_i = n_i/N_m$, $\sum n_i = N_m$. When N_m becomes large one should obtain estimates for the probabilities of various instances labelled by $i = 1, \dots, I$. The standard frequency interpretation of probability theory relies on the assumption is that these estimates converge in real topology so that the estimates $p(i, N_m + k) = n_i/N_m + k$, $k \ll N_m$ and $p(i, N_m) = n_i/N_m$ do not differ much for large values of N_m .

It is however quite possible that $p(N_m)$ converges in some p-adic topology which would mean that in the real topology the estimates would fluctuate wildly without any convergence, in a typically fractal manner. The estimates for probabilities would however converge p-adically in which case the system would be intentional and characterized by some p-adic prime p . The quantum-classical correspondence suggests that the sequence of N_m measurements performed for an intentional system during time interval T can be modelled as a sequence of measurements performed for a p-adic space-time sheet serving as its correlate. With this assumption one can immediately conclude that the estimates for the probabilities do not converge since various observables are continuous functions with respect to p-adic rather than real topology and ΔT does not approach zero at the limit $N_m \rightarrow \infty$ but fluctuates wildly. Only for N_m and $N_m + kp^n$ p-adic continuity guarantees that probabilities estimated in this manner are near each other.

It must be emphasized that the notion of p-adic probability based on frequency interpretation satisfies the Kolmogorov axioms as demonstrated by [A7] [A7]. The notion of resolution $\Delta T = T/N_m$ defining what $N_m \rightarrow \infty$ limit really means is an absolutely essential additional element. If one defines $N_m \rightarrow N_m + 1$ as an addition of one additional measurement to existing sequence of measurements, the frequencies convergence to ordinary real probabilities with a given resolution since only one of the numbers n_i changes in $N_m \rightarrow N_m + 1$. The notion of resolution makes sense also in spatial degrees of freedom.

The notion of resolution is unavoidable already in quantum field theories in order to reduce degrees of freedom which are not directly experimentally detectable since the that measurement resolution is always finite. The notion of renormalization group realizes mathematically the notion of finite resolution [B3]. Thus resolution dependent statistics is not anything new. What is new is p-adicity and the long range correlations reducing to the p-adic continuity because of different concept of

nearness. Note also that p-adically small structures have real sizes which are astrophysical so that cognition and intentionality are naturally astrophysical phenomena in accordance with the notions of magnetic body and ME.

These considerations suggest how one could try to demonstrate p-adic intentionality experimentally.

1. One might hope of demonstrating that intentional systems behave apparently randomly in short time scales but that there are long range temporal correlations in time scales $t_n = p^n \Delta T$, $\Delta T = T/N_m$. Wild fluctuation of the probability estimates as function of N_m is a direct signature of intentionality. The approximate invariance of the frequencies under the transformations $N_m \rightarrow N_m + p^n \Delta T$ in turn allow to identify the value p . This approach could be used to prove the presence of the p-adic intentionality even at the molecular level or at level of say solar and planetary magnetospheres by studying the temporal behavior of the fluctuations of magnetic fields. For instance, it is known that solar magnetic field has what might be called memory [E4], which should not be there if it were really random. For tornadoes the presence of short range chaos and long range order in at least spatial degrees of freedom is obvious. Period doubling in the systems approaching chaos could be a signature for the appearance of 2-adic intentionality in increasingly longer time scales. Also $1/f$ noise, not really understood in standard physics framework, might be related to intentionality.
2. One could also test the number theoretic information measures suggested by the p-adic approach using preferred resolutions defined by $N_m = kp^n$. Number theoretic information measures make sense for rational valued probabilities, and are obtained from Shannon entropy by replacing ordinary logarithm with the p-adic logarithm $Log_p(x) = \log(|x|_p) = \log(p^k) = k \log(p)$ to get $S_p = -\sum_n p_n Log_p(p_n)$. The number theoretic entropies can have also negative values in which case one can say that the ensemble contains genuine information.

How the p-adic primes involved with intentionality and ordinary physics are related?

In real physics the p-adic primes involved are very large, for instance, $p = 2^{127} - 1$ for electron. These large primes however labels real space-time sheets and characterize their fractality and *effective* p-adic topology. p-Adic length scale hypothesis in its basic form predicts that primary and n-ary length/time scales correspond to powers of $\sqrt{2}$ of the fundamental p-adic length/time scales so that 2-adic fractality would indeed be realized in this sense. Besides the basic units for time and length also their integer multiples can take the role of the basic unit, this of course in accordance with the very notion of fractality.

Small primes would characterize p-adic space-time sheets serving as correlates of intentions. It seems that only relatively small values p , $p = 2$ being the simplest guess, are realized as far as intentionality is considered. The octaves in music realize 2-adic fractality and it might not be an accident that binary mathematics is mathematics of computation.

3.4.4 Some paradoxes solved by the new view about time

In the sequel some paradoxes of modern physics and philosophy of mind related closely to the notion of time, are discussed.

Paradoxes related to quantum physics

The basic paradox is the conflict between the non-determinism of the state function reduction and the determinism of the Schrödinger equation. At a more general level this paradox is the conflict between the subjectively experienced actuality of the free will and the determinism of the objective world. The resolution of this paradox in TGD context is already discussed.

In the context of the deterministic physics, theoretician encounters three rather unpleasant paradoxes.

1. The determinism implies that the unique objective reality corresponds to a single solution of the field equations. The first question is "What determines the initial conditions, say at the moment of the big bang?". The attempt to answer this question leads necessarily outside the physical

theory: one possibility is to postulate anthropic principle. In TGD objective reality changes at each quantum jump and the localization in zero modes and Negentropy Maximization Principle imply a genuine p-adic evolution: therefore the recent objective reality is indeed an outcome of conscious selections.

2. The second paradox encountered by a theoretician is that in principle it is not possible to test a deterministic theory since only single solution of the field equations is realized and a genuine testing would require the comparison of the time developments for various initial data. In practice this problem can be circumvented by assuming the existence of identical sub-systems having very weak interactions with the external world but in principle the problem remains unsolved. In TGD framework the hopping in the space of quantum histories makes possible the conscious comparison of the "solutions of field equations".
3. A further paradox relates to the dualism between theories and reality. Sooner or later theoretician is forced to ask about in what sense the theories exists. In TGD framework there is no need to postulate any further reality behind the theory. Quantum histories/configuration space spinor fields are what exists, model of reality is the reality. The hopping around in the space of these mathematical structures gives rise to the experiences of the pain and the concepts of toe and stone.

The famous Einstein-Bohr debate was related with the question whether God plays dice or not. In TGD context both were correct in their own ways. Quantum histories are indeed deterministic but God can replace the old quantum history with a new one: perhaps one should not however call this act dice playing but simply an act of free will. Einstein was also an advocate of local realism: this led to Einstein-Podolski-Rosen paradox created by the possibility of quantum entanglement between distant system. In TGD framework local realism holds true at the level of the infinite-dimensional configuration space but not at the level of space-time since point like particles are replaced with 3-surfaces.

The phenomenon of dissipation is paradoxical from the point of view of standard physics. It is generally accepted that the fundamental laws of classical physics are reversible whereas everyday reality is manifestly irreversible. Thus the situation is rather schizophrenic. Two worlds, the reversible and extremely beautiful world of the fundamental physics and the irreversible and mathematically rather ugly "real" world, seem to exist simultaneously. The quantum jumps between quantum histories concept solves the paradox and one can understand the dissipative world as an effective description forming an 'almost'-envelope for the sequence of reversible worlds (time developments).

Paradoxes related to the theories of consciousness

Chalmers describes in his book 'Conscious Mind' [J31] several paradoxes related to the materialistic and dualistic theories of mind. A common denominator for these problems is the assumption that consciousness is a property of a physical state: hence these paradoxes disappear in TGD context. These paradoxes are encountered also in the quantum theories of consciousness identifying consciousness as a property of a macroscopic quantum state, say Bose Einstein condensate.

In the materialistic theories of mind, postulating a unique objective reality, consciousness is an epiphenomenon and free will is necessarily a peculiar illusion and one can always ask why the consciousness is needed at all. Nothing changes in the physical reality if consciousness is dropped away. It is also very difficult to understand how the contents of consciousness are determined by the state of the material world.

In the dualistic theories postulating a unique objective reality (say the theory of Chalmers [J31]), the problems are related to the coupling between matter and mind. The basic problem of the dualistic theories is what Chalmers calls hard problem: how the physical processes in the brain give rise to conscious experience? If the laws of the physics determine the behavior of the system completely then one ends up immediately either with a complete separation of the mind and matter so that our conscious experience tells nothing about the material world or with materialism and epiphenomenalism. One can also consider a non-trivial coupling between matter and "mind like" fields but assuming a deterministic physics one ends up with a situation in which the mind fields are effectively just additional physical fields and consciousness is again redundant.

In TGD framework, which could be called tripartistic, hard problem and other problems of the dualistic theories disappear since there is no need to assign consciousness to quantum history. Moment of consciousness as quantum jump between quantum histories hypothesis allows even to define measures for the information contents of the conscious experience despite the fact that one cannot write explicit formulas for the contents of conscious experience.

Logical paradoxes and concept of time

Many logical paradoxes could be resolved if one assumes that there are two times: geometric and subjective and that the space-time surface providing linguistic representations changes quantum jump by quantum jump. In particular, during the conscious argument leading to the logical paradox!

The objections of Uri Fidelman [J58] against the Platonic vision about reality involve the paradoxes of the cyclic cosmology (one might think that Turing machine in cyclic cosmology might be able to 'know' whether it has halted immediately after starting and thus be much more powerful than ordinary Turing machine). Basic paradox is that in cyclic cosmology allowing time travel one can imagine a psychopathic son who murders his mother.

It is interesting to consider this paradox as resulting from identification of the identification of subjective time with geometric time, which I see only as an approximation. In TGD the counterpart of time travel would be sequence of quantum jumps changing the entire classical history quantum jump by quantum jump and inducing the shift of the space-time region, where the contents of consciousness of time traveller are concentrated, to the geometric past. No paradoxes result since space-time is not a fixed arena of dynamics but changes in each quantum jump.

As a second example one can take the second objection of Uri Fidelman [J58] against Penrose's program known as Berry's paradox.

Non-formalizable theory cannot provide a model of the physical world which includes the brain's cognitive function, since such a model must be lingual, written or spoken. However, such a model implies the following paradox of Berry: Let n be the smallest number which cannot be defined by an English sentence having less than, say, a hundred letters. This number exists, since the number of all possible combinations of a hundred letters is finite. Nevertheless, it has just now been defined by a sentence comprising less than a hundred letters.

Berry's paradox could be understood when the piece of text is seen as inducing a sequence of quantum jumps in which the space-time region at which the argument is represented symbolically changes. For the initial space-time region representing my cognitive state there is indeed smallest number n which cannot be defined by using less than one hundred words (using the English in that space-time!). After reading the statement quantum history is replaced by a new, more complex one in which this this number can be defined by using less than one hundred words since a new reflective level of cognitive consciousness has emerged and is represented at space-time level.

This example encourages to think the possibility of replacing the idea of a fixed axiomatic system with a living and dynamically evolving system becoming conscious of new axioms from which new theorems can grow. Mathematician would not be anymore an outsider but an active participator affecting the mathematical system he is studying. For instance, when paradoxical statement represented symbolically becomes conscious in quantum jump sequence, also the context in which it was originally stated changes. This dynamical view about mathematical system could allow to solve antinomies.

3.4.5 Comparison with the approach of Barbour

The comparison of TGD based view about time with that of Barbour might help to understand what distinguishes TGD view from quantum general relativistic view. Barbour has proposed in his book "....." [J21] that time is illusion. Barbour is a proponent of canonically quantized general relativity, where the canonical quantization rules eliminate time completely from the formulation. This reflects that fact that the dynamical arena is the space of 3-geometries rather than 4-geometries. This is also the situation in the super-space approach of Wheeler, which served as an inspirer of the configuration space geometry approach in TGD framework. Barbour's conclusion that time is illusion is certainly counter-intuitive but perfectly logical if one identifies time as geometric time and takes canonically quantized general relativity completely seriously.

There are of course objections against this conclusion. General coordinate invariance is a four-dimensional symmetry and the notion of space-time is crucial in all practical applications of general

relativity: therefore the disappearance of time from quantum theory tells that something has gone wrong. Indeed, Schrödinger equation and canonical quantizations were derived originally for non-relativistic systems so that the application of the formalism in general relativity might lead to astray. Secondly, the mathematical formalism resulting exists only formally since the naive generalization of non-linear field equations to infinite-dimensional context fails.

Accepting for a moment the absence of geometric time, one can ask whether the experienced time could have a place in Barbour's universe. If one accepts the notion of quantum jump sequence also the space of 3-geometries, one would indeed have subjective time. In the transition to TGD Universe space-times become 4-surfaces and the geometric time would emerge automatically. The fundamental deviation from the canonical quantization is that the fundamental variational principle means something more than the extremization of the action defining the theory. After several guesses what the preferred extremals might be, it became clear that the formulation of the theory in terms of the modified Dirac equation requires the existence of infinite number of deformation of the space-time surface with vanishing second variation of Kähler action. This is nothing but classical correlate for quantum criticality.

Besides allowing to get rid of the infinities of the local quantum field theories, preferred extremal property implies generalized Bohr rules and assigns to given 3-surface (counterpart of 3-geometry) a unique space-time surface. This however requires generalization of the notion of 3-surface since standard form of determinism fails for Kähler action, Even this is not enough for having the psychological time: the localization of conscious experience requires classical non-determinism (which becomes determinism if 3-surfaces are generalized to sequences of 3-surfaces with time like separations). As found, also p-adic physics as physics of intentionality is required to understand the emergence of the psychological time.

3.5 Consciousness and time

The new view about time implies has quite far reaching implications. The notion of 4-dimensional body is the basic concept involved. One can understand long term memories as communications with the geometric past. Sensory perceptions can be seen as memories of magnetic body about the state of the material body in a time scale of a fraction of second. Also some other unexpected symmetries are predicted. Long term memory and precognition seem to be aspects of one and a same phenomenon. The same applies to psychokinesis and retro PK. In fact, both sensory perception, motor action, and memory can be seen as being based on the same mechanism if one accepts that personal magnetic body corresponds to "me". Libet's findings about active and passive aspects of consciousness provide empirical support for the notion of magnetic body.

3.5.1 Passive and active aspects of consciousness

The division of the aspects of conscious experience to active and passive ones is not so obvious as one might think. Sensory experiencing is more like building a piece of artwork than passive receipt of the sensory input and active processes like healing could be rather passive receipt of negative energy MEs from the patient so that the healee gets in this manner only metabolic energy and does the healing herself. It is also far from obvious whether precognition is passive experiencing of the geometric future or psychokinesis actively affecting it.

A precise theoretical dichotomy, at least apparently analogous to active-passive dichotomy, however exists if one accepts that MEs provide the basic mechanism of remote viewing and intentional action. Negative energy MEs can induce mere entanglement making sharing of mental images possible. This would naturally correspond to the passive aspects of consciousness as far as the receiver of negative energy MEs is considered. The generation of negative energy MEs makes possible remote metabolism at the end of system generating the negative energy ME. The receiver of the negative energy ME, say precognizer would be the passive counterpart whereas its sender, say an area of left cortex suffering from under-nutrition as might be in the case of synesthesia, would be the active counterpart. One must be however cautious here. It is not at all clear whether one can talk about sender/receiver of the negative energy ME since entanglement is completely symmetric process. In the sequel it is assumed that the notion of sucking of negative energy does not make sense.

Low frequency MEs can also contain also high frequency MEs inside them and positive energy MEs of this kind are especially natural for the realization of active aspects of consciousness. Positive energy MEs could directly provide energy to the receiver. They can also induce bridges along which various particles leak between space-time sheets so that basic metabolic activities are induced and controlled remotely.

3.5.2 Sensory perception, motor action, and time

TGD view about sensory perception differs dramatically from that of the standard neuroscience in that sensory organs are carriers of basic sensory representations and the magnetic body rather than body or brain is the experiencer with which we can identify ourselves. Magnetic body is also the intentional agent and both motor action, sensory perception, and long term memory which all involve also intentional elements, are based on the time mirror mechanism. Intentions are represented by p-adic MEs generated at the magnetic body. p-Adic ME is then transformed to a desire about a particular action and represented as a negative energy ME propagating to the direction of the geometric past. Actions are realized as responses to the negative energy MEs as various kinds of neural activities and as a generation of positive energy MEs. A more realistic model involves an entire sequence of this kind of steps proceeding like a sequence of sub-program calls downwards along the hierarchy of the magnetic bodies down to the level of CNS. A good metaphor is obtained by regarding magnetic bodies as bosses in the hierarchy of some organization and CNS as the lowest level ultimately realizing the desire of the big boss.

Sensory organs as seats of qualia

According to the music metaphor, sensory organs are responsible for the music whereas brain writes it into notes by building symbolic and cognitive representations communicated to the magnetic body. Back projection to the sensory organs is an essential aspect of this process and is discussed in [K32]. Sensory perception at the level of magnetic body involves the generation of negative energy MEs entangling with sensory organs involving possibly also brain as an intermediate entangler.

The assumption that sensory organs are carriers of the sensory representations entangling with symbolic representations realized at the level of cortex does not mean any revolution of neuroscience, just adding something what is perhaps lacking [K32].

Neuronal/symbolic level would do its best to symbolically represent what occurs naturally at the level of qualia. Color constancy could be understood as a basic characteristic of color qualia represented symbolically at the neuronal level. Center-surround opponency for the conjugate colors is the neural counterpart for the contrast phenomenon in which the boundary for a region of the perceptive field with a given color carries the conjugate color (black-white opponency associated with the luminance is only a special case of this). The contrast phenomenon at the level of visual qualia could derive from the vanishing of the net color quantum numbers for the electrodes of the retinal color capacitors.

The basic prediction is the presence of the back projection at least in the sensory modalities in which hallucinations are possible. MEs with MEs mechanism is the most natural candidate for realizing the back projection, negative/positive energy MEs would realize the back projection based on quantum/classical communications, and the capacitor model of the sensory receptor can be applied to model photoreceptors and retina. This picture integrates nicely with the various speculations about the role of the ciliary micro-tubules in vision. The obvious question is how the presence and character of the back projection reflects itself in the structure of the sensory pathways and sensory organs.

Basic facts about how gastrulation and neurulation proceed during the development of the embryo, lead to testable hypothesis about the character of the back projection for various sensory modalities. According to the hypothesis, one can speak about "brain senses" and "skin senses" according to whether the back projection is based on quantum or classical communications.

How motor action differs from sensory perception?

There is a deep similarity between sensory perception and motor action in TGD framework, the basic difference being that classical signals propagate in different direction in CNS and in geometric time. Motor action is initiated by the magnetic body by the sending of negative energy to motor organs

by generating negative energy MEs, and proceeds by similar processes backwards in the geometric time to the level of brain and magnetic body, very much like an instruction of a boss at the top of organization to the lower levels of hierarchy and induces lower level instructions. The analogy with computer program calls (quantum communications, desires) and their executions (classical signals, actions) is also obvious. Also classical signals from the magnetic body to the body and brain are possible.

Analogous picture applies to sensory perception with motor organs replaced by sensory organs except that the fundamental communications occur to geometric future from biological body to magnetic body via a hierarchy of EEGs. There is however also an active building of sensory percepts by feedback from the magnetic body which selects between quantum superposed alternative percepts already at the level of sensory organs.

Sensory *resp.* motor imagination differ from sensory perception *resp.* motor action only in that the magnetic body entangles with some higher level of CNS. Therefore there is no danger that imagined motor action would become real or that imagined sensory perception would be experienced as real. This picture is in accordance with the idea of quantum credit card implying maximal flexibility, and with respect to the geometric time would mean that motor actions are only apparently initiated from the brain.

Strange time delays of consciousness: experiments related to the active role of consciousness

Libet has carried out classical experiments about active and passive aspects of consciousness [J48, J72]. It has gradually become clear that these experiments can be interpreted as a support for the identification of "me" as the personal magnetic body. The first class of experiments [J70, J72] is related to the active role of consciousness. For example, the human subject moves his hand at free will. What happens is that neurophysiological processes (changes in EEG, readiness potential) start $T_1 = .35 - .45$ seconds before the conscious decision to move the hand whereas the awareness about the decision to move the hand comes $T_2 = .2 - .1$ seconds before the hand movement. Decision seems to be followed by the action rather than action by decision! This is in apparent accordance with the point of view that consciousness is indeed a passive spectator and the act of free will is pure illusion. What is interesting from the p-adic point of view, is that the most plausible estimates for the time delays involved are $T_1 \simeq .45$ seconds and $T_2 = .1$ seconds [J70]. T_1 is very near to the p-adic time scale $T(6, 43) = .4$ seconds and T_2 to the fundamental p-adic time scale $T(2, 127)$ defining the duration of the memetic codon.

One can imagine two explanations for the paradoxical findings. The explanations turn out to be mutually consistent.

1. The geometric past changes in quantum jump

Quantum jump between histories picture explains the time delays associated with the active aspect of consciousness nicely and also gives an example of two kinds of causalities.

1. The simplest assumption is that the subjective experience of the hand movement corresponds to the moment, when subject person experiences that hand movement occurs.
2. The space-time surfaces (resulting as the final state of quantum jump) associated with the new quantum history differ in a detectable manner from the old quantum history already before the moment of hand movement since otherwise the new space-time surface would contain an instantaneous and discontinuous jump from the initial to final body configuration, which is not allowed by field equations. Same argument applies to the state of brain. $\Delta T \sim .5$ seconds seems to be the relevant time scale.
3. The attempt of the experimenter to be objective means that in an ideal experiment the observations correspond to the new deterministic history in the associated quantum jump and hence experimenter sees neurophysiological processes as the (apparent) cause of the hand movement with respect to geometric time. With respect to the subjective time the cause of the hand movement is the decision of the subject person.

2. Motor action is initiated from the magnetic body and proceeds to shorter length scales in reversed direction of geometric time

The vision that motor actions are initiated by magnetic body by feeding negative energy to motor organs and proceed upwards in CNS in a reversed time direction is in accordance with the idea of quantum credit card implying maximal flexibility and would mean that motor actions are only apparently initiated from brain. Motor organs send negative energy MEs to get metabolic energy, say to cortex. If there is lapse $\sim .5$ seconds involved then the observed lapse would find explanation. This view concretizes the idea about the editing of the geometric past and is consistent with the more general explanation discussed above.

This view about motor action means that it proceeds from long length scales to short ones whereas in the standard neuroscience view motor action would be planned and initiated in the brain and proceed to the level of motor organs, from short to long length scales. This certainly seems to be the case if one looks only the classical communications (say nerve pulse patterns). The extreme coherence of and synchrony of motor activities is however in conflict with this picture: neuronal communications are simply too slow to achieve the synchrony. This has been emphasized by Mae-Wan Ho [I93]. Since quantum communications proceed backwards in geometric time, classical signalling such as nerve pulses from brain to motor organs are actually reactions to the initiation of the motor action from the magnetic body.

Strange time delays of consciousness: experiments related to the passive role of consciousness

Libet's experiments [J48] about the strange time delays related to the passive aspects of consciousness have served as a continual source of inspiration and headache. Every time I read again about these experiments, I feel equally confused and must start explanations from scratch.

What is so important and puzzling is that the backwards time referral of sensory experience is so immensely long: about .5 seconds. The time taken for nerve pulses to travel through brain is not more than .01 seconds and the time to arrive from sensory organs is at most .1 seconds (for axon with length of 1 meter and very slow conduction velocity 10 m/s). For the purposes of survival it would be advantageous to have a sensory input with a minimal time delay.

Why then this long delay? TGD inspired answer is simple: the "me" does not correspond to the material body but to the magnetic body associated with the physical body, and is analogous to the manual of electronic instrument, kind of a monitor screen to which sensory, symbolic and cognitive representations are projected by quantum and classical communications. Since the size of the magnetic body is measured using Earth's circumference as a natural unit, the long time lapse results from the finite velocity of light.

The following explanation is a variant of the model of the sensory representations on the magnetic canvas outside the body and having size measured by typical EEG wave lengths. The basic sensory representations are realized at the level of the sensory organs and entangled with magnetic body whereas symbolic representations are either shared as mental images by or communicated classically to the magnetic body. This differs from the original scenario in which sensory representations were assumed to result by classical communications from brain to the magnetic body.

1. Communications from brain to magnetic body

One must consider two kinds of communications from body to magnetic body corresponding to positive energy MEs generated by at least brain and negative energy ME sent by magnetic body to at least sensory organs. The assumptions are following.

1. Negative energy MEs bound state entangle the magnetic body with the sensory representations realized at the level of sensory organs, and constructed using back projection from brain and possibly also from higher levels. Fusion and sharing sensory mental images is involved. Also the classical communication of memories to magnetic body could be involved with the build up of sensory and symbolic representations at the magnetic body. In both cases sensory representations are memories with the same time lapse determined by the length of the MEs involved, a fraction of second typically if the magnetic body is of an astrophysical size. During sensory and motor imagination magnetic body entangles by negative energy MEs with some higher level of CNS.
2. Symbolic representations in brain can entangle with the sensory representations entangling in turn with the magnetic body so that CNS defines tree like structure with roots corresponding to

sensory organs and branches and leaves corresponding to the higher levels of CNS. Direction of attention selects some path along this tree somewhat analogous to the path defining computer file in some subdirectory.

3. Symbolic representations of the perceptive field can be projected to the magnetic body using also classical signalling by positive energy MEs with phase velocity in a good approximation equal to the light velocity. For instance, if perceptive field contains something important, classical signal to the magnetic body could induce the generation of negative energy MEs turning attention to a particular part of perceptive field. Projection to the magnetic flux tubes of the Earth's magnetic field is possible. The spatial direction of the object could be coded by the direction of ME located in brain whereas its distance could be coded by the dominating frequency of ME which corresponds to a magnetic transition frequency which varies along the radial magnetic flux tubes slowly so that place coding by magnetic frequency results. Field pattern could be realized the coding of information to bits in some time scale, perhaps even in the time scale of millisecond associated with the memetic code. Positive energy MEs generated by brain realize the representation and this implies time delay. In the original model it was assumed that the direction and distance of the object of perceptive field are coded as direction and distance at the magnetic body. The representations are expected to be rather abstract, and it might be enough to perform this coding at the level of magnetic bodies associated with the sensory organs.

2. Libet's findings

Libet's experiments [J48] about the strange time delays related to the passive aspects of consciousness serve as a continual source of inspiration and headache. Every time one reads again about these experiments, one feels equally confused and must start explanations from scratch. The following explanation is based on the model of the sensory representations on the magnetic canvas outside the body and having size measured by typical EEG wave lengths [K64] .

The basic argument leading to this model is the observation that although our brain changes its position and orientation, the mental image of the external world is not experienced to move: as if we were looking some kind of sensory canvas inside cortex from outside so that the motion of canvas does not matter. Or equivalently: the ultimate sensory representation is outside brain at a fixed sensory canvas. In this model the objects of the perceptive field are represented on the magnetic canvas. The direction of the object is coded by the direction of ME located on brain whereas its distance is coded by the dominating frequency of ME which corresponds to a magnetic transition frequency which varies along the radial magnetic flux tubes slowly so that place coding by magnetic frequency results.

According to the summary of Penrose in his book 'Emperor's New Mind' these experiments tell the following.

1. With respect to the psychological time of the external observer subject person becomes conscious about the electric stimulation of skin in about .5 seconds. This leaves a considerable amount of time for the construction of the sensory representations.
2. What is important is that subject person feels no time delay. For instance she can tell the time clock shows when the stimulus starts. This can be understood if the sensory representation which is basically a geometric memory takes care that the clock of the memory shows correct time: this requires backwards referral of about .5 seconds. Visual and tactile sensory inputs enter into cortex essentially simultaneously so that this is possible. The projection to the magnetic canvas and the generation of the magnetic quantum phase transition might quite well explain the time lapse of .5 seconds.
3. One can combine an electric stimulation of skin with the stimulation of the cortex. The electric stimulation of the cortex requires a duration longer than .5 seconds to become conscious. This suggests that the cortical mental image (sub-self) is created only after this critical period of stimulation. A possible explanation is that there stimulation generates quantum phase transition "waking up" the mental image so that threshold is involved.
4. If the stimulation of the cortex begins (with respect to the psychological time of the observer) for not more than .5 seconds *before* the stimulation of the skin starts, both the stimulation of

the skin and cortex are experienced separately but their time ordering is experienced as being reversed!

A crucial question is whether the ordering is changed with respect to the subjective or geometric time of the subject person. If the ordering is with respect to the subjective time of the subject person, as it seems, the situation becomes puzzling. The only possibility seems to be that the cortical stimulus generates a sensory mental image about touch only after it has lasted for .5 seconds. In TGD framework sensory qualia are at the level of of sensory organs so that the sensation of touch requires back-projection from cortex to the skin. If the formation of back projection would takes about .5 seconds the observations can be understood. Genuine sensory stimulus creates cortical mental image almost immediately: this mental image is then communicated to magnetic body (time like entanglement).

5. If the stimulation of the cortex begins in the interval $T \in [25 - .5]$ seconds *after* the stimulation of the skin, the latter is not consciously perceived. This effect - known as backward masking - looks really mysterious. It would be interesting to know whether also in this case there is a lapse of .5 seconds before the cortical stimulation is felt.

According to the TGD based vision sensory mental images are at the level of sensory organs and brain constructs symbolic representations about them using intensive back-projections to the sensory organs. These representations give rise to a decomposition of the perceptive field to standardized sensory mental images. The most effective manner to achieve back-projection is by using negative energy signals propagating backwards in geometric time just like in the case of intentional action. Accepting this framework one can at least make questions.

1. Could the stimulation of the cortex induce a negative energy back-projection signal to the skin representing a stimulus effectively interfering to zero with the real stimulus? That the skin stimulus is perceived consciously for $T < .25$ seconds means that the compensating back projection is sent only if cortex has received information about skin stimulation. One can imagine that it takes .25 seconds to form a symbolic representation about the sensory mental images at sensory organ. Why the back-projection would compensate the skin stimulus?

It is known that brain acts like a highly selective gardener applying strong inhibition to certain sensory stimuli and strong excitation to others in order to build percepts. If this principle applies also in time domain - as it should if the paradigm of 4-D brain is accepted- the elimination of the sensory stimulus could be seen as a tendency to build sensory percepts which are sharply localized in time. A precise localization in time is indeed important in the case of sensory percepts.

Second explanation would be based on compensating back-projection. Everyone who has been swimming in windy sea, feels the waves for a long time after coming to the shore. This sensation would correspond to back-projection in TGD framework but it is not clear to me whether this back-projection tends to compensate the actual sensation in order to achieve metabolic economy.

2. Could it be that the skin stimulus is actually consciously perceived but that this experience is not remembered? In TGD framework the memory about skin stimulus would be realized as a skin stimulus still continuing in the geometric past. If the cortical stimulation for some reason modifies the geometric past by destroying the skin stimulus using back-projection, there would be no memory about the skin stimulus.

3.5.3 Long term memories and time

TGD based model of long term memory requires no storage of memories of past to the brain of the geometric now. The memories are in the geometric past as dynamical self organization patterns and subject to changes.

1. In the case of active memory recall the desire to remember is communicated to the geometric past by sharing and fusion of mental images made possible by entanglement. In the case of episodal memories also the memory recall would result in this manner. For non-episodal memories the memory would be communicated from the geometric past using classical communications.

2. In the case of episodal memories active precisely targeted memory recall might be difficult since the entanglement with a correct mental image seems to require good luck. In principle it is possible to select the distance T to the geometric past where the memory comes from by selecting the fundamental frequency of ME. There are huge amounts of information, which is useless unless the person is an artist. Ironically, the loss of cognitive abilities would be compensated by episodal memories providing mental powers making an idiot a genius able to tell whether a given number is prime and to perform extremely complex calculations. A mild variant of the idiot savant phenomenon can be induced artificially by trascranial magnetic stimulation even in ordinary persons [J80] . The miraculous memory feats of synesthetes and idiot savants, and also sensory memories and strange abilities induced by electric and transcranial magnetic stimulation could involve the entanglement of the stimulated brain areas rather than that of magnetic body with sensory representations with brain areas taking the role of sucker of positive energy. In this kind of situation the starving magnetic body could send negative energy sensory MEs to a more distant geometric past and experience episodal memories instead of the sensory input.
3. Classically communicated memories are symbolic and thus the amount of information is minimized. They are also reliable since it is enough for the brain of the geometric past to share the desire to remember. If the desire is communicated to a wide temporal range in geometric past, some self of the geometric past is able to communicate the answer. Context sensitivity is the drawback of this memory mode. Memes defined as sequences of memes defined by sequences of 21 DNA triplets might define what might be called universal language helping to overcome the context sensitivity [K35] .
4. Brains could also generate automatically classical signals about often needed declarative memories to the geometric past at various lengths of magnetic flux tubes. The memory recall would require only the tuning to receive the classical signal. This would require an organization of brain analogous to sensory areas so that a particular neuron group is tuned to receive signals from a particular distance to geometric past. One can also imagine a situation in which the communication of the memory from the past occurs as repeated communications over shorter time interval, somewhat like ordinary communications using radio stations receiving and re-sending the message. For instance, classical communications could circulate around the magnetic loops associated with the personal magnetic body or that of Earth's magnetic field much like neural signals in neural circuits. This would make the memory retrieval more reliable. The automatic classical communications could be also involved with the communications by active memory recall. The extreme situation would be the transfer of information from the geometric past like a news about some event in a population via communications between individuals. This mechanism would also establish the memory representation along the entire life span.

Basic model for memory recall

For the time-mirror model of long term memory the ULF dark MEs must be generated both at the personal magnetic body and in the brain.

1. At the personal magnetic body cyclotron phase transition would give rise to negative energy neutral MEs sucking energy from the biological body of the geometric past. This radiation would be reflected back to the geometric future as positive energy neutral MEs. The response would depend on the state of the brain. Motor action would differ from memory recall only in that it would involve negative energy W MEs inducing exotic ionization at both ends and leading to a physiological outcome. The entanglement via W MEs could induce direct sensory memories relying on sharing and fusion of mental images.
2. The ULF radiation representing the response to the memory recall would correspond to Josephson radiation giving rise to a scaled up dark EEG in the relevant time scale characterized by the level of the dark matter hierarchy. The de-coherence of higher level dark photons to single ordinary EEG dark photon or their decay to EEG dark photons is probably involved with the memory call and would transform the response from the geometric past to ordinary cognitive and emotional input at personal magnetic body.

The time span of long term memories as signature for the level of dark matter hierarchy

Higher levels of dark matter hierarchy provide neat quantitative view about self hierarchy and its evolution. For instance, EEG time scales corresponds to $k = 4$ level of hierarchy and a time scale of .1 seconds [K25] , and EEG frequencies correspond at this level dark photon energies above the thermal threshold so that thermal noise is not a problem anymore. Various levels of dark matter hierarchy would naturally correspond to higher levels in hierarchy of consciousness and the typical duration of life cycle would give an idea about the level in question.

The level would determine also the time span of long term memories as discussed in [K26] . $k = 7$ would correspond to a duration of moment of conscious of order human lifetime which suggests that $k = 7$ corresponds to the highest dark matter level relevant to our consciousness whereas higher levels would in general correspond to transpersonal consciousness. $k = 5$ would correspond to time scale of short term memories measured in minutes and $k = 6$ to a time scale of memories measured in days.

The emergence of these levels must have meant evolutionary leap since long term memory is also accompanied by ability to anticipate future in the same time scale. This picture would suggest that the basic difference between us and our cousins is not at the level of genome as it is usually understood but at the level of the hierarchy of magnetic bodies [K43, K26] . In fact, higher levels of dark matter hierarchy motivate the introduction of the notions of super-genome and hyper-genome. The genomes of entire organ can join to form super-genome expressing genes coherently. Hyper-genomes would result from the fusion of genomes of different organisms and collective levels of consciousness would express themselves via hyper-genome and make possible social rules and moral.

How to achieve precisely time-targeted communication to and from geometric past?

Negative energy MEs are ideal candidates for sending a signal to the geometric past and inducing entanglement and sharing of the mental image representing the desire to remember. The magnetic flux tubes of the personal magnetic body with sizes measured in light years in turn can act as wave guides along which the negative energy curvilinear MEs propagate along or are parallel to. Also negative energy em MEs are possible since negative energy MEs interact very weakly with the external world in any case. Also the positive energy MEs sent to the direction of the geometric future as a response and representing classically communicated declarative memories would propagate along magnetic flux tubes. The same magnetic flux tube could be used for both communications.

One can consider several variants about how long terms memories are realized as communications between geometric now and geometric past.

1. Mirror model

The original idea was that MEs could be reflected at the ends or kinks of a magnetic flux tube serving as kind of mirrors. The outcome was the mirror model of long term memory in which the signal from the geometric past represented by ME is reflected at the end of the magnetic flux tube of astrophysical size. In the similar manner also the negative energy ME would be reflected. The model was still based on the idea that "me" is the physical body or brain. The basic objections are that there is no convincing identification of the mirrors and there is no guarantee that the mirrored ME returns to the original brain.

2. Loop model

One can also consider the possibility that closed magnetic flux tubes associated with the personal magnetic body could function as wave guides for curvilinear MEs, so that MEs would automatically return to the brain if they propagate while attached to the boundary of a closed magnetic flux tube. Also this model is still based on idea that the size of the personal magnetic body is not much larger than Earth's size so that one can idealize "me" as brain, at least in the length scale defined by the time span of the long term memories. Furthermore, despite the fundamental similarity between motor action, sensory perception, and memory, the mechanism of long term memory would differ from the mechanism of motor action and sensory perception. A further serious objection is that MEs parallel to the closed magnetic flux tubes and representing closed topological light rays might not be allowed as solutions of the field equations.

3. Brain and body as time like mirror

If one takes completely seriously idea about "me" as the magnetic body with size at least of order light lifetime which can be regarded as single quantum coherent structure, one ends up to a variant of the model a). First of all, the whole magnetic body becomes the experienter and classical communications need not be spatially precisely targeted. Secondly, brain and body serve as time like mirrors in the sense space-like reflection is replaced with both spatial and temporal reflection. Negative energy ME characterized by frequency and wave vector is replaced with time reflected positive energy ME: $(-E, -k) \rightarrow (E, k)$ in the reflection. Ideal reflection changes only the sign of the normal component of 3-momentum. If this is the case also now then also the magnitude of energy would be conserved so that the classically communicated memory would be automatically communicated to a correct temporal position in the geometric future.

If the transverse area S of flux tube codes for the temporal distance T to the geometric past by its transverse area ($T \propto S$) and thus by cyclotron frequency scale, the mechanism of long term memory becomes precisely identical with that of sensory perception and motor action. The desire to remember is communicated quantally from the magnetic body to brain along flux tube, and the reply arrives as a classical communication along same flux tube at the fundamental frequency and the reply communicated classically generates cyclotron transitions at the receiver's end at a correct temporal distance in future. In light of the fractality of consciousness, this model is certainly the unique one and is certainly consistent with the field equations.

The memory mental image communicated classically should reach the temporal position of the 4-D brain, which communicated the desire to remember. High precision communication is not absolutely necessary although it is favored by metabolic considerations: it is enough that the memory is communicated to a time interval containing the temporal position wherefrom the desire to remember was communicated. Memory could even diffuse like an interesting news in a 4-D society formed by mental images in brains at different times.

If MEs are amplified by Alfvén wave resonance (closed magnetic flux tubes or flux tubes with ends), the wave length of ME should correspond to the length of the magnetic flux tube involved. If negative and positive energy MEs are associated with same magnetic flux tubes and the thickness of the magnetic flux tube varies as $S \propto L$, cyclotron transitions occur automatically at a correct temporal and spatial position of the flux tube and the sender of the memory recall receives the answer. In this case however memory is communicated to some time interval in geometric future.

If temporally selective communication is required, the frequency associated with ME must correspond to the same time value for the negative and positive energy MEs involved. A relative precision of $\Delta f/f \simeq 10^{-9}$ is required if the time span of the memory is 10 years and precision about .1 seconds (sensory memories). Of course, the needed precision could be much lower already because the time span of short term memories is of the order of minute. The active loss of memories could result from the refusal or inability of the "mes" of the geometric past to communicate memories or of the "me" of now to generate memory recalls. Later a model of time like reflection which could conserve the frequency with this precision will be discussed.

Second solution to the problem is to have several copies of the memory mental image so that the probability to hit one of them is high. Very probably brain applies this trick. This would explain why the standard model for long term memories seems to work reasonably well.

4. Variants of the time-mirror model

One can consider several variants of the time-mirror model.

1. For the simplest model the MEs involved are more or less linear structures. For classical communications with light velocity the lengths $L = cT$ of the flux tubes would be measured in light years for a typical time span T of long term memory. If the memory recall originates simultaneously from various points of the magnetic body, the reply to the memory recall is received simultaneously by different part of the personal magnetic body in the approximation that the response at the biological body is instantaneous (so that also the received response emerges instantaneously). For EEG phase velocities L would be of the order of the size of the magnetic body of Earth for typical values of T so that the declarative memory could be communicated also to the magnetic Mother Gaia responsible for the third person aspects of the memory.
2. What is intriguing that for a typical EEG phase velocity v the distance $L_B = vT$ travelled during T corresponds to a wave length $\lambda = L_B = c/f_{high}$ of EEG wave propagating with light velocity.

This brings strongly in mind the scaling law of homeopathy and its generalizations [K36], and suggests that the boundary ME corresponds to EEG wave with EEG phase velocity v . This numerical coincidence encourages to consider also time like reflection in which energy is not conserved. The scaling law of homeopathy suggests that low frequency negative energy ME could transform in the reflection to high frequency positive energy ME:

$$f_{low} \rightarrow f_{high} .$$

This transformation could be interpreted in terms of the Alfvén resonance condition $f_{high} = c/L_B$ for a ME propagating in the flux loop of length L_B (recall however the objection against closed topological light rays).

3. Positive energy EEG MEs could propagate with light velocity along the closed loops of personal magnetic body of Earth's magnetic field and return again and again to brain very much like neural signals circulate in neural circuits. This would provide a manner to refresh often needed memories. The main theme of [K42] was indeed the fractal correspondence between the structures of the brain and magnetosphere.
4. Fractality suggests that magnetic loops of all possible sizes are involved with classical communications by boundary MEs, even the magnetic loops of the material body serving as templates for neural circuits. The requirement that frequencies are identical for these fractally scaled magnetic circuits could be seen as an entrainment phenomenon. This would predict ultra-slow neural signals serving as correlates for the classical communications of long term memories at brain level. It is indeed known that Ca_{++} have extremely wide velocity spectrum [A8].

The model based on W MEs as induces of motor actions explains these velocities explains these velocities differently. Classical W field depends on the light like longitudinal coordinate and single transversal coordinate. One expects that the maxima for the intensity of W field are the loci around which physiological effects concentrate. These maxima in general propagate in the transversal direction. This velocity could correspond to the velocity of the physiological wave.

3.5.4 Remote mental interactions and time

If the notion of magnetic body is taken completely seriously, sooner or later comes the realization that not only motor action, sensory perception, and memory, but also various forms of remote mental interactions could be based on essentially the same mechanism. Motor action and memory recall certainly involve the active aspect but so does sensory perception via direction of attention and selection between percepts.

Magnetic bodies are the intentional agents, and accompany even "non-living" targets. The intention of the magnetic body to achieve something is transformed first to a negative energy ME representing the communication of the desire to achieve something to the geometric past by sharing of mental images. Already the sharing of mental images might be enough, as in the case of remote viewing of the geometric past, in special case long term memory. Then the receiver of the negative energy ME, be it lower level magnetic body or material body, tries to realize the desire and generates classical signals. These signals could be also positive energy MEs and could propagate back to the magnetic body as in case of declarative memory recall. They could also propagate to another magnetic body, which would mean that mind-mind interactions are involved.

This unified view means that the distinction between active and passive aspects of remote mental interactions is far from trivial, and it is not so easy to tell where the boundary line between precognition and psychokinesis is. The first realization along these lines was that precognition and long term memory are different aspects of the same phenomenon. Then came the idea that also PK and retro PK could be seen as different aspects of the same phenomenon if PK can be regarded a generalized motor action in which target becomes effectively part of the body of the psychokinesist.

A possible view about remote viewing

The basic question is whether negative energy MEs are always generated actively by the system in the geometric future or whether also active sucking of the negative energy from the geometric future

is possible. The simplest assumption is that the sucking of negative energy is not a sensible concept. The motivation comes from the fact that it seems to be impossible to distinguish between sucking and passive receipt of the negative energy since the entangled systems are in a completely symmetric position.

1. *Active and passive aspects*

Whether one can regard remote viewing as active or passive process depends on whether it is geometric past or future which is viewed.

1. If geometric future is viewed, the task of the remote viewer is to tune to the "correct wave length" in order to be able to receive the negative energy ME from the geometric future. This requires that remote viewer tries to get rid of mental images competing for the metabolic resources and tend to mask the viewed mental image. The initiative is possessed by the system in the geometric future sending the negative energy ME. The reaction of the remote viewer realized as classical communications could give rise to PK effect in the target. If the time-mirror mechanism based on induced phase transition is involved also with remote viewing, the reaction of remote viewer would be automatic so that some kind of PK effect would be unavoidable.

One cannot completely exclude the possibility of time reversed classical communications. In ordinary classical communications the high frequency positive energy MEs absorbed by the receiver kicks it to a higher energy state wherefrom it returns to the ground state spontaneously. A system receiving high frequency negative energy MEs inside low frequency negative energy ME can drop to a lower energy state only if the magnitude of the energy is below thermal energy or if the system is analogous to population inverted laser. In the latter case the receiver would not however return spontaneously to the original state unless there is a feed of energy to the system.

2. If the geometric past is viewed, the process is active process and completely analogous to long term memory recall except that negative energy MEs generated by the remote viewer are not received by the brain of the viewer but some other system. Note that now also classical communications are possible and would be analogous declarative memories. These communications might be possible if the target is living system and be based on memetic code using the common vocabulary defined by common memes [K35] .

2. *Sharing of mental images*

Since remote viewing by the sharing of mental images does not involve classical communications at all so that one cannot characterize the process in terms of bit currents. There are indeed arguments that if the field patterns of EEG waves were responsible for the remote viewing realized as classical communications, the bit rates required would not be high enough since the frequency defines an upper bound for the bit rate.

Sharing of mental images does not pose any obvious upper bound for the amount of conscious information transferred. Measures for the amount of information contained by mental image could be provided by the number theoretical information measures predicted by TGD approach [K46, K52] .

What would be communicated would be more like impressions instead of messages consisting of symbol sequences. The message, say visual perception, would contain huge amounts of irrelevant information. Of course, the mental images could be also cognitive or symbolic representation, say internal speech. The translation of these impressions to language involves cognition and analytic thinking and can lead to misinterpretations. The reports about telepathic communications suggest that mental images transferred in telepathic communications are fragmented more like sensory and emotional impressions and often what might be regarded as separate "features" of the perceptive field rather than complete percepts. If sensory organs are the seats of the sensory representations, telepathy should thus involve entanglement of the viewer with the brain of the sender containing the symbolic representations. Fragmentation would reflect that fact that brain does for sensory input same as catabolism makes for food.

It is known that the entropy gradients associated with the target correlate with the probability that target is remote viewed [J42] . In TGD framework this can be explained as a basic characteristic of conscious experience [K32] . All gradients, also spatial gradients, such as textures of visual field or

gradients of illumination at particular wave length, are transformed to subjecto-temporal gradients and only changes are perceived in accordance with quantum jump as moment of consciousness identification. In TGD Universe the intensities of emotions are proportional to the gradients of entropies associated with various quantum number and zero mode increments and only objects generating strong enough emotional response catch the attention. Targets with low entropy gradients do not generate intense mental images in any perceiver (not necessarily human!), and thus do not generate remote perception by a sharing of mental images.

3. Remote viewing is not only viewer-target phenomenon

Remote viewing does not seem to be only a viewer-target phenomenon but involves many-brained magnetospheric selves receiving information from the brains involved with the typical experiment whose protocol is such that viewer does not know the location of the target. In particular, the ability of the remote viewer to view target about which he knows only coordinates having no significance as such to him but for someone involved with the protocol supports this view [J75]. Also the reported healings induced by prayer groups and meditation groups whose members do not know the healees and even where they are, support the same conclusion [J24]. Thus remote viewing as well as healing might involve multiple entanglement. For instance, healer would be entangled with higher level self in turn entangled with the healee. Fractality suggests that one could apply the wisdom about brain functioning to the modelling of the multi-brained selves. The notion of associations might make sense for instance. The analogy with brain encourages to think that also classical communications by positive energy MEs might be involved and make possible feedback and thus PK.

An interesting practical question is how to characterize the strength of the entanglement by negative energy MEs. The lifetime of the resulting bound state is one such measure. One could guess that this time scale is of the order of the relevant p-adic time scale. Somewhat paradoxically but in consistency with Uncertainty Principle, the duration would be the longer, the weaker the binding energy would be. Second measure is the number of MEs involved. If collective multi-brained selves are involved the number of brains involved and having information about target would be a significant factor.

Sharing of mental images as the basic mechanism of remote viewing

Sharing of mental images does not require neither target nor receiver to be able to communicate symbolically. Therefore the target and receiver could be any living system: animal, plant, even bacterium. In TGD Universe one cannot exclude even "non-living" systems as targets and even sharers of mental images. The remote viewing of non-living targets is indeed possible and in this case either mental images of target or some system perceiving target are shared.

Support for the extreme generality of the sharing of the mental images as a basic mechanism of remote viewing comes the fascinating experimental discoveries made by Cleve Backster [J14, J19]. These findings have led Backster to introduce the notion of primary perception, which seems to have a natural identification as sharing of mental images.

1. Plants, eggs, and even bacteria are able to have primary perceptions. Backster tells in the interview that even yoghurt got wild when he took a chicken out of refrigerator and began pulling off strips of meat. Plants respond electrically to strong negative emotions and to the violence or death suffered by other living organisms. That primary perception correlates with the strength of emotions conforms with the view that entropy gradients with respect to subjective time, which are indeed identifiable as emotions, measure the strength of perception.
2. Distance does not seem to matter much. Sperm separated by a large distance from its donor reacted when the donor inhaled amyl nitrate. White cells were found to remotely react to the emotions of their donors. Same was found to apply to plants and their owners.
3. Plants and even bacteria seem to have a defence mechanism resembling shock. If bacteria share the mental images of suffering organisms by receiving negative energy MEs sent by them, the shock could be interpreted as resulting from the depletion of positive energy resources (all excited states of population inverted many-sheeted lasers decay to the ground state) or be a mechanism preventing this depletion.

An interesting question is whether humans have lost this ability or is this reaction usually unconscious at our level of self hierarchy and whether human skin could exhibit GSR to say death of other life-forms.

Precognition and memory as different aspects of the same phenomenon?

It is tempting to see precognition and long term memory as different aspects of the same phenomenon involving sharing of the mental image resulting as fusion of mental images by time-like entanglement induced by negative energy ME.

1. This identification would explain why precognition is a rare instance whereas memories would pop up more or less spontaneously. The reason is that precognition means giving energy to the future self whereas memory means receiving it. During wake-up period brain has to utilize its metabolic energy to build sensory representations, to plan and realize motor actions, and cognize. Therefore not much energy is not available unless these activities are silenced. This kind of silencing is indeed a prerequisite for precognition [J75] .
2. Sleep state is for metabolic reasons ideal for precognition. During sleep state it is however the larger self resulting as a fusion of brain with some other self which precognizes, so that these precognitions are usually not remembered. It should be however possible to precognize during dreams, especially so during lucid dreaming. The problem is that dreams are forgotten very rapidly unless they are documented immediately. The classic work "Experiment with time" of Dunne provides strong support for the prediction that dreams can be precognitive [J40] . Also Joe McMoneagle has told in his book about height ened precognitive abilities during lucid dreaming [J75] . Probably almost anyone has had dreams which develop logically to the ringing of the alarm clock.
3. In this picture the one who remembers, that is generates negative energy ME, is a natural candidate for the active participant in the process. Therefore precognizer can only calm his/her mind and try to "tune at the same wave length" in order to entangle with the self of geometric future and try to eliminate the mental images that would mask the precognized one and compete for metabolic resources. The tuning to the same wave length has quite literal meaning since the fundamental frequency of ME determined by its temporal duration characterizes what might be called the extension of the memory field. There is indeed evidence for the notion of memory field [J60] . If memory and precognition are aspects of the same phenomenon then also the notion of precognitive field makes sense.

PK and retro PK as essentially same phenomenon?

The ideas that PK is just motor action with target taking the role of the motor organs and motor action involves negative energy W ME leads to a new view about PK and retro PK.

1. Ordinary motor actions are initiated by higher level selves by sucking negative energy from motor organs and the process proceeds upwards in CNS to the direction of geometric past wherefrom classical response comes from. In the case of PK this would mean that psychokinesis would be initiated by psychokinesists by sucking energy from the target by sending negative energy MEs to the target. If this picture is correct, all motor actions, in particular PK, would be by definition retro PK since the reaction would occur in the geometric past always and only the time scale of the time lapse would distinguish between PK and retro PK.
2. One can of course imagine also a situation in which positive energy W MEs are generated and exotically ionize and entangle part of brain with a system located in the geometric future. Certainly this mechanism is not the one favored by the life in jungle. It is also far from obvious whether magnetic body has the needed metabolic energy resources to generate positive energy W MEs.

In the case of non-living targets one can imagine that PK able person is able to transfer the metabolic energy of his own biological body to the target, perhaps by sucking it first to his own magnetic body and sending then to the target. Target could also generate negative energy MEs send most naturally to motor organs or perhaps skin of the psychokinesist. This could induce

the flow of various particles to say atomic space-time sheets, where they can induce dissipative effects. This and the universality of metabolism based on zero point kinetic energies forces to consider quite seriously the possibility that the magnetic body of almost any system can be a conscious experiencer or an intentional agent.

3. Not all targets are optimal. Targets should allow the generation of dark plasmoids giving rise to dark plasma oscillations. Capacitor like systems near di-electric breakdown would be optimal in this respect and this kind of systems has been used in PK experiments (this is discussed in [K63] . Targets made of organic material are also favored. If all PK is actually retro PK, PK is possible only if the target is able to provide or receive from some source the metabolic energy needed. Organic or living targets would be optimal but one might expect that living systems have developed immune systems in order to avoid of becoming possessed by alien magnetic bodies. There are indeed reports about PK effects on films which have gelatin as one component [I55] : I have discussed a model for these effects in [K36] .
4. MEs can also play a role of mere control function by acting as bridges along which particles can flow between various space-time sheets but not accelerating the charges. The flow of particles between say magnetic flux tubes and atomic space-time-sheets induces a recoil effect and the explanation for the report of Modanese and [H8] [H7] about a new kind of radiation which induces motion of material particles without giving them appreciable energy, supports the view that this recoil effect can induce macroscopic motion. Also the model for the PK effects induced by Russian psychokinesists in charged objects at table near the critical potential inducing discharge leads to the idea that the flow of ions between space-time sheets inducing recoil effects is responsible for PK effect [K63] . Psychokinesist would provide the energy needed for the control of motion but that part of the momentum could come from (say) magnetic flux tubes carrying the ionic supra currents.
5. The idea about long term memory and precognition as different aspects of the same phenomenon does not generalize as such. Psychokinesist would perform (retro) PK to the target while living target could communicate sensory data as a reaction to the motor action coded into Josephson radiation giving rise to generalized EEGs. Hence remote sensing could appear as one aspect of PK and make possible controlled OK in the case that direct sensory input from the target is not available.

In the famous chicken-robot [J83] experiments chicken was imprinted to a robot with the consequence that the robots motion in room coded earlier to a random number sequence changed so that the robot tended to stay near chicken. In this case one could say that chicken performed retro PK in the computer program responsible for generating the random number sequence or sequence itself by generating negative energy MEs. The resulting PK effect on chicken was at the level of chicken brain and provided for chicken metabolic energy. Perhaps the interaction between child and parents involves a similar transfer of energy.

From remote viewing to quantum remote sensing?

Ordinary remote sensing technology is limited by the finite velocity of light making it impossible to remote sense actively objects that are too faraway. Time mirror mechanism (see Fig. 3.6.4) not only makes it possible to survive utilizing .3-.5 seconds old sensory data but also suggest a technology of active remote sensing based on time reflection at the studied object and thus involving no time lapse, and making possible remote sensing of arbitrarily distant, even astrophysical, objects.

A phase conjugate laser wave would travel to the geometric past and time-reflect back as an ordinary laser wave from an object containing population inverted many-sheeted laser mirrors. If negative energy ME is able to draw some critical number of particles to the ground state, a phase transition to the ground state occurs since the rate for the transition is proportional to the number of particles already existing in the ground state. The only additional condition is the presence of the many-sheeted population reversal. This condition could be satisfied for living matter at least.

Dela-Warr camera [J108] might be based on this mechanism. Even more science-fictively and a little bit of tongue in cheek, one can consider also the possibility of communicating with the civilizations of the geometric future by using population inverted lasers. Send to the geometric future classical k-bit

signals (k harmonics of the fundamental) at p-adic frequencies $f(n, k)$ to tell that we have discovered p-adic cognitive codes, and wait whether the population inverted lasers at these frequencies return to the ground state with an abnormally high rate! One can easily imagine simple codes for communication. For instance, for p-adic length scales corresponding to visible wave lengths the typical number of bits would be 163.

In the technological context remote metabolism would translate to a remote utilization of energy stores making un-necessary the costly transport of the fuel. Only negative energy signal of critical intensity would be required to generate amplified positive energy signal from the geometric past providing the energy instantaneously and over long distances. For instance, the need to carry large amounts of fuel and the limitations posed by the maximal classical signal velocity are the basic problems of the space technology. The technological variant of the remote metabolism might provide at least a partial solution to these problems.

3.6 About the nature of time

3.6.1 Background

The notion of time remains one of the most problematic concepts of physics. In classical physics the different properties of the time of Newton's equations and thermodynamical time are puzzling. In special relativity and general relativity the notion of simultaneity becomes a problematic concept and challenges the naive Newtonian view about time flow as a motion of 3-D time=constant snapshot of 4-D space-time. The replacement of time=constant 3-surface with past directed light-cone assignable to the world-line of observer resolves this problem. In general relativity the problem is that past light-cones need make sense only locally. In quantum measurement theory the localization of the state function reduction process into a finite space-time volume is in conflict with the determinism of Schrödinger equation. In biology the presence of self-organization processes like self assembly challenge second law of thermodynamics in short time scales. In neuroscience the finding of Libet suggesting that neural activity seems to precede conscious decision forces to give up the notion of free will or the naive identification of experienced and geometrical time.

In this essay I will consider a new view about time based on Topological Geometroynamics [K90], which can be regarded as an attempt to unify fundamental interactions assuming that space-times are representable as 4-dimensional surfaces of certain higher-dimensional space-time $H = M^4 \times CP_2$ (M^4 denotes 4-D Minkowski space and CP_2 complex projective space of 2 complex dimensions) fixed by the requirement that the theory explains standard model symmetries and provides a geometrization of classical gauge fields and gravitational fields.

The construction of quantum TGD leads to a radical revision of space-time concept (many-sheeted space-time and topological field quantization), and forces also to generalize the original view about imbedding space. p-Adic physics as physics of cognition and intentionality is part of TGD inspired theory of consciousness and the need to fuse real and p-adic physics to single coherent whole forces to revise the notions of number and space-time. It has been also necessary to replace the standard positive energy ontology with what I call zero energy ontology. These generalizations are of special importance in TGD inspired theory of consciousness and of quantum biology.

There are several first principle approaches to quantum TGD and following gives only a very concise summary of them.

1. Generalization of Einstein's program of geometrizing classical physics so that quantum theory can be seen as a theory of *classical* spinor fields in the world of classical worlds (WCW) consisting of light-like 3-surfaces and possessing Kähler geometry [K18, K16]. By general coordinate classical physics becomes an exact part of quantum theory in a well-defined sense. A geometrization of Fermi statistics is obtained, and the Clifford algebra associated with the spinors of WCW can be regarded as a direct sum of von Neumann algebras known as hyper-finite factors of type II₁ (HFFs) closely related to quantum groups and non-commutative geometry;
2. Quantum TGD as almost topological field theory (TQFT) with fundamental objects identified as light-like 3-surfaces and having generalized super-conformal symmetries as symmetries [K20, K19]: the notion of braid is the basic building block of this approach;

3. There are two kinds of conformal symmetries corresponding to the boundary of light-cone of Minkowski space and light-like 3-surfaces, and these symmetries alone dictate to high degree the physics. Quite recently it turned that also a symplectic analog of conformal field theory emerges naturally in TGD framework (super-symplectic symmetries) and this led to a concrete proposal for how to construct n-point functions needed to calculate M-matrix [K90] ;
4. Physics as a generalized number theory involving three different threads corresponding to need fuse real and various p-adic physics to single coherent whole by using a generalization of number concept obtained by gluing reals and various p-adic number fields and their extensions together along rationals and common algebraics [K79] ; the observation that standard model symmetries and dynamics of quantum and classical TGD are to high degree dictated by classical number fields [K80] ; and the ideas inspired by the notion of infinite prime [K78] ;
5. The identification of WCW Clifford algebra elements as hyper-octonion (subspace of complexified octonions spanned by real unit and octonionic imaginary units multiplied by the commuting additional imaginary unit) valued conformal fields having values in HFF provides a justification for the concept of number theoretic braid needed both in the fusion of real and p-adic physics and in TGD as almost TQFT approach;
6. The hierarchy of Planck constants realizing quantum criticality [K29] forces a generalization of the notion of imbedding space by replacing it with a book like structure having as its pages singular coverings and factor spaces of H and allowing to realize geometric correlates for the choice of quantization axis in quantum measurement: the particles at different pages of this book are "relatively dark" since they do not possess local interaction vertices which means a radically new manner to interpret dark matter;
7. Zero energy ontology and the notion of finite measurement resolution formulated in terms of inclusions of HFFs fix quantum dynamics highly in terms of Connes tensor product allowing to interpret quantum theory as a square root of thermodynamics [K90, K19] : finite measurement resolution has number theoretic braid as its space-time correlate so that various approaches to TGD are closely related;
8. Quantum theory of consciousness as a generalization of quantum measurement theory to include observer to the theory [L13] .

The notion of number theoretic braid is a common denominator of various approaches to quantum TGD and leads to effective discretization of the imbedding space which is however due to the finite measurement resolution and number theoretic constraints rather than being something fundamental so that there are no problems with standard conservation laws.

The article series about TGD and its applications to biology and consciousness [L15, L13, L12, L9, L11, L10, L8, L14] gives an overall view about quantum TGD. In the following I will concentrate only on the aspects of quantum TGD relevant for the notion of time. I will first describe zero energy ontology and p-adicization program and after that consider the problem of time.

3.6.2 The most recent vision about zero energy ontology and p-adicization

The generalization of the number concept obtained by fusing real and p-adics along rationals and common algebraics is the basic philosophy behind p-adicization. One must be able to speak about rational points common to real and various p-adic variants of H . The basic objection is the necessity to fix some special coordinates in turn implying the loss of a manifest general coordinate invariance. The isometries of the imbedding space could save the situation provided one can identify some special coordinate system in which isometry group reduces to its discrete subgroup. The loss of the full isometry group could be compensated by assuming that WCW is union over sub-WCWs obtained by applying isometries on basic sub-WCW with discrete subgroup of isometries.

The combination of zero energy ontology realized in terms of a hierarchy of causal diamonds (CD s) and hierarchy of Planck constants providing a description of dark matter and leading to a generalization of the notion of imbedding space suggests that it is possible to realize this dream. The article [K90] provides a brief summary about recent state of quantum TGD helping to understand the big picture behind the following considerations.

Zero energy ontology briefly

1. The basic construct in the zero energy ontology is the space $CD \times CP_2$, where the causal diamond CD is defined as an intersection of future and past directed light-cones with time-like separation between their tips regarded as points of the underlying universal Minkowski space M^4 . In zero energy ontology physical states correspond to pairs of positive and negative energy states located at the boundaries of the future and past directed light-cones of a particular CD .
2. CD s form a fractal hierarchy and one can glue smaller CD s within larger CD s. This construction recipe when combined with TGD inspired theory of consciousness allows to understand the asymmetry between positive and negative energies and why the arrow of experienced time corresponds to the arrow of geometric time and why the contents of sensory experience is located to so narrow interval of geometric time. One can imagine evolution to occur as quantum leaps in which the size of the largest CD in the hierarchy of personal CD s increases in such a manner that it becomes sub- CD of a larger CD . p-Adic length scale hypothesis [K90] follows if the values of temporal distance T between tips of CD come in powers of 2^n : $T = 2^n T_0$. All conserved quantum numbers for zero energy states have vanishing net values. The interpretation of zero energy states in the framework of positive energy ontology is as physical events, say scattering events with positive and negative energy parts of the state interpreted as initial and final states of the event.
3. In the realization of the hierarchy of Planck constants $CD \times CP_2$ is replaced with a Cartesian product of book like structures formed by almost copies of CD s and CP_2 s defined by singular coverings and factor spaces of CD and CP_2 with singularities corresponding to intersection $M^2 \cap CD$ and homologically trivial geodesic sphere S^2 of CP_2 for which the induced Kähler form vanishes. The coverings and factor spaces of CD s are glued together along common $M^2 \cap CD$. The coverings and factor spaces of CP_2 are glued together along common homologically non-trivial geodesic sphere S^2 . The choice of preferred M^2 as subspace of tangent space of X^4 at all its points and interpreted as space of non-physical polarizations, brings M^2 into the theory also in different manner. S^2 in turn defines a subspace of the much larger space of vacuum extremals as surfaces inside $M^4 \times S^2$.
4. Configuration space (the world of classical worlds, WCW) decomposes into a union of sub-WCWs corresponding to different choices of M^2 and S^2 and also to different choices of the quantization axes of spin and energy, color isospin and hyper-charge for each choice of this kind. This means breaking down of the isometries to a subgroup. This can be compensated by the fact that the union can be taken over the different choices of this subgroup.
5. p-Adicization requires a further breakdown to discrete subgroups of the resulting sub-groups of the isometry groups but again a union over sub-WCWs corresponding to different choices of the discrete subgroup can be assumed. Discretization relates also naturally to the notion of number theoretic braid.

WCW spinor fields

In TGD framework zero energy states correspond to the modes of completely classical WCW spinor fields with fermionic second quantization at space-time level having purely geometric interpretation at the level of WCW. The analysis of the degrees of freedom involved demonstrates that WCW spinor fields are analogous to ordinary quantum fields but have infinite number of components.

1. WCW decomposes to a sub-WCWs association with unions of causal diamonds (CD s). Individual CD is partially characterized by the moduli defined by the positions of its upper and lower tips. The proposal is that the temporal distances between the tips are quantized in octaves of CP_2 time scale and thus coming in good approximation as secondary p-adic time scales for primes very near to power of two. The most general proposal is that also the position of the upper tip at proper time = constant hyperboloid of future lightcone M^4_+ is quantized for positive energy states. For negative energy states this happens to the lower tip. This discrete set would provide a discretized quantum version of Robertson-Walker cosmology with discretized lattice like structure replacing the continuum. The interpretation would be that first tip corresponds

to the usual Minkowski space-time of special relativity and the discretized position of second tip - or rather the space M_{\pm}^4 representing the relative position of the tips- to the space-time of cosmology. This implies very strong predictions such as the quantization of cosmic redshifts which is indeed observed [K73]. Similar quantization would take place in CP_2 degrees of freedom for either tip. WCW spinor fields for single CD would depend on these moduli and for positive (negative) states one would have wave functions in the space formed by sub-WCWs with wave function basis consisting of products of plane waves in M^4 with a wave function in the discrete subset of M_{\pm}^4 . These degrees of freedom generalize those of a quantum field in Minkowski space. If the upper tip is assigned with observer, the sub- CD s in the interior of CD correspond to astrophysical objects and M_{\pm}^4 as empty Robertson-Walker cosmology predicts automatically cosmic redshift.

2. The notion of generalized imbedding space forces to assign to a given CD a selection of quantization axis of energy and spin which in the case of M^4 boils down to a choice of a preferred plane $M^2 \subset M^4$ plus a choice of time direction (rest system). In the case of CP_2 the choice of quantization axes of color isospin and hypercharge means a choice of a homologically trivial geodesic sphere of CP_2 plus preferred isospin quantization axes. The space for possible choices of quantization axis defines additional moduli. The selection of quantization axes in state function reduction means a localization in these degrees of freedom. The space characterizing the selections of color quantization axis represents an example of so called flag manifold. It has already earlier appeared in TGD inspired biology with a motivation coming from the observation of topologists Barbara Shipman that the mathematical model for honeybee dance leads naturally to the introduction of this space. Shipman speculated that quarks have some role in biology [A13]. Dark matter hierarchy indeed makes indeed possible scaled up copies of QCD type theory in biological length scales.
3. WCW spinor fields restricted to a CD with fixed moduli have infinite number of bosonic and fermionic degrees of freedom. Spin-like degrees of freedom for these fields correspond to WCW spinors, which describe many-fermion states consisting of quarks and leptons and bosons defined as their bound states. This Fock state is assigned to each 3-surface and the dependence on 3-surface defines purely bosonic ('orbital') degrees of freedom, which can be coded by using a state basis whose elements have well-defined spin and color quantum numbers. The bosonic and fermionic degrees of freedom are super-symmetrically related.

Is it really possible to speak about zero energy states for a given sector defined by generalized imbedding space with fixed M^2 and S^2 ? Classically this is possible and conserved quantities are well defined. In quantal situation the presence of the light-cone boundaries breaks full Poincare invariance although the infinitesimal version of this invariance is preserved. Note that the basic dynamical objects are 3-D light-like "legs" of the generalized Feynman diagrams glued together along their ends at generalized vertices.

Definition of energy in zero energy ontology

The approach relying on the two super conformal structures of quantum TGD gives hopes of defining the notion of energy for positive and negative energy parts of the state.

1. CD allows translational invariance only in its interior and since partonic two surfaces are located to the boundary of CD , one can argue that translations assigned to them lead out from CD . One can however argue that if it is enough to assign eigentates of four-momentum to partons and require that only the total four-momentum generators acts on the physical state by shifting CD . Since total four-momentum vanishes for CD this would mean that wave function in cm degrees of CD is just constant plane wave. Super-conformal invariance would indeed allow to assign momentum eigenstates to the super-conformal representations.
2. A more stringent condition would be that four-momentum generators act as translation like operators on partons themselves. Since light-like 3-surfaces assignable to incoming and outgoing legs of the generalized Feynman diagrams are the basic objects, one can hope of having enough translational invariance to define the notion of energy. If translations are restricted

to time-like translations acting in the direction of the future (past) then one has local translation invariance of dynamics for classical field equations inside δM_{\pm}^4 as a kind of semigroup. Also the M^4 translations leading to interior of X^4 from the light-like 2-surfaces surfaces act as translations. Classically these restrictions correspond to non-tachyonic momenta defining the allowed directions of translations realizable as particle motions. These two kinds of translations have been assigned to super-symplectic conformal symmetries at $\delta M_{\pm}^4 \times CP_2$ and and super Kac-Moody type conformal symmetries at light-like 3-surfaces. Equivalence Principle in TGD framework states that these two conformal symmetries define a structure completely analogous to a coset representation of conformal algebras so that the four-momenta associated with the two representations are identical [K20] .

Finite M^4 translations to the interior of CD do not respect the shape of the partonic 2-surface. Local M^4 translations vanishing at the boundary of CD however act as Kac-Moody symmetries of the light-like 3-surfaces and reduce physically to gauge transformations: hence one could allow also the deformations of the partonic 2-surface in the interior of the light-like 3-surface. This corresponds to the effective metric 2-dimensionality stating that all information both about the geometry of WCW and quantum physics is carried by the partonic 2-surfaces X^2 resulting as intersections of the light-like 3-surfaces X_1^3 and space-like 3-D surfaces X^3 at the boundaries of CD and the distribution of 4-D tangent planes of X^2 .

3. The condition selecting preferred extremals of Kähler action is induced by a global selection of $M^2 \subset M^4$ as a plane belonging to the tangent space of X^4 at all its points [K20] and interpreted as a plane of nonphysical polarizations so that direct connection with number theory and gauge symmetries emerges. The M^4 translations of X^4 as a whole in general respect the form of this condition in the interior. Furthermore, if M^4 translations are restricted to M^2 , also the condition itself - rather than only its general form - is respected. This observation, the earlier experience with p-adic mass calculations, and also the treatment of quarks and gluons in QCD encourage to consider the possibility that translational invariance should be restricted to M^2 translations so that mass squared, longitudinal momentum and transversal mass squared would be well defined quantum numbers. This would be enough to realize zero energy ontology. Encouragingly, M^2 appears also in the generalization of the causal diamond to a book-like structure forced by the realization of the hierarchy of Planck constant at the level of the imbedding space.
4. That the cm degrees of freedom for CD would be gauge like degrees of freedom sounds strange. The paradoxical feeling disappears as one realizes that this is not the case for sub- CD s, which indeed can have non-trivial correlation functions with either upper or lower tip of the CD playing a role analogous to that of an argument of n-point function in QFT description. One can also say that largest CD in the hierarchy defines infrared cutoff.

p-Adic variants of the imbedding space

The need to fuse p-adic physics with TGD emerged originally from the discovery that p-adic mass calculations based on p-adic thermodynamics give excellent predictions for elementary particle masses if one assumes p-adic length scale hypothesis stating that primes near integer powers of 2 are physically favored [K90] . Later came the interpretation of p-adic physics as cognition cognition and intentionality. The following somewhat technical construction of p-adic variants of the imbedding space provides new insights concerning the understanding of the arrow of geometric time.

1. Rational values of p-adic coordinates are non-negative so that light-cone proper time $a_{4,+} = \sqrt{t^2 - z^2 - x^2 - y^2}$ is the unique Lorentz invariant choice for the p-adic time coordinate near the lower tip of CD . For the upper tip the identification of a_4 would be $a_{4,-} = \sqrt{(t-T)^2 - z^2 - x^2 - y^2}$. In the p-adic context the simultaneous existence of both square roots poses additional conditions on T . For 2-adic numbers $T = 2^n T_0$, $n \geq 0$ (or more generally $T = \sum_{k \geq n_0} b_k 2^k$), would allow to satisfy these conditions, which would be one additional reason for $T = 2^n T_0$ implying p-adic length scale hypothesis. The remaining coordinates of CD are naturally (hyperbolic) cosines and sines of the spherical coordinates θ and ϕ (hyperbolic angle $\eta_{\pm,4}$).
2. The existence of the preferred plane M^2 of un-physical polarizations would suggest that 2-D light-cone proper times $a_{2,+} = \sqrt{t^2 - z^2}$ $a_{2,-} = \sqrt{(t-T)^2 - z^2}$ can be also considered. The remaining coordinates would be naturally $\eta_{\pm,2}$ and cylindrical coordinates (ρ, ϕ) .

3. The p-adically transcendental values of a_4 and a_2 are literally infinite as real numbers and could be visualized as points in infinitely distant geometric future so that the arrow of time might be said to emerge number theoretically.
4. The selection of the preferred quantization axes of energy and angular momentum unique apart from a Lorentz transformation of M^2 would have purely number theoretic meaning in both cases. One must allow a union over sub- WCW s labeled by points of $SO(1, 1)$. This suggests a deep connection between number theory, quantum theory, quantum measurement theory, and even quantum theory of mathematical consciousness.
5. In the case of CP_2 there are three real coordinate patches involved [A16]. The compactness of CP_2 allows to use cosines and sines of the preferred angle variable for a given coordinate patch.

$$\begin{aligned}\xi^1 &= \tan(u) \exp(i \frac{(\Psi + \Phi)}{2}) \cos(\frac{\Theta}{2}) , \\ \xi^2 &= \tan(u) \exp(i \frac{(\Psi - \Phi)}{2}) \sin(\frac{\Theta}{2}) .\end{aligned}\tag{3.6.1}$$

The ranges of the variables u, Θ, Φ, Ψ are $[0, \pi/2], [0, \pi], [0, 4\pi], [0, 2\pi]$ respectively. Note that u has naturally only positive values in the allowed range. S^2 corresponds to the values $\Phi = \Psi = 0$ of the angle coordinates.

6. The rational values of the (hyperbolic) cosine and sine correspond to Pythagorean triangles having sides of integer length and thus satisfying $m^2 = n^2 + r^2$ ($m^2 = n^2 - r^2$). These conditions are equivalent and allow the well-known explicit solution [A1]. One can construct a p-adic completion for the set of Pythagorean triangles by allowing p-adic integers which are infinite as real integers as solutions of the conditions $m^2 = r^2 \pm s^2$. These angles correspond to genuinely p-adic directions having no real counterpart. Hence one obtains p-adic continuum also in the angle degrees of freedom. Algebraic extensions of the p-adic numbers bringing in cosines and sines of the angles π/n lead to a hierarchy increasingly refined algebraic extensions of generalized imbedding space. Since the different sectors of WCW directly serve as correlates of selves, this means a direct correlation with the evolution of the mathematical consciousness. Trigonometric identities allow to construct points which in the real context correspond to sums and differences of angles.
7. Negative rational values of the cosines and sines correspond as p-adic integers to infinite real numbers and it seems that one use several coordinate patches obtained as copies of the octant ($x \geq 0, y \geq 0, z \geq 0, .$). An analogous picture applies in CP_2 degrees of freedom.

3.6.3 Zero energy ontology, self hierarchy, and the notion of time

Consider now the formulation of TGD inspired quantum theory of consciousness [L13] and quantum biology [L12] in terms of zero energy ontology.

One should understand the asymmetry between positive and negative energies and between two directions of geometric time at the level of conscious experience, the correspondence between experienced and geometric time, and the emergence of the arrow of time. One should explain why human sensory experience is about a rather narrow time interval of about .1 seconds and why memories are about the interior of much larger CD with time scale of order life time. One should have a vision about the evolution of consciousness: how quantum leaps leading to an expansion of consciousness occur.

Negative energy signals to geometric past - about which phase conjugate laser light represents an example - provide an attractive tool to realize intentional action as a signal inducing neural activities in the geometric past (this would explain Libet's classical findings), a mechanism of remote metabolism, and the mechanism of declarative memory as communications with geometric past. One should understand how these signals are realized in zero energy ontology and why their occurrence is so rare.

In the following I try to demonstrate that TGD inspired theory of consciousness and quantum TGD proper indeed are in tune.

Space-time and imbedding space correlates for selves

Quantum jump as a moment of consciousness, self as a sequence of quantum jumps integrating to self, and self hierarchy with sub-selves experienced as mental images, are the basic notions of TGD inspired theory of consciousness. In the most ambitious vision self hierarchy reduces to a fractal hierarchy of quantum jumps within quantum jumps. Quantum classical correspondence demands selves to have space-time correlates both at the level of space-time and imbedding space.

At the level of space-time the first guess for the correlates is as light-like or space-like 3-surfaces. If one believes on effective 2-dimensionality and quantum holography, partonic 2-surfaces plus their 4-D tangent space distribution would code the information about the space-time correlates. By quantum classical correspondence one can also identify space-time sheets as the correlates modulo the gauge degeneracy implied by super-conformal symmetries.

It is natural to interpret *CDs* as correlates of selves at the level of the imbedding space. *CDs* can be interpreted either as subsets of the generalized imbedding space or as sectors of WCW. Accordingly, selves correspond to *CDs* of the generalized imbedding space or sectors of WCW, literally separate interacting quantum Universes. The spiritually oriented reader might speak of Gods. Sub-selves correspond to sub-*CDs* geometrically. The contents of consciousness of self is about the interior of the corresponding *CD* at the level of imbedding space. For sub-selves the wave function for the position of tip of *CD* brings in the delocalization of sub-WCW.

The fractal hierarchy of *CDs* within *CDs* is the geometric counterpart for the hierarchy of selves: the quantization of the time scale of planned action and memory as $T(k) = 2^k T_0$ suggest an interpretation for the fact that we experience octaves as equivalent in music experience.

Why sensory experience is about so short time interval?

CD picture implies automatically the 4-D character of conscious experience and memories form part of conscious experience even at elementary particle level. Amazingly, the secondary p-adic time scale of electron is $T = 0.1$ seconds defining a fundamental time scale in living matter. The problem is to understand why the sensory experience is about a short time interval of geometric time rather than about the entire personal *CD* with temporal size of order life-time. The explanation would be that sensory input corresponds to subselves (mental images) with $T \simeq .1$ s at the upper light-like boundary of *CD* in question. This requires a strong asymmetry between upper and lower light-like boundaries of *CDs*.

The localization of the contents of the sensory experience to the upper light-cone boundary and local arrow of time could emerge as a consequence of self-organization process involving conscious intentional action. Sub-*CDs* would be in the interior of *CD* and self-organization process would lead to a distribution of *CDs* concentrated near the upper or lower boundary of *CD*. The local arrow of geometric time would depend on *CD* and even differ for *CD* and sub-*CDs*.

1. The localization of contents of sensory experience to a narrow time interval would be due to the concentration of sub-*CDs* representing mental images near the either boundary of *CD* representing self.
2. Phase conjugate signals identifiable as negative energy signals to geometric past are important when the arrow of time differs from the standard one in some time scale. If the arrow of time establishes itself as a phase transition, this kind of situations are rare. Negative energy signals as a basic mechanism of intentional action and transfer of metabolic energy would explain why living matter is so special.
3. Geometric memories would correspond to subselves in the interior of *CD*, the oldest of them to the regions near "lower" boundaries of *CD*. Since the density of sub-*CDs* is small there geometric memories would be rare and not sharp. A temporal sequence of mental images, say the sequence of digits of a phone number, would correspond to a temporal sequence of sub-*CDs*.
4. Sharing of mental images corresponds to a fusion of sub-selves/mental images to single sub-self by quantum entanglement: the space-time correlate could be flux tubes connecting space-time sheets associated with sub-selves represented also by space-time sheets inside their *CDs*.

Arrow of time

TGD forces a new view about the relationship between experienced and geometric time. Although the basic paradox of quantum measurement theory disappears the question about the arrow of geometric time remains. There are actually two times involved. The geometric time assignable to the space-time sheets and the M^4 time assignable to the imbedding space.

Consider first the the geometric time assignable to the space-time sheets.

1. Selves correspond to CD s. The CD s and their projections to the imbedding space do not move anywhere. Therefore the standard explanation for the arrow of geometric time cannot work.
2. The only plausible interpretation at classical level relies on quantum classical correspondence and the fact that space-times are 4-surfaces of the imbedding space. If quantum jump corresponds to a shift for a quantum superposition of space-time sheets towards geometric past in the first approximation (as quantum classical correspondence suggests), one can understand the arrow of time. Space-time surfaces simply shift backwards with respect to the geometric time of the imbedding space and therefore to the 8-D perceptive field defined by the CD . This creates in the materialistic mind a temporal variant of train illusion. Space-time as 4-surface and macroscopic and macro-temporal quantum coherence are absolutely essential for this interpretation to make sense.

Why this shifting should always take place to the direction of geometric past of the imbedding space? Does it so always? The proposed mechanism for the localization of sensory experience to a short time interval suggests an explanation in terms of intentional action.

1. CD defines the perceptive field for self. Negentropy Maximization Principle (NMP) or its strengthened form could be used to justify the hypothesis that selves quite universally love to gain information about the un-known. In other words, they are curious to know about the space-time sheets outside their perceptive field (the future). Therefore they perform quantum jumps tending to shift the superposition of the space-time sheets so that unknown regions of space-time sheets emerge to the perceptive field. Either the upper or lower boundary of CD wins in the competition and the arrow of time results as a spontaneous symmetry breaking. The arrow of time can depend on CD but tends to be the same for CD and its sub- CD s. Global arrow of time could establish itself by a phase transitions establishing the same arrow of time globally by a mechanism analogous to percolation phase transition.
2. Since the news come from the upper boundary of CD , self concentrates its attention to this region and improves the resolution of sensory experience. The sub- CD s generated in this manner correspond to mental images with contents about this region. Hence the contents of conscious experience, in particular sensory experience, tends to be about the region near the upper boundary.
3. Note that the space-time sheets need not to continue outside the CD of self but self does not know this and believes that there is something there to be curious about. The quantum jumps inducing what reduces to a shift in region sufficiently far from upper boundary of CD creates a new piece of space-time surface! The non-continuation of the space-time sheet outside CD would be a correlate for the fact that subjective future does not exist.

The emergence of the arrow of time at the level of imbedding space reduces to a modification of the oldest TGD based argument for the arrow of time which is wrong as such. If physical objects correspond to 3-surfaces inside future directed light-cone then the sequence of quantum jumps implies a diffusion to the direction of increasing value of light-cone proper time. The modification of the argument goes as follows.

1. CD s are characterized by their moduli. In particular, the relative coordinate for the tips of CD has values in past light cone M^4 if the future tip is taken as the reference point. An attractive interpretation for the proper time of M^4 is as cosmic time having quantized values. Quantum states correspond to wave functions in the modular degrees of freedom and each U process creates a non-localized wave function of this kind. Suppose that state function reduction implies

a localization in the modular degrees of freedom so that CD is fixed completely apart from its center of mass position to which zero four-momentum constant plane wave is assigned. One can expect that in average sense diffraction occurs in M_+^4 so that the size of CD tends to increase and that the most distant geometric past defined by the past boundary of CD recedes. This is nothing but cosmic expansion. This provides a formulation for the flow of time in terms of a cosmic redshift. This argument applies also to the positions of the sub- CD s inside CD . Also their proper time distance from the tip of CD is expected to increase.

2. One can argue that one ends up with contradiction by changing the roles of upper and lower tips. In the case of CD itself is only the proper time distance between the tips which increases and speaking about "future" and "past" tips is only a convention. For sub- CD s of CD the argument would imply that the sub- CD s drifting from the opposite tips tend to concentrate in the middle region of CD unless either tip is in a preferred position. This requires a spontaneous selection of the arrow of time. One could say that the cosmic expansion implied by the drift in M_+^4 "draws" the space-time sheet with it to the geometric past. The spontaneous generation of the asymmetry between the tips might require the "curious" conscious entities.

The mechanism of self reference

Self reference is perhaps the most mysterious aspect of conscious experience. When formulated in somewhat loose manner self reference states that self can be conscious about being conscious of something. When trying to model this ability in say computer paradigm one is easily led to infinite regress. In TGD framework a weaker form of self referentiality holds true: self can become conscious that it *was* conscious of something in previous quantum jump(s). Self reference therefore reduces to memory. Infinite regress is replaced with evolution recreating Universe again and again and adding new reflective levels of consciousness. It is however essential to have also the experience that memory is in question in order to have self reference. This knowledge implies that a reflective level is in question.

The mechanism of self reference would reduce to the ability to code information about quantum jump into the geometry and topology of the space-time surface. This representation defines an analog of written text which can be read if needed: memory recall is this reading process. The existence of this kind of representations means quantum classical correspondence in a generalized sense: not only quantum states but also quantum jump sequences responsible for conscious experience can be coded to the space-time geometry. The reading of this text induces self-organization process re-generating the original conscious experience or at least some aspects of it (say verbal representation of it). The failure of strict classical determinism for Kähler action is absolutely essential for the possibility to realize quantum classical correspondence in this sense.

Consider now the problem of coding conscious experience to space-time geometry and topology so that it can be read again in memory recall. Let us first list what I believe to know about memories.

1. In TGD framework memories corresponds to sub- CD s inside CD s and are located in geometric past. This means fundamental difference from neuroscience view according to which memories are in the geometric now. Note that standard physicist would argue that this does not make sense: by the determinism of field equations one cannot think 4-dimensionally. In TGD however field equations fail to be deterministic in the standard sense: this actually led to the introduction of zero energy ontology.
2. The reading wakes up mental images which are essentially 4-D self-organization patterns inside sub- CD s in the geometric past. Metabolic energy is needed to achieve this wake up. What is needed is generation of space-time sheets representing the potential images making possible memories.

This picture combined with the mechanism for generating the arrow of psychological time and explaining why sensory experience is located to so short time interval as it is (.1 second, the time scale of CD associated with electron by p-adic length scale hypothesis) allows to understand the mechanism of self reference. It deserves to be mentioned that the discussion with Stephen Paul King in Time discussion group served as the midwife for this step of progress.

1. When the film makes a shift to the direction of geometric past in quantum jump subselves representing mental images representing the reaction to the "news" are generated. These correspond to sub-CDs contains space-time surfaces as correlates of subselves created and the information contents of immediate conscious experiences is about this region of space-time and imbedding space. They are like additional comment marks on the film giving information about what feelings the news from the geometric future stimulated.
2. In subsequent quantum jumps film moves downwards towards geometric past and markings defined in terms of space-time correlates for mental images are shifted backwards with the film and define the coding of information about previous conscious experience. In memory recall metabolic energy is feeded to these subsystems and they wake up and regenerate the mental images about the remembered aspect of the previous conscious experience. This would not be possible in positive energy ontology and if determinism in strict sense of the world would hold true.
3. Something must bring in the essential information that these experiences are memories rather than genuine sensory experiences (say). Something must distinguish between genuine experiences and memories about them. The space-time sheets representing self reference define cognitive representations. If the space-time sheets representing the correlates for self-referential mental images are p-adic, this distinction emerges naturally. That these space-time sheets are in the intersection of real and p-adic worlds is actually enough and also makes possible negentropic entanglement carrying the conscious information. In TGD inspired quantum biology this property is indeed the defining characteristic of life.
4. There is quite concrete mechanism for the realization of memories in terms of braidings of magnetic flux tubes discussed in [K28] .

Interesting questions relate to the role of p-adicity and the realization of the active aspects of consciousness. One can consider also quantum jumps in which the space-time surface inside CD does not suffer mere passive shift downwards but is affected also in the geometric past. The mechanism of intentional action, which could have been inspired by Libet's finding that neuronal activity seems to precede conscious decision, can be understood in terms of negative energy signals sent to the geometric past, where they generate neuronal activity replacing the space-time surface with a new one.

If p-adicity is involved, the possibility seems that comes to mind is that the space-time sheets representing the signal to the geometric past are first generated as p-adic space-time sheets representing intention and transformed in quantum jump to their real counterparts representing the "desire" for action in turn generating the action.

Can selves interact and evolve?

Interesting questions relate to how dynamical selves are.

1. Is self doomed to live inside the same sub-WCW eternally as a lonely god? This question has been already answered: there are interactions between sub-CDs of given CD, and one can think of selves as quantum superposition of states in CDs with wave function having as its argument the tips of CD, or rather only the second one since T is assumed to be quantized.
2. Is there largest CD in the personal CD hierarchy of self in an absolute sense? Or is the largest CD present only in the sense that the contribution to the contents of consciousness coming from very large CDs is negligible? Long time scales T correspond to low frequencies and thermal noise might mask these contributions. Here however the hierarchy of Planck constants and generalization of the imbedding space could come in rescue by allowing dark EEG photons to have energies above thermal energy.
3. Can selves evolve in the sense that the size of CD increases in quantum leaps so that the corresponding time scale $T = 2^k T_0$ of memory and planned action increases? Geometrically this kind of leap would mean that CD becomes a sub-CD of a larger CD - either at the level of conscious experience or in absolute sense. The leap can occur in two senses: as an increase of the largest p-adic time scale in the personal hierarchy of space-time sheets or as increase of

the largest value of Planck constants in the personal dark matter hierarchy. At the level of individual organism this would mean emergence of new lower frequencies of generalized EEG and levels of personal dark matter hierarchy with larger value of Planck constant.

3.6.4 What arrow of time means at the level of quantum states

?

The above discussion does not touch the question what arrow of time means at the level of quantum states. Therefore the notion of negative energy signal propagating backwards in geometric time crucial for TGD inspired quantum biology remains somewhat fuzzy. The recent progress in the understanding of the basic properties of zero energy states makes it possible to understand what arrow of geometric time and the notion of negative energy state and signals propagating to the direction of geometric past mean at the level of zero energy states. This understanding has surprisingly non-trivial philosophical implications.

Arrow of time as an inherent property of zero energy states?

The basic idea can be expressed in very concise form. In positive energy ontology arrow of time characterizes dynamics. In zero energy ontology arrow of time characterizes quantum states.

1. The breaking of time reversal invariance [K6] means that zero energy states can be localized with respect to particle number and other quantum numbers only for future or past light-like boundary of CD but not both. M -matrix generalizing S -matrix provides the time-like entanglement coefficients expressing the state at the second boundary as quantum superposition of states with well-defined particle numbers and other quantum numbers. But only at the second end of CD since one cannot choose freely the states at both boundaries: if this were the case the counterpart of Schrödinger equation would be completely non-deterministic. This is what the breaking of time reversal symmetry means. It occurs spontaneously and assigns to the arrow of subjective time geometric arrow of time.

This picture gives a precise meaning to the arrow of geometric time and therefore also for the otherwise fuzzy notion of negative energy signals propagating backwards in space-time playing key role in TGD based models of memory, metabolism, and intentional action [?]

2. Quantum jump begins with the unitary U -process between zero energy states generating a superposition of zero energy states. After that follows state function reduction cascade proceeding from the level of CD to the level of sub- CD s forming a fractal hierarchy. The reductions cannot take independently at both light-like boundaries of CD as is also clear from the fact that scattering state leads from a prepared state to a quantum superposition of prepared states.

The first guess is that the cascade takes place for the second boundary of CD only so that the arrow of geometric time would be same in all scales. This need not be the case always: the geometric arrow of time seems to change in some situations: phase conjugate laser light and spontaneous self-assembly of bio-molecules are good examples about this [K87, K88]. In fact, one of the defining properties of living matter could be just the possibility that the arrow of geometric time is not same in all scales (size scales of CD s) so that memory, metabolism, and intentional action become possible. In any case, the second end remains a superposition of quantum states.

The lack of quantum measurements at the second end of space-times could explain why the conscious percepts are sharply localized in time at the second end of CD . This could also allow to understand memories as reductions occurring at the second, non-standard, end of sub- CD s in the geometric past.

3. The correspondence between the reduced state and the quantum superposition of states at the opposite boundary of CD allows an interpretation in terms of logical implication arrow with all statements present in the superposition implying the statement represented by the reduced state. Only implication arrow rather than equivalence is possible unless the M -matrix is diagonal meaning that there are no interactions. If it is possible to diagonalize M -matrix then in diagonal basis one has equivalences. It must be however emphasized that the physically preferred state

basis fixed as in terms of eigenstates of density matrix does not allow diagonal M -matrix. Number theoretic conditions required that the density matrix corresponds to fixed algebraic extension of rationals can also make possible the diagonalization without leaving the extension and this condition might be highly relevant in the TGD inspired view about cognition relying on p -adic number fields and their algebraic extensions [K79].

4. In classical logic implication corresponds to the inclusion of subset by subset. In quantum case it corresponds to the inclusion for sub-space of state space. The inclusions of hyper-finite factors (WCW spinors define HFF of type II_1) realize the notion of finite measurement resolution, which would suggest that inclusion arrow has also interpretation in terms of finite measurement resolution.

All quantum states equivalent with a given state in the resolution used imply it. Finite measurement resolution would mean that there would infinite number of instances always in the quantum superposition representing the rule $A \rightarrow B$. Ironically, both finite measurement resolution and dissipation implying the arrow of geometric time and usually regarded as something negative from the point of view of information processing would be absolutely essential element of logical thinking in this framework.

5. Conscious theorem proving would have as correlate to building of sequences zero energy states representing $A \rightarrow B$, $B \rightarrow C$, $C \rightarrow D$ with basic building bricks representing simple basic rules. These sequences would represent more complex truths.

Does state function-state preparation sequence correspond to alternating arrow of geometric time?

The state function reduction at light-like boundary of CD implies delocalization at the opposite boundary. This inspires so fascinating questions.

1. Could the state function reduction process take place alternately at the two boundaries of CD so that a kind of flip-flop in which the arrow of geometric time changes back and forth would result, and have interpretation as an alternating sequence of state function reductions and state preparations in the framework of positive energy ontology?
2. State function reductions are needed for sensory percepts. Could the sleep-wake-up period correspond to this kind of process so that during what we call sleep the past boundary of our personal CD would be in wake-up state? Could dreams and memories represent sharing of mental images of this kind of consciousness? Could it be that in the time scale of entire life cycle death is accompanied by birth at the second boundary of personal CD ? Could this quantum physics representation for endless sequence of deaths and rebirths? Could the fact that old people often spend their last years in childhood have interpretation in this framework?
3. State preparation-reduction cycle might characterize only living matter whereas for inanimate matter second choice for the arrow of time would be dominant between two U -processes. TGD based reformulation [K86] of entropic gravity idea of Verlinde [B6] in terms of ZEO does not assume the absence of gravitons and the emergence of space-time. The formulation leads to the proposal that thermodynamical stability selects the arrow of the geometric time and that it could be different for matter and antimatter implying that matter and antimatter reside at different space-time sheets. This would explain the apparent absence of antimatter and also support the view that the arrow alternates only in living matter.

The arrow of geometric time and the arrow of logical implication

If physics is mathematics in the sense that there is nothing behind quantum states regarded as purely mathematical objects, Boolean logic must have a direct manifestation in the structure of physical states. Physical states should represent quantal Boolean statements which get their meaning via quantum jumps. In TGD framework WCW ("world of classical worlds") spinor fields represent quantum states of the Universe and WCW spinors correspond to fermionic Fock states for second quantized induced spinor fields at space-time surface. Fock state basis has interpretation in terms of Boolean algebra. In positive energy ontology the problem is that fermion number as a super-selection rule

would allow very limited number of Boolean statements to be represented. In ZEO the situation changes.

The fermionic parts of positive and negative energy parts can be seen as quantum superpositions of Boolean statements with fermion number in given mode (equal to 0 or 1) representing yes/no or true/false. Also various spin like quantum numbers associated with oscillator operators have same interpretation. Zero energy state could be seen as quantum superposition of pairs of elements of Boolean algebras associated with positive and negative energy parts of the zero energy state.

The first - and incorrect - interpretation is that zero energy state represents a quantum superposition of equivalent statements $a \leftrightarrow b$ and thus abstraction $A \leftrightarrow B$ involving several instances of A and B . The breaking of time reversal invariance allowing localization to definite fermionic quantum numbers at single end of CD only however implies that quantum states can only represent abstraction of logical implication to $A \rightarrow B$ rather than equivalence. p-Adic physics for various primes p could represent correlates for cognition and intentionality.

Figures

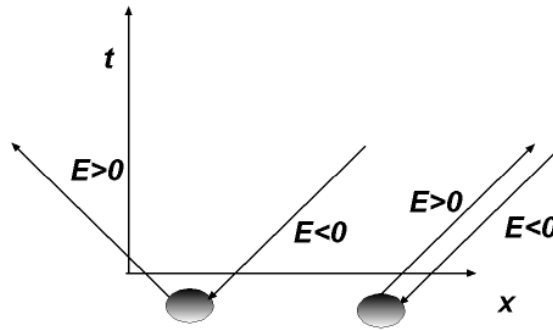


Figure 3.1: Time mirror mechanism

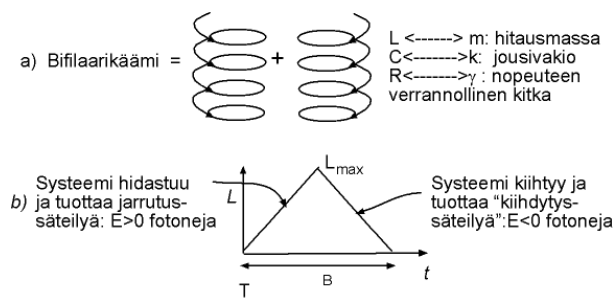


Figure 3.2: a) The structure of bi-filar coils and the mechanical analog of RCL circuit as a harmonic oscillator. b) The reduction of the mass of the harmonic oscillator at the second half of the magnetic pulse implies acceleration and generation of negative energy photons in order to get energy.

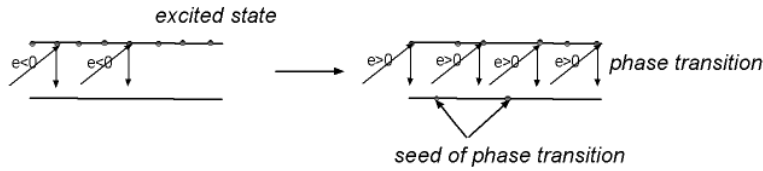


Figure 3.3: A mechanism of energy production based on negative energy topological light rays and population inversion.

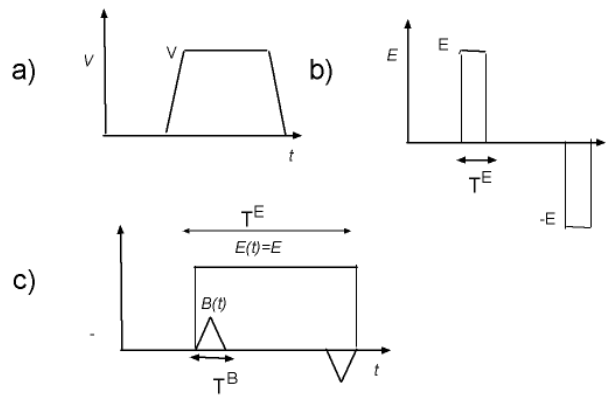


Figure 3.4: Constant voltage pulse (a) and the corresponding electric (b) and magnetic (c) pulses in the bi-filar coil.

$$p\text{-adic distance } |x-y|_p = p^{-n} \ll 1$$

$$\text{real distance } |x-y| = p^n \gg 1$$

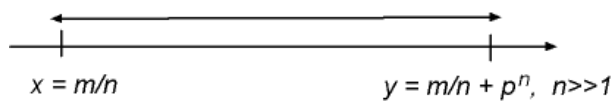


Figure 3.5: Rational valued points x and $y = x + p^n$, which are close to each other p-adically, are far from each other in real sense.

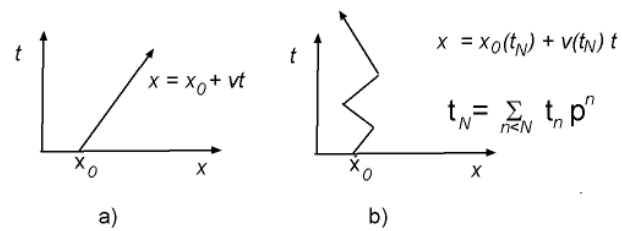


Figure 3.6: The non-determinism of p-adic differential equations in the case of a free particle. a) In real case the initial position x_0 and and velocity v determine the orbit. b) In the p-adic case x_0 and v are piecewise constant functions of time and the orbit resembles that associated with Brown motion.

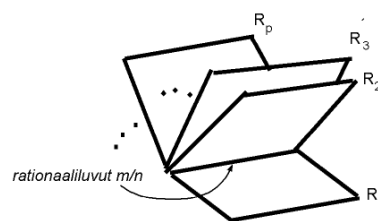


Figure 3.7: Rational numbers are common to both reals R and all p-adic number fields R_p , $p = 2, 3, \dots$. These number fields can be "glued" together along the rational numbers to form a book like structure. Rational numbers correspond to the rim of the book and different number fields to its pages.

Part II

**BIO-SYSTEMS AS CONSCIOUS
HOLOGRAMS**

Chapter 4

Macro-Temporal Quantum Coherence and Spin Glass Degeneracy

4.1 Introduction

The basic objection against quantum consciousness theories is that the de-coherence times for macroscopic quantum states are quite too short. This argument has been put in quantitative form by Mark Tegmark [J98] .

These counter arguments are however problematic. First of all, the notions of quantum coherence and de-coherence are problematic in standard physics framework since the non-determinism of the state function reduction is in conflict with the determinism of Schrödinger equation. The intuitive idea is however that one can estimate the de-coherence times as essentially lifetimes of quantum states. Secondly, the estimates for de-coherence times are based on standard physics, and it is quite possible that new physics is essential for understanding living matter. The belief that standard physics is enough is based only on the reductionistic dogma.

Penrose and Hameroff [J62] have proposed that some future theory of quantum gravitation makes it possible to replace the phenomenological notion of state function reduction with a more fundamental notion which they call Orch OR, that quantum gravitational effects make possible macroscopic quantum states of required long de-coherence time, and that micro-tubules are the systems, where these effects are especially important so that one might even speak about reduction of the consciousness to the micro-tubular level. Penrose and Hameroff have also proposed that micro-tubules could act as quantum computers. The quantum states involved would be quantum superpositions of tubulin conformations and quantum gravitation would somehow make these quantum superpositions stable. Long enduring quantum superpositions of the conformations of (say tubulin) molecules would allow to perform a multi-verse simulation for the conformational behaviour of the molecules and this would certainly have evolutionary value.

4.1.1 Macrotemporal quantum coherence is suggested by quantum classical correspondence

Topological Geometro-dynamics inspired theory of consciousness [K82] leads to a first principle theory of state function reduction and preparation free of the logical paradoxes, allows precise definitions for the notions of quantum coherence and de-coherence, and predicts a mechanism making the lifetimes of macroscopic bound states much longer than predicted by the standard physics. By quantum-classical correspondence the argument can be formulated at space-time level and configuration space (world of classical worlds) level.

At the space-time level coherence regions are identifiable as space-time sheets. They indeed are coherence regions for both classical fields and induced spinor fields defining single particle limit of the quantum theory. By quantum criticality of TGD Universe there is no upper bound for neither the spatial or temporal size of the space-time sheet and one obtains a p-adic hierarchy of coherence lengths

and de-coherence times. Finiteness of de-coherence time corresponds to the fact that energy flows to the space-time sheet from larger space-time sheet first and then back. Note that in the standard quantum field theory the entire Minkowski space M^4 is the natural identification for the coherence region, and it is difficult to understand how to describe the reduction to a smaller region of M^4 .

4.1.2 Macrotemporal quantum coherence from spin glass degeneracy?

At configuration space level the argument supporting macroscopic and macrotemporal quantum coherence goes as follows. The basic distinction between TGD and standard physics is quantum spin glass degeneracy [K69], which among other things implies that quantum bound states of, say, two molecules have enormous spin glass degeneracy absent in the free state. The intuitive expectation is that the system spends much longer time in bound states than in free states and this implies much longer de-coherence time than expected otherwise.

One can formulate this argument more rigorously using unitarity conditions implying that forward scattering amplitude for bound states is very large due to the spin glass degeneracy. The almost degenerate spin glass states differ only by their classical gravitational energy so that gravitation is indeed important. The importance of quantum gravitation is also obvious from the fact that genuine quantum gravitational states are state functionals in the world of worlds rather than in world so that they are expected to represent in some sense higher abstraction level than ordinary quantum states in the hierarchy of consciousness.

4.1.3 Dynamical Planck constant and dark matter hierarchy

Towards the end of 2004 I learned that there is evidence that planetary orbits obey Bohr quantization rules with a gigantic value of Planck constant [E6]. Nottale does not assume that this quantization is genuine but regards it as a hydrodynamical effect. In TGD framework the most natural interpretation is in terms of a dynamical Planck constant, and TGD predicts correctly the basic dimensionless parameter involved [K72, K92, K25]. TGD also forces to identify the matter in a phase with large Planck constant as dark matter.

This identification led to a vigorous evolution of ideas still continuing while I am writing this. Entire dark matter hierarchy with levels labelled by increasing values of Planck constant is predicted, and in principle TGD predicts the values of Planck constant if physics as a generalized number theory vision is accepted [K92]. Also a good educated guess for the spectrum of Planck constants emerges. The implications are non-trivial already at the level of hadron physics and nuclear physics and imply that condensed matter physics and nuclear physics are not completely disjoint disciplines as reductionism teaches us. One condensed matter application is a model of high T_c superconductivity predicting that the basic length scales of cell membrane and cell as scales are inherent to high T_c superconductors.

Living matter as ordinary matter quantum controlled by the dark matter hierarchy has turned out to be a particularly successful idea. The hypothesis has led to models for EEG predicting correctly the band structure and even individual resonance bands and also generalizing the notion of EEG [K26]. Also a generalization of the notion of genetic code emerges resolving the paradoxes related to the standard dogma [K43, K26]. A particularly fascinating implication is the possibility to identify great leaps in evolution as phase transitions in which new higher level of dark matter emerges [K26].

It seems safe to conclude that the dark matter hierarchy with levels labelled by the values of Planck constants explains the macroscopic and macro-temporal quantum coherence naturally. That this explanation is consistent with the explanation based on spin glass degeneracy is suggested by following observations. First, the argument supporting spin glass degeneracy as an explanation of the macro-temporal quantum coherence does not involve the value of \hbar at all. Secondly, the failure of the perturbation theory assumed to lead to the increase of Planck constant and formation of macroscopic quantum phases could be precisely due to the emergence of a large number of new degrees of freedom due to spin glass degeneracy. Thirdly, the phase transition increasing Planck constant has concrete topological interpretation in terms of many-sheeted space-time consistent with the spin glass degeneracy.

4.1.4 Implications of macrotemporal quantum coherence

The idea that the brain and perhaps all bio-matter, and even the entire Universe, can be regarded as a hologram of some type (see for instance, the articles of Miller and Webb [J77] and of Gariaev *et al* [I75]) has a long history but the question about the precise physical sense in which this holds true has remained without a satisfactory answer.

The concrete Maxwellian idea about hologram plate resulting as an outcome of interference of the reference beam and light scattered from an object can serve only as a guiding metaphor. First of all, coherence occurs only in what are called coherence regions and the problem is that Maxwellian theory does not really provide a first principle definition for the coherence regions. In quantum theory similar problem is encountered. Secondly, in living matter it is not at all clear whether reference beam exists at all. Third, living matter is a dynamic granular structure and far from a homogeneous hologram plate. Fourth, the idea about storing memories, one of the basic motivations of the hologram paradigm, has its own problems although multi-holograms are certainly possible.

In TGD framework topological quantization provides a precise first principle description of coherence. Topological quanta are the coherence regions of the classical field and classical de-coherence means the splitting of the space-time surface to topological quanta. This process gives rise to the granular structure of matter and space-time sheets in various length scales are excellent candidates for basic units of hologrammic structures at the this level of the p-adic length scale hierarchy. At quantum level bound state quantum entanglement having join along boundaries bonds as a space-time correlate is responsible for the macroscopic and macro-temporal quantum coherence. The new view about time means that there is no need for storing large number of holograms in the same physical substrate.

In the sequel I will discuss the following topics related to the macroscopic and macro-temporal quantum coherence.

1. The notion of the many-sheeted space-time and basic ideas of TGD inspired quantum theory of consciousness and bio-systems.
2. How macroscopic and temporal quantum coherence is made possible by the spin glass degeneracy in TGD Universe.
3. How a hierarchy of dark matter with levels labelled by the values of Planck constant emerges in TGD framework and how it implies macrotemporal quantum coherence.
4. Macro-temporal quantum coherence from the point of view of physics (thermodynamical, energetic and information theoretic aspects) with some comments about the implications for quantum computing.
5. Macro-temporal quantum coherence from the point of view of biology and conscious experience, in particular micro-tubular model for long term memories.

4.2 Background

To make things easier for the reader the basic ideas of TGD inspired theory of consciousness are summarized before the discussion of the macro-temporal quantum coherence.

4.2.1 The notions of quantum jump and self

The basic notions of TGD inspired theory of consciousness are quantum jump between quantum histories (rather than time=constant snapshots of single quantum history) as moment of consciousness, and the notion of self as sub-system able to remain unentangled in subsequent quantum jumps [K45, K70] . There is deep structural analogy with physics: quantum jump is the elementary particle of consciousness and selves are atoms, molecules,... of consciousness. What this ability to remain unentangled in subsequent quantum jumps really means is a highly non-trivial question. In the later sections an answer involving number theoretical considerations in an essential manner will be proposed.

Quantum jump as a moment of consciousness

Each quantum jump replaces the solution of field equations (universe) with a new one. Quantum jump involves three steps:

1. The unitary time development U giving rise to the S-matrix summarizing quantum physics as it is understood by particle physicist;
2. the counterpart of state function reduction;
3. and state preparation involving a sequence of self measurements.

U can be said to generate multi-verse, quantum superposition of potentialities, a state of oneness in which everything is entangled with everything. State function reduction and preparation in turn mean gradual decomposition of universe to maximally disentangled subsystems interpretable as conscious analysis. Thus oneness and separation are both basic aspects of consciousness. The sequence of quantum jumps defines subjective time whereas geometric (or physicist's) time corresponds to the fourth spatial coordinate. The distinction between these times allows to resolve the basic paradoxes of modern physics and philosophy of mind.

In zero energy ontology zero energy states replace positive energy states. They have vanishing total conserved quantum numbers and decompose into entangled pairs of positive and negative energy states localizable at the light-like boundaries of causal diamonds (CDs) defined as intersections of future and past directed light-cones. In zero energy ontology one state preparation and reduction combine to single reduction process with reduction and preparation assigned to positive and negative energy parts of the state.

Self

Self is by definition a sub-system able to remain unentangled in subsequent quantum jumps. Only bound state entanglement is stable in quantum jump and selves correspond to regions of the space-time surface having local topology in a given number field (real or p-adic number fields labelled by primes). p-Adic regions are interpreted as physical (non-conscious) correlates for imagination, intention and cognition whereas real regions correspond to matter. The unitary operator U could in principle generate entanglement also between p-adic and real regions (rational entanglement coefficients make sense in any number field), which is destroyed in the state function reduction step. This might be crucial for the generation of cognitive maps assigning to the states of matter (say reading of physical measurement apparatus) cognitive states (say mental image about the reading of the measurement apparatus).

The contents of consciousness of self are determined as the average over the quantum jumps occurred after it was created (the real or p-adic space-time region corresponding to self appeared in quantum jump). Selves can have sub-selves and self experiences them as mental images. Self can represent a mental image of a higher level self. Self experiences only the average of its sub-selves. Thus statistical averaging is involved in both subjecto-temporal sense and spatially and is of central importance in the theory of qualia. This suggests that the foundations of, not only quantum measurement theory, but also statistical physics, reduce to the theory of consciousness. Quantum entanglement between sub-selves means fusion of mental images. The simplest assumption is that entangling self loses its consciousness.

The sharing of mental images by quantum entanglement is purely TGD based prediction. What happens is rather paradoxical: the subselves of unentangled selves bound state entangle so that the resulting fused mental image is shared by both selves. This is not possible if one applies the standard notion of quantum mechanical sub-system as a tensor factor. The p-adic hierarchy of space-time sheets forces to generalize the notion of sub-system (note that also real space-time sheets are characterized by p-adic prime determining the size scale).

Smaller space-time sheets glued to larger space-time sheets are glued to it by wormhole contacts having size of order CP_2 length and having Euclidian signature of the induced metric. This implies the presence of elementary particle horizons at which metric around wormhole contacts changes its signature from Minkowskian to Euclidian. At these 3-dimensional surfaces the induced metric is degenerate so that these surfaces are effectively 2-dimensional and allow conformal invariance crucial for the construction of the quantum theory. The analogy with black hole horizon is obvious. Black

holes cannot be described as tensor factors of the entire universe and the same holds true for topologically condensed space-time sheets. The reason is that the elementary particle horizon, which from the view point of the imbedding space has one time-like direction, becomes a causal determinant for the field equations. One must just postulate a hierarchy of systems labelled by p-adic primes and allow entanglement between sub-systems of unentangled systems. In terms of length scale thinking of quantum field theories, one can say that the entanglement between sub-systems is not visible in the p-adic length and time scales of the systems themselves.

A more precise view about the notion of self

The rough definition of self is as a subsystem able to remain unentangled during sequential quantum jumps. Self would lose consciousness when it entangles. What this statement really means is far from obvious and I have proposed several interpretations. the following picture represents the recent views.

1. The idea that even slightest entanglement leads to a loss of consciousness does not sound realistic. This suggests that entanglement should be defined only modulo finite measurement resolution. System would be conscious only provided that its entanglement entropy with the external world is below the value defined by the measurement resolution. For hyper-finite factors of type II₁ the notion of finite measurement resolution is unavoidable. The concrete interpretation at space-time level would be that space-time sheets (subselves) topologically condensed at larger space-time sheets (selves) can be connected by flux tubes to form an entangled state. The selves represented by the larger space-time sheets would remain unentangled in the resolution applying to the systems themselves (flux tubes would be invisible in this resolution). This invisible entanglement would however give rise to a sharing and fusion of mental images implying what might be called stereo consciousness.
2. How the notion measurement resolution should be defined is far from obvious. p-Adication approach suggests that finite measurement resolution boils down to a binary cutoff for the p-adic entanglement entropy represented as a series in powers of p . This binary cutoff should have also space-time correlate. For hyper-finite factors of type II₁ and type III₁ emerging naturally in quantum TGD entanglement entropy is always defined only modulo finite measurement resolution, which can be characterized in terms of inclusions of hyper-finite factors [K92]. The included factor defines the measurement resolution in the sense that its action creates states not distinguishable from the original in the resolution used. There should exist a connection between the two approaches.
3. A further complication is due to the fact that also the p-adic variants of Shannon entropy obtained by replacing the logarithm of probability with the logarithm of the p-adic norm of probability make sense if entanglement probabilities are rational or have values in some algebraic extension of rationals. The fact that number theoretic entanglement entropy can be negative is especially attractive from the point of view of consciousness theory and also quantum computation since entanglement indeed carries information. There is also a temptation to identify evolution as the emergence of increasingly complex systems having negative entanglement entropy. The generation of negative entanglement entropy could correspond to a kind of enlightenment experience-fusion to a sea of consciousness- instead of a loss of consciousness.
4. This forces to reconsider the original vision that everything is conscious but consciousness can be lost as the system entangles in U process. U process generates highly entangled states and the sub-sequent state function reduction (possibly modulo measurement resolution) repeatedly decomposes the Universe (or CD) into unentangled pairs of subsystems. The process stops for any subsystem for which all subsystem pairs have either bound state entanglement or negentropic entanglement. If the bound state entanglement is entropic, the entangled subsystems lose consciousness. If the entanglement between the subsystems is negentropic the process stops but subsystems remain conscious. Mystics might associate the entropic entanglement to what they call attachment and negentropic entanglement to a relationship which they might characterize as love.
5. Zero energy ontology brings in additional aspects. Zero energy states correspond to entangled pairs of positive and negative energy states located at the opposite light-like boundaries of a

given causal diamond (CD) defined as the intersection of future and past directed light-cones. Strictly speaking a Cartesian product of CD with CP_2 is in question. CD s form a fractal hierarchy. In the ordinary ontology zero energy state corresponds to a physical event. The time-like entanglement between positive and negative energy states defines M -matrix generalizing the notion of S -matrix. Time-like entanglement must be fundamental also from the point of view of consciousness as a reduction of quantum state to a state with well defined values of observables for the initial (positive energy) and final (negative energy) states.

The identification of the space-time correlates of selves is not so obvious as one might think. One can imagine three options. The spaced-time correlates of selves are space-time sheets or CD s or somehow combinations of these two.

1. If space-time sheets serve as correlates for selves, the space-time correlate for the entanglement is the presence of join along boundaries bonds connecting the space-time sheets serving as correlates for selves. The entanglement which corresponds to join along boundaries bonds associated with subselves (smaller space-time sheets topologically condensed at the space-time sheet representing self) is below the measurement resolution assignable to self. In this kind of situation selves remain conscious whereas subselves loose consciousness for positive entanglement entropy and fuse to form single stereo mental image of self. For negative entanglement entropy subselves would remain conscious.
2. In zero energy ontology [K20] one is forced to ask whether the notion of self should be defined at the level of imbedding space rather than at the level of space-time sheets so that a given CD would serve as a correlate for self. This identification leads to a beautiful argument for how the arrow of subjective time, the flow of subjective time, and the localization of the contents of conscious experience around a narrow time interval takes place [K6]. There is no reason for why CD s should not be allowed to overlap and this overlap would be a natural correlate for the sharing and fusion of mental images. Both of these identifications look natural and one can argue that the geometric correlates of self exist at both imbedding space and space-time level.
3. If both space-time sheets and CD s serve as correlates for selves, the join along boundaries bonds would connect space-time sheets associated with the two CD s and would belong to their intersection. One can also require that the CD s are at the same p-adic level of hierarchy. In other words, CD s correspond to the same value of p-adic prime near a power of two meaning that the temporal distance between the tips of CD s is same octave of CP_2 time for the standard value of Planck constant. The hierarchy of Planck constants [K29] means an additional complication in this picture but does not bring in anything essentially new.

One should also understand how the experience about the flow of subjective time emerges.

1. It seems obvious that quantum jumps must somehow integrate to self: quantum jump would be the elementary particle of consciousness and self the many particle state -possibly bound state (one can of course wonder what the notion of bound state means in case of zero energy states: can one say that positive and negative energy parts of the state form a bound state?) This analogy and the identification of zero energy states as events suggests that the notion of self could be reduced to that of quantum jumps so that self hierarchy would correspond to a hierarchy of quantum jumps within quantum jumps and also to the hierarchy of CD s within CD s.
2. The state function for the zero energy state should create the fundamental experience about time flow. The value of the time increment associated with the quantum jump would be determined by the temporal distance between the tips of CD and determine the interval about which the contents of consciousness is about. Note that for quantum states identified as time equal to constant snapshots quantum jump cannot give rise to an experience about flow of time since information about two values of geometric time is not present. Before zero energy ontology the proposed way out of this problem was the failure of classical determinism in the standard sense and zero energy ontology could be seen as a manner to formalize this failure.

3. The fractality of zero energy ontology implies that zero energy states are analogous to self-organization patterns and that a sequence of quantum jumps leads to an asymptotic self-organization pattern in 4-D sense. The M-matrix defining the generalization of S-matrix is indeed a "complex square root" of the density matrix so that statistical and thermodynamical aspects are present already at the fundamental level.

Since self behaves effectively like a separate autonomous universe, an attractive hypothesis is that the typical decomposition of self-organized system to almost autonomous subsystems corresponds to the decomposition of universe to selves. This means very close connection between self-organization theory and theory of consciousness.

Dark matter hierarchy and the notion of self

The mathematical realization for the hierarchy of Planck constants leads to a generalization of the imbedding space to a book like structure. The pages of the Big Book are characterized by two numbers x_a and x_b assignable to M^4 and CP_2 degrees of freedom. The values of these numbers are either integers or their inverses depending on whether the page of the book is a singular covering or factor space defined by a discrete subgroup of $SU(2)$. For a given CD the sectors characterized by different integers are glued together along $M^2 \subset M^4$ defining quantization axis of energy and spin. In CP_2 degrees of freedom the gluing is along a homologically trivial geodesic sphere of CP_2 and also now a fixing of the quantization axes is involved. The positions of the tips of CD and preferred points of CP_2 at the two light-like boundaries of CD fix the quantization axis and moduli space for CD s. An attractive hypothesis is that the relative positions of tips and corresponding preferred points of CP_2 form discrete spaces. The quantization of the temporal distance between tips in powers of two implies p-adic length scale hypothesis.

The arguments related to a model of anyons lead to the proposal that Planck constant equals to the product $x_a x_b$ and the value spectrum consists of rationals. One can expect that certain values are preferred ones for number theoretic reasons. For instance, ruler-and-compass integers expressible as product of a power of two with a product of different Fermat primes define an extension of p-adic numbers involving only square root operation applied to rationals. Only four Fermat primes are known and they are given by $F_k = 2^{2^k} + 1$, $k = 1, 2, 3, 4$. Primes and their inverses are also favored values for x_a and x_b . Since large values of Planck constant are favored in living matter, coverings of both M^4 and CP_2 are favored. The finite discrete symmetries of biomolecules (such as 5- and 6-fold rotational symmetries of aromatic molecules) might correspond to singular factor spaces of CD and therefore to $x_a = 1/n_a$.

The original working hypothesis was motivated by the model for planetary orbits with gigantic Planck constant $\hbar_{gr} = GMm/v_0$, $v_0/c \simeq 2^{-11}$. [K72] . v_0 has an interpretation as a velocity like parameter. This motivated the working hypothesis that preferred values of Planck constant come as products of ruler and compass integers [K26] . A more stringent hypothesis is that the preferred values of Planck constant come as powers $r = \hbar/\hbar_0 = 2^{k_d}$, where the values of k_d are dictated by Mersenne hypothesis [K26] . Living matter provides some support for this hypothesis consistent also with ruler-and-compass hypothesis. This hierarchy means for a given particle a hierarchy of zoomed up Compton lengths and times making possible macroscopic quantum coherence by the overlap criterion of space-time sheets having sizes of order Compton length. It must be however emphasized that much more general spectrum for the preferred values of Planck constant is expected.

A possible criterion for the phase transition to larger \hbar phase at the lowest level is that the interaction strength αQ^2 for particles of charge Q and gauge coupling strength α satisfies $\alpha Q^2 \geq 1$ and implies the increase of \hbar by $\hbar \rightarrow Q^2 \alpha \hbar / v_0$ implying the reduction of the interaction strength as $Q^2 \alpha \rightarrow v_0$. Another such criterion could be energy minimization.

Dark matter hierarchy suggests also a slight modification of the notion of self. Each self involves a hierarchy of dark matter levels, and one is led to ask whether the highest level in this hierarchy corresponds to single quantum jump rather than a sequence of quantum jumps. The averaging of conscious experience over quantum jumps would occur only for sub-selves at lower levels of dark matter hierarchy and these mental images would be ordered, and single moment of consciousness would be experienced as a history of events. One can ask whether even entire life cycle could be regarded as a single quantum jump at the highest level so that consciousness would not be completely lost even during deep sleep. This would allow to understand why we seem to know directly that this biological body of mine existed yesterday.

The fact that we can remember phone numbers with 5 to 9 digits supports the view that self corresponds at the highest dark matter level to single moment of consciousness. Self would experience the average over the sequence of moments of consciousness associated with each sub-self but there would be no averaging over the separate mental images of this kind, be their parallel or serial. These mental images correspond to sub-selves having shorter wake-up periods than self and would be experienced as being time ordered. Hence the digits in the phone number are experienced as separate mental images and ordered with respect to experienced time.

General view about psychological time and intentionality

A natural guess is that the resolution of the problems related to the preferred role of single moment of time for conscious experience could be based on the idea that biological growth and self-organization is a 4-dimensional phase transition proceeding in the direction of the geometric future quantum jump by quantum jump. And, in particular, that the dominating contribution to the conscious experience comes from the front of the phase transition where the volition is.

What is then this fundamental phase transition giving rise to what we call life? The front of phase transition corresponds naturally to volitional consciousness. Volition as a transformation of intention to action in TGD universe corresponds to the p-adic-to-real phase transitions of space-time sheets taking place in quantum jumps (for more detailed arguments see [K88]). Thus the natural conclusion is that p-adic-to-real phase transition is the fundamental phase transition guiding the biological self-organization.

This transition would occur as a leakage through the that part of world of classical worlds (WCW common to the p-adic and real worlds. The minimal scenario requires only that the partonic 2-surfaces at light-like boundaries of CD s together with their tangent plane distributions are expressible in terms of functions allowing interpretation in both real and p-adic contexts. This suggests that the attempts to understand the arrow of psychological time and the localization of the contents of conscious sensory experience and experienced volition to such a narrow time interval as .1 seconds should rely on zero energy ontology. I have proposed several scenarios trying to answer to these questions [K87, K88]. The most argument below summarizes the more the most recent view [K6], which can be found from [K88].

1. Why sensory experience is about so short time interval?

The picture based on CD s implies automatically the 4-D character of conscious experience and memories form part of conscious experience even at elementary particle level. Amazingly, the secondary p-adic time scale of electron is $T = 0.1$ seconds defining a fundamental time scale in living matter. The problem is to understand why the sensory experience is about a short time interval of geometric time rather than about the entire personal CD with temporal size of order life-time. The explanation would be that sensory input corresponds to subselves (mental images) with $T \simeq .1$ s at the upper light-like boundary of CD in question. This requires a strong asymmetry between upper and lower light-like boundaries of CD s.

The localization of the contents of the sensory experience to the upper light-cone boundary and local arrow of time could emerge as a consequence of self-organization process involving conscious intentional action. Sub- CD s would be in the interior of CD and self-organization process would lead to a distribution of CD s concentrated near the upper or lower boundary of CD . The local arrow of geometric time would depend on CD and even differ for CD and sub- CD s.

1. The localization of contents of sensory experience to a narrow time interval would be due to the concentration of sub- CD s representing mental images near the either boundary of CD representing self.
2. Phase conjugate signals identifiable as negative energy signals to geometric past are important when the arrow of time differs from the standard one in some time scale. If the arrow of time establishes itself as a phase transition, this kind of situations are rare. Negative energy signals as a basic mechanism of intentional action and transfer of metabolic energy would explain why living matter is so special.
3. Geometric memories would correspond to subselves in the interior of CD , the oldest of them to the regions near "lower" boundaries of CD . Since the density of sub- CD s is small there

geometric memories would be rare and not sharp. A temporal sequence of mental images, say the sequence of digits of a phone number, would correspond to a temporal sequence of sub-*CDs*.

4. Sharing of mental images corresponds to a fusion of sub-selves/mental images to single sub-self by quantum entanglement: the space-time correlate could be flux tubes connecting space-time sheets associated with sub-selves represented also by space-time sheets inside their *CDs*.

2. Arrow of time

TGD forces a new view about the relationship between experienced and geometric time. Although the basic paradox of quantum measurement theory disappears the question about the arrow of geometric time remains. There are actually two times involved. The geometric time assignable to the space-time sheets and the M^4 time assignable to the imbedding space.

Consider first the the geometric time assignable to the space-time sheets.

1. Selves correspond to *CDs*. The *CDs* and their projections to the imbedding space do not move anywhere. Therefore the standard explanation for the arrow of geometric time cannot work.
2. The only plausible interpretation at classical level relies on quantum classical correspondence and the fact that space-times are 4-surfaces of the imbedding space. If quantum jump corresponds to a shift for a quantum superposition of space-time sheets towards geometric past in the first approximation (as quantum classical correspondence suggests), one can understand the arrow of time. Space-time surfaces simply shift backwards with respect to the geometric time of the imbedding space and therefore to the 8-D perceptive field defined by the *CD*. This creates in the materialistic mind a temporal variant of train illusion. Space-time as 4-surface and macroscopic and macro-temporal quantum coherence are absolutely essential for this interpretation to make sense.

Why this shifting should always take place to the direction of geometric past of the imbedding space? Does it so always? The proposed mechanism for the localization of sensory experience to a short time interval suggests an explanation in terms of intentional action.

1. *CD* defines the perceptive field for self. Selves are curious about the space-time sheets outside their perceptive field and perform quantum jumps tending to shift the superposition of the space-time sheets so that unknown regions of space-time sheets emerge to the perceptive field. Either the upper or lower boundary of *CD* wins in the competition and the arrow of time results as a spontaneous symmetry breaking. The arrow of time can depend on *CD* but tends to be the same for *CD* and its sub-*CDs*. Global arrow of time could establish itself by a phase transitions establishing the same arrow of time globally by a mechanism analogous to percolation phase transition.
2. Since the news come from the upper boundary of *CD*, self concentrates its attention to this region and improves the resolution of sensory experience. The sub-*CDs* generated in this manner correspond to mental images with contents about this region. Hence the contents of conscious experience, in particular sensory experience, tends to be about the region near the upper boundary.

The emergence of the arrow of time at the level of imbedding space reduces to a modification of the oldest TGD based argument for the arrow of time which is wrong as such. If physical objects correspond to 3-surfaces inside future directed light-cone then the sequence of quantum jumps implies a diffusion to the direction of increasing value of light-cone proper time. The modification of the argument goes as follows.

1. *CDs* are characterized by their moduli. In particular, the relative coordinate for the tips of *CD* has values in past light cone M^4 if the future tip is taken as the reference point. An attractive interpretation for the proper time of M^4 is as cosmic time having quantized values. Quantum states correspond to wave functions in the modular degrees of freedom and each *U* process creates a non-localized wave function of this kind. Suppose that state function reduction implies a localization in the modular degrees of freedom so that *CD* is fixed completely apart from its

center of mass position to which zero four-momentum constant plane wave is assigned. One can expect that in average sense diffraction occurs in M_-^4 so that the size of CD tends to increase and that the most distant geometric past defined by the past boundary of CD recedes. This is nothing but cosmic expansion. This provides a formulation for the flow of time in terms of a cosmic redshift. This argument applies also to the positions of the sub- CD s inside CD . Also their proper time distance from the tip of CD is expected to increase.

2. One can argue that one ends up with contradiction by changing the roles of upper and lower tips. In the case of CD itself is only the proper time distance between the tips which increases and speaking about "future" and "past" tips is only a convention. For sub- CD s of CD the argument would imply that the sub- CD s drifting from the opposite tips tend to concentrate in the middle region of CD unless either tip is in a preferred position. This requires a spontaneous selection of the arrow of time. One could say that the cosmic expansion implied by the drift in M_-^4 "draws" the space-time sheet with it to the geometric past. The spontaneous generation of the asymmetry between the tips might require the "curious" conscious entities.

4.2.2 Many-sheeted space-time, topological field quantization, and spin glass degeneracy

Many-sheeted space-time allows to understand topologically the generation of structures. Even the macroscopic objects of every-day world correspond to space-time sheets. The replacement of point-like particles with 3-surfaces of arbitrarily large implies the crucial non-locality at space-time level. Concerning the understanding of bio-super-conductivity, the basic observation is that the space-time sheets, which are much larger than atomic space-time sheets, contain very low densities of ordinary particles so that the temperature can be extremely low and macroscopic quantum phases are possible.

Topological field quantization, which is implied both by topological reasons and by the fact that only the extremals of Kähler action allowing infinite number of deformations with a vanishing second variation, implies that space-time surfaces are counterparts of Bohr orbits and have complex topology. This means that topologically relatively featureless linear Maxwell fields are replaced by extremely complex topological structure, which can be regarded as kind of a generalized Feynmann diagram obtained by thickening the lines to four-dimensional space-time sheets.

Quantum-classical correspondence has been a basic guideline in the construction of the theory and states that classical space-time physics provides classical correlates for various quantum aspects of physical system leads to the view that the topological field quanta accompanying a given material system provide a representation for its quantum structure, kind of a manual.

The topological self-referentiality generalizes further to the idea that the inherent non-determinism of the p-adic dynamics makes possible space-time representation of quantum jump sequences and classical non-determinism of Kähler action the non-determinism inherent to the linguistic representations for the contents of consciousness of self. This in turn implies feedback loop to the configuration space (of 3-surfaces) level: configuration space spinor fields can represent (not faithfully) quantum jump sequences and thus the contents of consciousness associated with a sequence of quantum jumps (self), so that the ability to become conscious about being conscious about something can be understood.

One can also speak about 'field body' (or actually hierarchy of them) as being associated with the material system. This field body, which is much larger than the material system, serves as a sensory canvas at which sensory representations are realized and could also perform motor control. This means radical modification of the neuro-science view about brain as the sole seat of consciousness [K42, K40]

The basic variational principle underlying quantum TGD states that the space-time surface associated with a given 3-surface is absolute minimum of so called Kähler action, which is essentially Maxwell action for a Maxwell field, which is obtained by projecting CP_2 Kähler form to space-time surface. Thus primary dynamical variables are CP_2 coordinates rather than vector potential. This implies huge vacuum degeneracy: any space-time surface having CP_2 projection, which is Legendre manifold, that is at most a 2-dimensional surface of CP_2 having vanishing induced Kähler form, is a vacuum extremal. New vacua are obtained by the canonical transformations of CP_2 acting as $U(1)$ gauge transformations on Kähler gauge potential. This symmetry is also approximate for non-vacuum extremals and broken only by classical gravitation represented by the induced metric.

Physically this means spin glass degeneracy: the geometric $U(1)$ gauge invariance ceases to be gauge invariance (nothing to do with ordinary gauge invariance) and implies huge almost-degeneracy of physical states. Gravitational energy distinguishes between these almost physically equivalent states. The standard manner to visualize the situation is by using the notion of the energy landscape. Spin glass energy landscape (now energy corresponds to Kähler function) is a fractal structure containing valleys inside valleys inside... This symmetry is responsible for a very large class of phenomena distinguishing between TGD and standard physics and also makes possible macro-temporal quantum coherence.

4.3 Macro-temporal quantum coherence from spin glass degeneracy

At the space-time level the generation of macroscopic quantum coherence is easy to understand if one accepts the identification of the space-time sheets as coherence regions. Quantum criticality and the closely related spin glass degeneracy are essential for the fractal hierarchy of space-time sheets. The problem of understanding macro-temporal and macroscopic quantum coherence at the level of configuration space (of 3-surfaces) is a more tricky challenge although quantum-classical correspondence strongly suggests that this is possible. In the sequel the notion of macro-temporal quantum coherence is discussed in quantum TGD framework and the argument for how quantum spin glass degeneracy implies macro-temporal quantum coherence is developed.

4.3.1 What does quantum coherence mean in TGD Universe?

Concerning macro-temporal quantum coherence, the situation in quantum TGD seems at the first glance to be even worse than in standard physics. The problem is that simplest estimate for the increment in psychological time in single quantum jump is about 10^{-39} seconds derived from the idea that single quantum jump represent a kind of elementary particle of consciousness and thus corresponds to CP_2 time of about 10^{-39} seconds. If this time interval defines coherence time one ends up to a definite contradiction with the standard physics. Of course, the average increment of the geometric time during single quantum jump could vary and correspond to the de-coherence time. The idea of quantum jump as an elementary particle of consciousness does not support this assumption.

To understand how this naive conclusion is wrong, one must look more precisely the anatomy of quantum jump. The unitary process $\Psi_i \rightarrow U\Psi_i$, where Ψ_i is a prepared maximally unentangled state, corresponds to the quantum computation producing maximally entangled multi-verse state. Then follows the state function reduction and after this the state preparation involving a sequence of self measurements and given rise to a new maximally unentangled state Ψ_f .

1. What happens in the state function reduction is a localization in zero modes, which do not contribute to the line element of the configuration space metric. They are non-quantum fluctuating degrees of freedom and TGD counterparts of the macroscopic, classical degrees of freedom. There are however also quantum-fluctuating degrees of freedom and the assumption that zero modes and quantum fluctuating degrees of freedom are correlated like the direction of a pointer of a measurement apparatus and quantum numbers of the quantum system, implies standard quantum measurement theory.
2. Bound state entanglement is assumed to be stable against state function reduction and preparation. Bound state formation has as a geometric correlate formation of join along boundaries bonds between space-time sheets representing free systems. Thus the members of a pair of disjoint space-time sheets are joined to single space-time sheet. Half of the zero modes is transformed to quantum fluctuating degrees of freedom and only overall center of mass zero modes remain zero modes. These new quantum fluctuating degrees of freedom represent macroscopic quantum fluctuating degrees of freedom. In these degrees of freedom localization does not occur since bound states are in question.

Both state function reduction and state preparation stages leave this bound state entanglement intact, and in these degrees of freedom the system behaves effectively as a quantum coherent system. One can say that a sequence of quantum jumps binds to form a single long-lasting

quantum jump effectively. This is in complete accordance with the fractality of consciousness. Quantum jumps represent moments of consciousness which are elementary particles of consciousness and in macro-temporal quantum coherent state these elementary particles bind to form atoms, molecules, etc. of consciousness.

3. The properties of the bound state plus its interaction with the environment allow to estimate the typical duration of the bound state. This time takes the role of coherence time. This suggests a connection with the standard approach to quantum computation.

4.3.2 Spin glass degeneracy and classical gravitation as stabilizer of irreducible bound state entanglement

This picture gives connection with the standard physics view but does not yet explain why de-coherence times are so long. New physics is required to explain why the life times of bound states are much longer than predicted by the standard physics. Spin glass degeneracy provides this physics. There are two arguments: probabilistic argument based on intuition and the more rigorous argument based on unitarity.

Probabilistic argument

The probabilistic argument goes as follows.

1. Suppose that spin glass degeneracy gives rise to a huge number of almost degenerate bound states for which only the classical gravitational energy is different, and that for non-bound states this degeneracy is much smaller. The dominant part of the binding energy is of course something else than gravitational. If this is the case, the number of the bound states is so large as compared to the number of unbound states that the branching ratio for the decay to unbound state is very small. This means that the time spent in bound states is much longer than the time spend in free states and this means that de-coherence time is much longer than without spin glass degeneracy.
2. If the join along boundaries bonds are sufficiently near to vacuum extremals, they indeed allow immense spin glass degeneracy with slightly different gravitational interaction energies and the desired situation can be achieved.

The argument based on unitarity

A more refined argument is based on unitarity of S-matrix. The S-matrix can be written as sum of unit matrix and reaction matrix T : $S = 1 + iT$.

1. The unitarity conditions $SS^\dagger = 1$ read in terms of T-matrix as

$$i(T - T^\dagger) = TT^\dagger . \quad (4.3.1)$$

For diagonal elements one has

$$2 \times \text{Im}(T_{mm}) = \sum_r |T_{mr}|^2 \geq 0 . \quad (4.3.2)$$

What is essential that the right hand side is non-negative and closely related to the total rate of transitions. If this rate is high also the imaginary part at the left hand side of the equation is large and therefore also the rate for the diagonal transition. For instance, in the case of low energy strong interactions this implies that the total reaction rates are high but transitions occur mostly in the forward direction. In this case the mere large number of final many-hadron states implies that most transitions occur in the forward direction.

In the recent case one must consider both free states and bound states. Let us use capitals M, N as labels for bound states and small letters m, n as labels for free states.

2. The diagonal unitarity conditions can be written for both of these states as

$$\begin{aligned} 2\text{Im}(T_{mm}) &= \sum_r |T_{mr}|^2 + \sum_R |T_{mR}|^2 \geq 0 , \\ 2\text{Im}(T_{MM}) &= \sum_R |T_{MR}|^2 + \sum_r |T_{Mr}|^2 \geq 0 . \end{aligned} \quad (4.3.3)$$

In both cases there is a large number of the degenerate states involved at the right hand side so that one expects that the right hand side has a large value. For bound states the number of degenerate states is much higher due to the additional degeneracy brought in by the join along boundaries bonds. Thus the lifetime and de-coherence time should be considerably longer than expected on basis of standard physics.

3. For the non-diagonal transitions from bound states to free states one has

$$i(T_{Mm} - \bar{T}_{mM}) = \sum_r T_{Mr} \bar{T}_{mr} + \sum_R T_{MR} \bar{T}_{mR} . \quad (4.3.4)$$

The right hand side is not positive definite and since a large number of amplitudes between widely different free and bound states are involved, one expects that a destructive interference occurs. This is consistent with a small value of the non-diagonal amplitudes T_{Mm} and with the long lifetime of bound states.

4. What happens for non-diagonal transitions between degenerate states? The unitarity conditions read as

$$\begin{aligned} i(T_{mn} - \bar{T}_{nm}) &= \sum_r T_{mr} \bar{T}_{nr} + \sum_r T_{mR} \bar{T}_{nR} , \\ i(T_{MN} - \bar{T}_{NM}) &= \sum_R T_{MR} \bar{T}_{NR} + \sum_r T_{Mr} \bar{T}_{Nr} . \end{aligned} \quad (4.3.5)$$

The right hand side is not anymore positive definite and there is a very large number of summands present. Hence a destructive interference could occur and the amplitude would be very strongly restricted in the forward direction. This need not however be true in the case of degenerate states since they are expected to be very similar to each other.

5. One can indeed play with the idealization that the transition amplitudes between degenerate states are identical $T_{MN} = T$ and that the amplitudes T_{Mr} are independent of M and given by $T_{Mr} = T_r$.

In this case T-matrix would have the form $T = t \times X$, where X is a matrix for which all elements are equal to one. t can be written as $|t| \exp(i\phi)$. T -matrix is maximally degenerate and the diagonalized form T^D of T-matrix has only a single non-vanishing element equal to Nt , N the number of degenerate states. t must satisfy the unitarity condition $|t| = 2 \times \sin(\phi)/N$. S-matrix would reduce to an almost unit matrix for the diagonalized bound states.

What about the stability of the bound states in this case? The decay amplitudes for bound states corresponding to the vanishing eigen values of T are given by $T^D(M, r) = \sum c_M T_{Mr} = \sum_M c_M \times T_r = 0$ by the orthogonality of these states with the state with a non-vanishing eigen value. Thus the lifetimes of all bound states expect the one with the non-vanishing eigen value of T are infinitely long in this idealization.

Color confinement and spin glass degeneracy

This mechanism has applications also outside consciousness theory. For instance, one can understand color confinement. When quarks form color bound states, their space-time sheets are connected by color flux tubes (this is the aspect of confinement which goes outside QCD). Also color flux tubes possess huge spin glass degeneracy. Free quark states do not possess this degeneracy since join along boundaries bonds are absent. Thus the time spent in free states in which color flux tubes are absent is negligible compared with the time spent in color bound states so that the states consisting of free quarks are unobservable.

A more precise phrasing of this idea relies on unitarity conditions and the assumptions $T_{MN} \simeq T$ and $T_{Mr} \simeq T_r$. Here capital subscripts refer to degenerate hadronic states and small letter subscripts to free many-quark states. In this idealization hadronic degenerate states are stable against decay to free many-quark states with only single exception. The exceptional state should act as a doorway making possible the transition to quark-gluon plasma phase.

S-matrices associated with a hierarchy of de-coherence times

The Hamiltonian time evolution would more or less correspond to a unitary operator resulting as a product of the actions of the unitary operators U associated with the quantum jumps of the sequence. The interpretation is as a length/time scale dependent time development operator obtained by integrating over the spin glass degrees of freedom. This is natural since spin glass degrees of freedom represent hidden variables and degenerate bound states correspond to one and the same bound state in the standard physics view about Universe. Discretized time development emerges automatically in this framework. The Schrödinger equation at the infinitesimal level does not make sense but this is of course not a practical problem. One could say that the sequence of quantum jumps defining the conscious experience of self is able to simulate the unitary time evolution associated with single quantum history.

One might argue that this kind of description is unsatisfactory since unitarity might be only approximate. The fractality of consciousness however suggests that the unitary might be exact. First of all, the standard definition of sub-system must be replaced with a length scale dependent one involving length scale cutoff (sharing of mental images is one important implication). This is expected to be true also in the temporal domain so that also S-matrices form a hierarchy characterized by the durations of macro-temporal quantum coherence. The spatial and temporal resolutions would not be due to the limitations of the theorist or of the experimenter but basic properties of the subjective, physical, and mathematical existences, and p-adic length scale hierarchy would provide the natural hierarchy of resolutions. The finite geometro- and subjecto-temporal resolutions might make possible exact unitarity for the S-matrices appearing in this hierarchy.

S-matrix would be replaced by a collection of S-matrices. At space-time level this presumably means the possibility and necessity to assign S-matrices to space-time sheet defining coherence regions. De-coherence, which would involve the decay of the space-time sheet to smaller space-time sheets representing outgoing particles and the generation of coherence as a time reversal of this process involving incoming particles would be an essential part of the construction of S-matrix. The relationship between hadronic physic and quark physics brings strongly in mind this situation.

4.4 Macro-temporal quantum coherence and dynamical \hbar

Neither the classical argument nor spin-glass degeneracy based argument in favor of macroscopic and macro-temporal quantum coherence need be consistent with ordinary quantum theory as such. Planck constant is usually regarded as a universal constant which can be taken to be $\hbar = 1$ if units are chosen suitably. For some reason that possibility that Planck constant might be dynamical has not been considered as a possible option by quantum consciousness theorists. My own views changed profoundly as I learned about the work of Laurent Nottale [E6].

4.4.1 Quantization of planetary orbits with a gigantic value of Planck constant and dark matter as a macroscopic quantum phase

There is evidence that planetary orbits obey Bohr quantization rules with a gigantic value of Planck constant [E6]. Nottale does not assume that this quantization is genuine but regards it as a hydrodynamical effect. In TGD framework the most natural interpretation is in terms of dynamical Planck constant and TGD even predicts correctly the basic dimensionless parameter involved [K72, K92, K25].

The notion of a macroscopic Bohr orbit is not a problem in TGD framework since the basic variational principles implies that space-time surfaces can be regarded as generalized Bohr orbits. The assignment of a Schrödinger amplitude to ordinary matter in astrophysical length and time scales is of course non-sensible in standard physics approach. The resolution of the paradox comes from the identification of dark matter in terms of a hierarchy of macroscopically quantum coherent large \hbar phases around which visible matter condenses. There is no direct interaction between phases of matter with different values of \hbar since all particles in fundamental vertices have same value of \hbar . De-coherence phase transition reducing the value of \hbar and the reverse of this phase transition are possible. At classical level intricate interaction mechanisms are possible due to the properties of the many-sheeted space-time. For instance, this kind of mechanism plays key role in the model of nerve pulse generation [K62].

4.4.2 Criterion for the occurrence of a phase transition changing Planck constant

One ends up also to a criterion for the occurrence of the the phase transition increasing the value of the Planck constant. The idea is that when perturbation theory in powers of the gauge coupling constants fails, a phase transition increasing the value of \hbar occurs so that coupling constant strength which is proportional to $1/\hbar$ is reduced and the resulting perturbation theory converges rapidly. Somewhat paradoxically, the large value of Planck constant implying formation of macroscopic quantum phases means also that the resulting system behaves more classically in the sense that higher order contributions in perturbation theory become small.

This picture leads to a rather precise vision about what happens in color confinement (valence quarks correspond to large value of \hbar). The implications are highly nontrivial also at the level of nuclear physics and lead to an identification of nuclei as highly folded stringlike structures. The model also forces to give up the assumption that nuclear physics and condensed matter physics have nothing to do with each other.

4.4.3 Large value of Planck constant implies macroscopic and macrotemporal quantum coherence

The large values of \hbar mean macroscopic and macrotemporal quantum coherence. Various quantum scales such as Compton time and length are proportional to \hbar and are scaled up by λ in the phase transitions increasing \hbar . Also de-coherence times and lengths are scaled up. These scales correspond at the space-time level the scales of the space-time sheets involved. Thus a phase transition increasing λ but not affecting particle densities can lead to a situation in which the space-time sheets associated with particles zoomed up by λ overlap so that the criterion for macroscopic quantum coherence is satisfied.

4.4.4 Are the two explanations for the macro-temporal quantum coherence consistent?

The dark matter hierarchy with levels labelled by the values of Planck constants explains macroscopic and macro-temporal quantum coherence naturally. That this explanation is consistent with the explanation based on spin glass degeneracy is suggested by the following observations.

1. The argument based on spin glass degeneracy does not involve the value of \hbar at all. The failure of the perturbation theory assumed to lead to the increase of Planck constant and formation of

macroscopic quantum phases could be precisely due to the emergence of a large number of new degrees of freedom assignable to increased spin glass degeneracy.

2. The phase transition increasing Planck constant has a concrete topological interpretation in terms of the replacement of space-time sheet with its λ -fold covering so that the phase transition is analogous to a period doubling and thus brings in new degrees of freedom as is clear from school examples for what happens in the transition to chaos via period doublings. For instance, the replacement of the integers m characterizing angular momentum with m/λ means that the number of angular momentum eigen states becomes λ -fold.

4.5 Basic implications

In the sequel the physical aspects of the macro-temporal quantum coherence are discussed.

4.5.1 Thermodynamical aspects

During macro-temporal quantum coherence dissipation is absent in the quantum coherent degrees of freedom. This implies the breaking of the second law of thermodynamics in time scales shorter than the duration of bound states in the sense that entropy does not grow. [It is also possible that the geometric arrow of psychological time is reversed at the space-time sheets having negative time orientation: in this case second law holds true with respect to subjective time but corresponds to a decrease of entropy with respect to the geometric time of the external observer.]

p-Adic length scale hypothesis suggests a hierarchy of time scales for bound state lifetimes so that a hierarchical structure for the breaking of the second law is predicted. At space-time sheet characterized by p-adic prime p the second law would be broken below the time scale $T_p = L_p/c$, $L_p = \sqrt{p} \times l_0$, where l_0 is essentially CP_2 length scale about 10^4 Planck lengths. Breaking could also occur only below n-ary p-adic time scales $T_p(n) = p^{(n-1)/2} L_p$.

Quite recently it has been found that second law is indeed broken below .1 seconds for certain systems [D15]. This time scale corresponds to the secondary p-adic time scale $T_p(2)$ associated with the Mersenne prime $M_{127} = 2^{127} - 1$ defining the p-adic length scale of electron. This time scale is fundamental in the TGD based model of living system and corresponds to the time scale of alpha band and the time resolution of the sensory experience (duration of sensory mental images). The reversal of the arrow of geometric time below p-adic time scale might be fundamental aspect of living systems and this point will be discussed later in more detail.

4.5.2 Energetic aspects

The generation of quantum bound state involves liberation of the binding energy as a usable energy. This might provide a new kind of metabolic mechanism in which co-operation by the formation of macroscopic quantum bound states allows a liberation of metabolic energy. The energy bill must be paid sooner or later, and the energy feed from environment takes care of this by destroying the bound state in average time defined by the duration of the bound state. The fact that oxidative metabolism is anomalously low during the neuronal synchrony [J46] supports the view that neuronal synchrony might give rise to bound-state entangled multineuron states. This mechanism is quite general and even ordinary metabolism could be based on this mechanism as will be proposed later. Also the bound state entanglement between different organisms might be possible and liberate energy. Thus the notion of 'synergy' might be much more than a mere metaphor.

4.5.3 Information theoretic aspects

TGD framework forces to reconsider also the notion of information itself, and the new number-theoretic view about information suggests a profoundly new view about the distinction between dead and living matter and about about consciousness as the basic driving forces behind evolution. At practical level this might have radical implications for quantum computation. These aspects are discussed in detail in [K69] and in the following only the main points are discussed.

Number theoretic information measures

The notion of information in TGD framework differs in some respects from the standard notion.

1. The definition of the entropy in p-adic context is based on the notion p-adic logarithm depending on the p-adic norm of the argument x only ($x = p^n r/s$, r and s not divisible by p ; $\text{Log}_p(x) = \log_p(|x|_p) = -n$) [K46]. For rational- and even algebraic number valued probabilities this entropy can be regarded as a real number. The entropy defined in this manner can be negative so that the entanglement can carry genuine positive information. Thus p-adic bound state entanglement giving rise to a fusion of cognitive mental images is a natural correlate for the experience of understanding, and one can assign to heureka's a well defined amount of information. Rationally entangled p-adic system has a positive information content only if the number of the entangled state pairs is proportional to a positive power of the p-adic prime p .
2. This kind of definition of entropy works also in the real-rational and even real-algebraic cases and makes always sense for finite real world ensembles and for entanglement between real (p-adic) systems. Entanglement probabilities are indeed algebraic numbers for both rational and algebraic entanglement coefficients. Here the problem is how to fix the value of the prime p and the only reasonable criterion is maximization of information.
3. The modified definition of entropy would have deep implications. For the ordinary definition of the entropy NMP [K46] states that real entanglement is minimized in the state preparation process. For the number theoretic definition of entanglement entropy NMP stabilizes the entanglement with positive information content. The fragility of quantum coherence is the basic problem of quantum computation and the good news would be that Nature itself (according to TGD) tends to stabilize quantum coherence if entanglement is rational/algebraic.

Life as islands of rational/algebraic numbers in the seas of real and p-adic continua?

The possibility to define entropy differently for rational/algebraic entanglement and the fact that number theoretic entanglement entropy can be negative raises the question about which kind of systems can possess this kind of entanglement. I have considered several identifications but the most elegant interpretation is based on the idea that living matter resides in the intersection of real and p-adic worlds, somewhat like rational numbers live in the intersection of real and p-adic number fields.

The observation that Shannon entropy allows an infinite number of number theoretic variants for which the entropy can be negative in the case that probabilities are algebraic numbers leads to the idea that living matter in a well-defined sense corresponds to the intersection of real and p-adic worlds. This would mean that the mathematical expressions for the space-time surfaces (or at least 3-surfaces or partonic 2-surfaces and their 4-D tangent planes) make sense in both real and p-adic sense for some primes p . Same would apply to the expressions defining quantum states. In particular, entanglement probabilities would be rationals or algebraic numbers so that entanglement can be negentropic and the formation of bound states in the intersection of real and p-adic worlds generates information and is thus favored by NMP.

This picture has also a direct connection with consciousness.

1. Algebraic entanglement is a prerequisite for the realization of intentions as transformations of p-adic space-time sheets to real space-time sheets representing actions. Essentially a leakage between p-adic and real worlds is in question and makes sense only in zero energy ontology. since various quantum numbers in real and p-adic sectors are not in general comparable in positive energy ontology so that conservation laws would be broken. Algebraic entanglement could be also called cognitive. The transformation can occur if the partonic 2-surfaces and their 4-D tangent space-distributions are representable using rational functions with rational coefficients in preferred coordinates for the imbedding space dictated by symmetry considerations. Intentional systems must live in the intersection of real and p-adic worlds. For the minimal option life would be also effectively 2-dimensional phenomenon and essentially a boundary phenomenon as also number theoretical criticality suggests.
2. The generation of non-rational (non-algebraic) bound state entanglement between the system and external world means that the system loses consciousness during the state function reduction

process following the U -process generating the entanglement. What happens that the Universe corresponding to given CD decomposes to two un-entangled subsystems, which in turn decompose, and the process continues until all subsystems have only entropic bound state entanglement or negentropic algebraic entanglement with the external world.

3. If the sub-system generates entropic bound state entanglement in the the process, it loses consciousness. Note that the entanglement entropy of the sub-system is a sum over entanglement entropies over all subsystems involved. This hierarchy of subsystems corresponds to the hierarchy if sub- CD s so that the survival without a loss of consciousness depends on what happens at all levels below the highest level for a given self. In more concrete terms, ability to stay conscious depends on what happens at cellular level too. The stable evolution of systems having algebraic entanglement is expected to be a process proceeding from short to long length scales as the evolution of life indeed is.
4. U -process generates a superposition of states in which any sub-system can have both real and algebraic entanglement with the external world. This would suggest that the choice of the type of entanglement is a volitional selection. A possible interpretation is as a choice between good and evil. The hedonistic complete freedom resulting as the entanglement entropy is reduced to zero on one hand, and the algebraic bound state entanglement implying correlations with the external world and meaning giving up the maximal freedom on the other hand. The hedonistic option is risky since it can lead to non-algebraic bound state entanglement implying a loss of consciousness. The second option means expansion of consciousness - a fusion to the ocean of consciousness as described by spiritual practices.
5. This formulation means a sharpening of the earlier statement "Everything is conscious and consciousness can be only lost" with the additional statement "This happens when non-algebraic bound state entanglement is generated and the system does not remain in the intersection of real and p-adic worlds anymore". Clearly, the quantum criticality of TGD Universe seems has very many aspects and life as a critical phenomenon in the number theoretical sense is only one of them besides the criticality of the space-time dynamics and the criticality with respect to phase transitions changing the value of Planck constant and other more familiar criticalities. How closely these criticalities relate remains an open question.

A good guess is that algebraic entanglement is essential for quantum computation, which therefore might correspond to a conscious process. Hence cognition could be seen as a quantum computation like process, a more appropriate term being quantum problem solving. Living-dead dichotomy could correspond to rational-irrational or to algebraic-transcendental dichotomy: this at least when life is interpreted as intelligent life. Life would in a well defined sense correspond to islands of rationality/algebraicity in the seas of real and p-adic continua.

The view about the crucial role of rational and algebraic numbers as far as intelligent life is considered, could have been guessed on very general grounds from the analogy with the orbits of a dynamical system. Rational numbers allow a predictable periodic decimal/pinary expansion and are analogous to one-dimensional periodic orbits. Algebraic numbers are related to rationals by a finite number of algebraic operations and are intermediate between periodic and chaotic orbits allowing an interpretation as an element in an algebraic extension of any p-adic number field. The projections of the orbit to various coordinate directions of the algebraic extension represent now periodic orbits. The decimal/pinary expansions of transcendentals are un-predictable being analogous to chaotic orbits. The special role of rational and algebraic numbers was realized already by Pythagoras, and the fact that the ratios for the frequencies of the musical scale are rationals supports the special nature of rational and algebraic numbers. The special nature of the Golden Mean, which involves $\sqrt{5}$, conforms the view that algebraic numbers rather than only rationals are essential for life.

Quantum computation and quantum problem solving in TGD Universe

Macro-temporal quantum coherence makes also quantum computation like processes possible since a sequence of quantum jumps effectively binds to a single quantum jump with a duration, which corresponds to the lifetime of the bound state. Quantum computation like process starts, when the quantum bound state is generated and halts when it decays. Spin glass degeneracy increases the

duration of the quantum computation to time scales which are sensical for human consciousness. In case of cognitive quantum computation like processes the quantum coherence is stabilized by NMP.

1. Spin glass degeneracy provides the needed huge number of degrees of freedom making quantum computations very effective. These degrees of freedom are associated with the join along boundaries bonds and are essentially gravitational so that a connection with Penrose-Hameroff hypothesis emerges.
2. Bio-systems would be especially attractive candidates for performers of both non-cognitive and cognitive quantum computation like processes. The binding of molecules by lock and key mechanism is a basic process in living matter and the binding of information molecules to receptors is a special case of this process. All these processes would involve new physics not taken into account in the standard physics based biochemistry.
3. The possibility of cognitive quantum computation like information processing forces generalize the standard quantum computer paradigm also because ordinary quantum computers represent only the lowest, 2-adic level of the p-adic intelligence. Qubits must be replaced by qupits since for algebraic $R - R_p$ entanglement two-state systems are naturally replaced with p-state systems and for $R_{p_1} - R_{p_2}$ entanglement with $p_1 \times p_2$ state systems. For primes of order say $p \simeq 2^{167}$ (the size of small bacterium) this means about 167 bits, which means gigantic quantum computational resources. The secondary p-adic time scale $T_2(127) \simeq .1$ seconds basic bit-like unit corresponds to $M_{127} = 2^{127} - 1$ M_{127} -qupits making about 254 bits. The idea about neuron as a classical bit might be a little bit wrong!
4. It might be more appropriate to talk about conscious problem solving instead of quantum computation. In this framework the periods of macro-temporal quantum coherence replace the unitary time evolutions at the gates of the quantum computer as the basic information processing units and entanglement bridges between selves act as basic quantum communication units with the sharing of mental images providing a communication mode not possible in standard quantum mechanics.

Information concept at space-time level

Quantum-classical correspondence suggests that the notion of information is well defined also at the space-time level. The non-determinism of Kähler action and p-adic non-determinism plus algebraic information measures suggest a natural approach to the problem of defining the information concept. This approach provides also a new light to the problem of assigning a p-adic prime to a given real space-time sheet.

1. How to assign an information measure to a space-time sheet

In the presence of the classical non-determinism of Kähler action and p-adic non-determinism one can indeed define ensembles, and therefore also probability distributions and entropies. For a given space-time sheet the natural ensemble consists of the deterministic pieces of the space-time sheet regarded as different states of the same system. The probability for the appearance of a given value of observable is of the general form $p_i = m_i/N$, $m_i < N$, where N is the number of deterministic pieces and S_p is always negative, when p divides N .

Obviously the primes dividing N define natural candidates for the information measures but the problem is which criterion selects one of them. There are three options.

1. Require that the information measure corresponds to the prime p for which S_p is smallest. Obviously p must divide N .
2. Define the information as sum

$$I = - \sum_{p|N} S_p ,$$

(here $p|N$ means that p divides N) so that all contributions are positive.

3. Include all primes dividing N or m_i in $p_i = m_i/N$:

$$I = - \sum_{p|N \text{ or } p|m_i} S_p ,$$

In this case also negative contributions are present. This definition is actually equivalent with a definition

$$I = - \sum_p S_p ,$$

in which the summation appears over all primes. One could say that the information decomposes into different kinds of informations labeled by primes.

What is interesting is that, the ordinary Shannon entropy S for rational probabilities can be expressed as a sum of all p-adic entropies using the adelic decomposition $|x| = \prod_p |x|_p^{-1}$:

$$S = - \sum_p S_p = I .$$

The sum of real and p-adic entropies vanishes. Real dis-information and the p-adic information would compensate each other completely. Whether the adelic formula for information theory might have some deeper interpretation remains open.

2. How to assign p-adic prime or primes to a real space-time sheet?

A long-standing problem of quantum TGD is how to associate to a given *real* (not only p-adic) space-time sheet a unique p-adic prime (or possibly several of them) as required by the p-adic length scale hypothesis.

1. One could achieve this by requiring that for this prime the negentropy associated with the ensemble is maximal. The simplest hypothesis is that a real space-time sheet consisting of N deterministic pieces corresponds to the p-adic prime defining the largest factor of N .
2. One could also consider a more general possibility. If N contains p^n as a factor, then the real fractality above n-ary p-adic length scale $L_p(n) = p^{(n-1)/2} L_p$ corresponds to smoothness in the p-adic topology. This option is more attractive since it predicts that the fundamental p-adic length scale L_p for a given p can be effectively replaced by any integer multiple NL_p , such that N is not divisible by p . There is indeed a considerable evidence for small p p-adicity in long length scales. For instance, genetic code and the appearance of binary pairs like cell membrane consisting of liquid layers suggests 2-adicity in nano length scales. This view means that the fractal structure of a given real space-time sheet represents both an integer N and its decomposition to prime factors physically. This would also mean that one can assign several p-adic information measures to the real space-time sheet. This obviously conforms with the physics as a generalized number theory vision.
3. Intuitively it seems obvious that there must be a physical mechanism selecting one prime amongst all possible primes which characterizes the information measure associated with the ensemble of the deterministic pieces associated with the real space-time sheet. Conscious information requires the presence of cognition: the real space-time sheet must be entangled with a p-adic space-time sheet. Quantum-classical correspondence means that the cognitive entanglement of the real system with p-adic system has as a space-time correlate join along boundaries bond connecting the real and p-adic space-time sheet and glued to the boundary of the real space-time sheet along common rational points. One could argue that the p-adic join along boundaries bonds are most probable when the p-adic prime is such that it defines an effective p-adic topology for the real space-time sheet. This would mean that the prime-power factors of N define preferred p-adic length scales to the real space-time sheet.

4. The hypothesis that the prime factorization of N determines the effective p-adic topologies associated with the real space-time sheet inspires the hypothesis that the rational (or algebraic) p-adic-real entanglement necessary for cognitive quantum measurements is probable/possible only for the p-adic primes dividing N .

3. Does classical space-time physics represent factorization of integers?

Quantum-classical correspondence suggests that quantum computation processes might have counterparts at the level of space-time. An especially interesting process of this kind is the factorization of integers to prime factors. The classical cryptography relies on the fact that the factorization of large integers to prime factors is a very slow process using classical computation: the time needed to factor 100 digit number using modern computer would take more than the recent age of the universe. For quantum computers the factorization is achieved very rapidly using the famous Shor's algorithm. Does the factorization process indeed have a space-time counterpart?

Suppose that one can map the integer N to be factored to a real space-time sheet with N deterministic pieces. If one can measure the powers $p_i^{n_i}$ of primes p_i for which the fractality above the appropriate p-adic length scale looks smoothness in the p-adic topology, it is possible to deduce the factorization of N by direct physical measurements of the p-adic length scales characterizing the representative space-time sheet (say from the resonance frequencies of the radiation associated with the space-time sheet). If only the p-adic topology corresponding to the largest prime p_1 is realized in this manner, one can deduce first it, and repeat the process for N/p_1^n , and so on, until the full factorization is achieved. A possible test is to generate resonant radiation in a wave guide of having length which is an integer multiple of the fundamental p-adic length scale and to see whether frequencies which correspond to the factors of N appear spontaneously.

Seeing the prime factorization might be also possible via a direct sensory perception. Oliver Sacks tells in his book 'The man who mistook his wife for a hat' [J91] about twins, John and Michael, who had a mysterious ability to 'see' large numbers and their prime factorizations despite the fact that their intelligence quotient was about 60 and they did not have any idea about the notions of integer and prime. For instance, matchbox was dropped from the table and its contents were spread along the floor. Both twins shouted immediately '111!'. Then John mumbled '37', Michael repeated it and John said '37' third time. Obviously this was their sensory representation for the decomposition $111 = 3 \times 37$ of number 111 to a product of primes! The explanation of these strange feats suggested in the [K70] is a less general idea about physical representation of the factorization. The proposed mechanism could indeed explain prime factorization as a sensory perception involving no algorithmic cognition at all.

4.6 Macro-temporal quantum coherence, consciousness, and biology

This section is devoted to a brief discussion of the aspects of macro-temporal quantum coherence related to consciousness and biology.

4.6.1 Macro-temporal quantum coherence and states of "one-ness"

Selves can be regarded as ensembles of quantum jumps with contents of conscious experience determined by qualia identified as statistical averages over increments of quantum numbers *resp.* zero modes over quantum jumps (non-geometric *resp.* geometric qualia such as colors *resp.* geometric shape. In general selves, and in particular sub-selves representing mental images of self become fuzzy during ageing since the entropies associated with the distributions of quantum number/zero mode increments increase with the increasing size. Macro-temporal quantum coherence allows to avoid this problem and mental image stays sharp as long as the bound state lasts.

The formation of quantum bound states corresponds to the fusion of mental images (sub-selves) to form large mental images and in the ideal situation all mental images fuse to single mental image. The fusion of the right and left visual fields to a single visual field giving rise to stereo vision is basic example of this process. Quite generally, the fusion of more or less identical mental images gives rise to a 'stereo-consciousness'. Synchronous neuronal firing is the physical correlate for the fusion of

mental images and is made possible by the formation of join along boundaries bonds. In case that the mental images are too different this kind of fusion is not useful, and at least in the case of vision, sensory rivalry selects either of the visual images as a conscious percept [J46] .

An interesting question is what kind of conscious experience this process corresponds. A natural guess is that the fusion of mental images to single mental images gives rise to a mystic experience of 'one-ness'. In p-adic context rational bound state entanglement can have negative p-adic entanglement entropy under rather natural definition of entanglement entropy. Perhaps the fusion of p-adic mental images representing cognitive mental images gives rise to the experience of understanding. As found, the definition of entanglement entropy used in p-adic-rational context applies as such in real-rational context. Thus also sensory mental images could carry positive information.

Bound state entanglement for mental images means sharing and fusion of mental images and this kind of mechanism could be crucial for the formation of social structures and establishment of common value systems and moral rules. The experience of love might be the conscious experience associated with the sharing of mental images. TGD predicts also the possibility of bound state quantum entanglement even in astrophysical length scales and sharing of mental images provides a basic mechanism of remote mental interactions by making remote system effectively a part of the system. The realization of sensory representations at the magnetic body and probably also at magnetosphere is based on this kind of remote mental interaction. Rather paradoxically, paranormal phenomena would be completely normal.

4.6.2 Macro-temporal quantum coherence and biology

The formation of bound states is a generic mechanism for generating new quantum fluctuating degrees of freedom and could make possible quantum computation like processes and multi-verse states of consciousness containing large amounts of conscious information. At the macro-level sexual organism could be a basic example of a multi-verse state of one-ness generated by the formation of a macroscopic quantum bound state of partners. Neuro-scientists are used to talk about rewards and punishments, and one might argue that life involves kind of sexual or spiritual pleasure as a reward for the formation of bound states at all levels of hierarchy. Spiritual experiences would represent the most abstract experiences of this kind involving the formation of bound states of the field bodies by MEs serving as field bridges.

Some examples are in order.

1. The binding of molecules by lock and key mechanism is a fundamental process in living matter and could generate large number of quantum fluctuating degrees of freedom and generate conscious intelligence. This could explain why long linear macro-molecules are so important for life. From the viewpoint of classical chemistry it is not obvious why DNA is arranged into long chromosomes rather than separate short threads. In TGD universe the reason why would be that for chromosomes the number of quantum fluctuating degrees of freedom and thus the amount of conscious intelligence is maximized.
2. The binding of the information molecules to receptors is a universal control mechanism in the living matter. In TGD universe information molecule would initiate genuine quantum information processing lasting for the lifetime of the information molecule-receptor complex. In particular, neurotransmitters could induce molecular states of one-ness in the receptor-neurotransmitter complex or perhaps even in larger-sized structures. If neurotransmitters have join along boundaries bonds to other neurons mediated by magnetic flux tube structures or MEs, they could act as conscious quantum links in quantum web and induce quantum computation like processes involving distant neurons just as the links in the web induce classical computations involving distance computers.
3. One could see information molecules and receptors as representatives of opposite molecular sexes: information molecules would be active quantum binders free to move from flower to flower whereas receptors would be the passive party attached to some structure. The binding of the information molecule to the receptor would be the molecular analog of the sexual intercourse. Usually the receptors are bound to larger structures such as cell membrane and also the zero modes for some parts of these larger structures could become quantum fluctuating in the process.

4. As found, the new number-theoretic definition of entropy is very attractive from the point of view of consciousness theory also in the real context. An especially interesting biological application of the number-theoretic entropy would be to the genetic code: in this case the number of bases is proportional to at least $p = 3$. Does the number N of DNA triplets of gene or of information bearing fragments of gene have a tendency to be proportional to powers of some relatively large primes? Could one order the genes hierarchically by the prime number decomposition of the number N so that large primes would correspond to high level bio-control and small primes to low level bio-control? Could the prime number decomposition of N define natural decompositions of gene to sub-modules of the biological program defined by the gene? For instance, $N = 10 = 2 \times 5$ would correspond to 5 (2) sub-modules consisting of 2 (5) DNA triplets.

4.6.3 Macro-temporal quantum coherence and long term memory

The energies liberated in the transitions between spin glass states should correspond to gravitational binding energies. MEs would be the space-time correlates for the radiation emitted in these transitions. These MEs are very near to vacuum extremals and in the simplest situation have CP_2 projection belonging to a homologically trivial geodesic sphere of CP_2 . They would be electromagnetically neutral and carry only Z^0 fields and gravitational fields. Another basic kind of MEs would carry classical em , W fields, and gravitational fields and would correspond to CP_2 projection in homologically non-trivial geodesic sphere. The transitions for MEs near vacuum extremals could realize the mirror mechanism of long term memories.

Mirror mechanism of long term memories and gravitonic topological light rays

To remember what happened (more precisely, happens subjectively now) in the geometric past at a temporal distance of one year is to look at a quantum mirror at a distance of one half light year. To have an intention is to look at a p-adic quantum mirror which is in the geometric future.

MEs (topological light rays) with fundamental frequencies with a time scale measured using year as a natural unit are needed in the mirror model of long term memories. The gravitational transitions between a huge number of almost degenerate spin glass states could be coded to the fundamental frequencies of MEs. In particular, structures with sizes slightly above cell membrane thickness, such as micro-tubules, could generate these MEs as a topological correlate for graviton emission with frequency (length) of ME equal to the increment of the gravitational binding energy in quantum jump involved. Thus there would be a direct correlation with long term memories and micro-tubules: micro-tubule conformations could code for long term memories.

The mirror mechanism of long term memory allows a beautiful interpretation in terms of topological correlates for virtual graviton exchange with vacuum.

1. The light reflected in mirror corresponds to topological light rays assignable to gravitons and is reflected from the curved vacuum. Topological counterpart of virtual graviton is emitted by (say) a tubulin, reflected by the vacuum, and finally absorbed by the tubulin. Curved vacuum acts as a mirror for gravitons and self can see the self of the geometric past in this mirror.
2. Why gravitons are the only possibility in time scale of years is simply that they interact so weakly that they can propagate light years before absorbed by curved vacuum. Note however that Z^0 MEs interact classically with the matter and this interaction is especially strong in cellular length scales and presumably makes possible the reflection of the ME from the vacuum. Time scales come out correctly and micro-tubules are known to be crucial for long term memories (Alzheimer's disease involves changes at the micro-tubular level).
3. One could interpret the low energy topological graviton rays responsible for long term memory as a particular kind of $1/f$ noise accompanying all critical systems, in particular TGD Universe, which can be regarded as a quantum critical quantum spin glass. Gravitonic $1/f$ noise would be emitted in the transitions between almost degenerate spin glass states and would be kind of analog for gravitational brehmstrahlung.

If this view is correct, the time scales of long term memory at DNA level would correspond to very long time scales characterizing consciousness at the level of species. This in fact conforms with

the role of DNA as a species memory. As a matter fact, the gravitational binding energy associated with $L(139) \sim .1$ nm (atomic physics) corresponds to the age of the universe: perhaps this explains why Schrödinger equation applies to the description of atom. $1/R$ dependence of the gravitational interaction energy would explain why very short length scales code biological information about very long time scales rather than vice versa.

Order of magnitude estimate for gravitational binding energies

A rough order of magnitude estimate for the gravitational binding energy for a cubic blob of water (that is living matter) having size given by p-adic length scale $L(k)$ is

$$E_{gr}(cubic, k) \sim \frac{GM^2}{L(k)} = G\rho^2 L^5(k) \sim \frac{Gm_p^2}{L(137)} \frac{L^5(k)}{L^5(137)} \simeq 2^{-127} 2^{5/2(k-137)} \frac{1}{L(137)} .$$

Gravitational binding energy is larger than the p-adic energy $2\pi/L(k)$ for $L(k = 179) \simeq .169$ mm. In the range $L(163) = 640$ nm and $L(167) = 2.56$ μ m gravitational binding frequency varies between 1 Hz and 1 kHz, that is over EEG range up to the maximal frequency of nerve pulses. If the binding energy gives estimate for the lifetime of the gravitationally bound states, this might fit nicely with EEG energies in typical cell length scales!

For $k = 157$ and $k = 151$ (the range from cell 10 nm-80 nm, micro-tubules are at the lower end of this range) the gravitational binding frequency corresponds to a time scale of 8.5 hours and 32 years respectively so that the time scales relevant for life are spanned by the Gaussian Mersennes. What sounds paradoxical is that short length scales would correspond to long time scales but this indeed follows from the inverse square law for the gravitational force.

One can perform a similar estimate for linear structures. Parameterizing the micro-tubular transversal area to be $d = x^2 L^2(151)$, $L(151) = 10$ nm, one has

$$E_{gr}(lin, k) = x^5 \times E_{gr}(cubic, 151) \frac{L(k)}{L(151)} .$$

This gives for $L(k) \sim 1$ meter, the frequency of $.1 \times x^5$ Hz. The time scale varies between $10/x^5$ seconds and $32/x^5$ years and certainly covers the time scale for human long term memories. Of course, this rough estimate involves numerical factor which can increase the upper bound. One must also remember that the change of the classical gravitational energy for spin glass transitions is in question and this energy is smaller than binding energy itself so that actual time scales are considerably longer.

Together with the known facts about the correlations of micro-tubuli with long term memories this leads to the idea that micro-tubuli represent long term memories. What is so beautiful in this idea is that there is no need for long term static storage of memories since memory is represented in the geometric past. The instantaneous configurations of the micro-tubuli define the memories and they are allowed to change in quite rapid time scales. The two conformations of tubulin dimers are ideal for representing declarative memories as bit sequences and micro-tubuli provide huge information storage capacities. One can also understand why sensory pathways tend to maximize their length. The loss of long term memories at old age respects the oldest memories and this naturally corresponds to the degeneration of the long micro-tubuli first with shortest micro-tubuli being the most stable ones. In [K66] the model for long term memories is developed in detail.

4.7 Co-operation and competition as different aspects of quantum consciousness

4.7.1 Breaking of super-conductivity, metabolism and homeostasis

The assumption that magnetic flux tubes of say Earth's magnetic field serve as carriers of supra currents in living manner leads to concrete views about breaking of super-conductivity as a basic mechanism of metabolism and homeostatic control.

Leakage mechanism

The basic mechanism for the breaking of super-conductivity is the generation of 'bridges' between super-conducting magnetic flux tubes and some smaller space-time sheets, which need not be atomic space-time sheets as assumed in the earlier formulation of the model. The energy of photons inducing the bridges corresponds naturally to the difference for the energies of the ion at atomic space-time sheet and super-conducting magnetic flux tube. In the case that the energy at magnetic flux tube is very small as compared to the zero point kinetic energy at smaller space-time sheet, the energy of photon must be the zero point kinetic energy at least. This option will be discussed in the sequel. The ions at the smaller space-time sheet dissipate their energy and end up to having only zero point kinetic energy plus possible thermal energy.

Quantum-classical correspondence suggests that it should be possible to understand how the absorption of photons corresponds to the process in which 'bridges' are generated by MEs. MEs carry transversal electric and magnetic fields. There is infinity variety of various kinds of MEs but for the simplest MEs electric and magnetic fields have constant linear direction orthogonal to each. Electric field defines a potential difference which is constant in length scales much shorter than the wave length of ME. By generalizing the quantization of magnetic flux to that for electric flux one obtains that the the potential difference satisfies

$$eV = n\omega = nf \times 2\pi .$$

This means that an ion having a charge e accelerating in the radial field gets energy $E = n\omega$. Thus absorption of photon with energy $n\omega$ corresponds classically to an acceleration in the electric field of ME and getting same energy. For ion having opposite charge acceleration would be replaced by deceleration and one must speak of emission of photon with energy $E = n\omega$. The model for ADP-ATP process is indeed based on the assumption that metabolic energy generates an electric potential in which protons are accelerated to get energy of .5 eV. for TGD based model see [K38]).

New manner to interpret gap energy of bio-super-conductor

The values of the gap energies of super conductors are identifiable as differences of zero point kinetic energies for the space-time sheets, which correspond to the value of p-adic prime nearest to that associated with the magnetic flux tubes in question and present in the topological condensate. For Earth's magnetic field one has $k = 169$ from flux quantization. For proton the zero point kinetic energy at $k = 151$ space-time sheet is about $E_0 = 2^{137-151} \times .5$ eV, which corresponds to a critical temperature of about $T_{cr} \sim E_0 = .3$ K. For $k = 149$ the critical temperature is about 1.2 K. For $k = 139$ the critical temperature would be 1250 K. If this picture is correct, high T_c super conductors result, when the intermediate space-time sheets between those representing super-conducting magnetic flux tubes and atomic space-time sheets are eliminated somehow from the material. This goal could be achieved by using strong enough magnetic fields for which the p-adic prime is larger than $k = 151$ so that there are not so many p-adic primes to be eliminated. Also secondary p-adic primes are allowed. For instance, $L_2(71)$ resp. $L_3(37)$ corresponds effectively to $k = 142$ resp. $k = 141$ and critical temperature of 156 K resp. 312 K.

The new view about metabolism

This picture about breaking of bio-super-conductivity leads to a new view about metabolism. .5 eV is the value of the quantum of metabolic energy and corresponds to the zero point kinetic energy of proton. The interpretation is that this energy is the minimum energy needed to kick proton from magnetic flux tube of the Earth's magnetic field (say) to the atomic space-time sheets and is liberated in the reverse process. Irradiation by coherent IR photons with energy of .5 eV induces both the formation of the bridges making possible the transfer of protons to atomic space-time sheet and dropping them back. The first process is like pumping of atoms to excited states and the second process is like laser emission of coherent light amplified by the presence of IR photons (also absorption of negative energy photons could be involved as will be discussed below). The process is also accompanied by cyclotron radiation (scaling law of homeopathy). When glucose is metabolized IR photons of energy of .5 eV are liberated and these photons induce both pumping and induced emission. This process

involves the $F_0 - F_1$ machine responsible for the metabolic control. Phase conjugates of IR laser waves should reverse the functioning of $F_0 - F_1$ machine if this view is correct.

Also other ions, even electrons, can be involved in this kind of metabolic cycles and the process can occur between other pairs of space-time sheets. For instance, $k = 151$ space-time sheets microwave photons could induce similar metabolic cycle for protons or of their Cooper pairs and also other ions. The value of the zero point kinetic energy depends on the details of the local environment and this would make possible very effective control of the process. For a given microwave energy the ions associated with only particular kind of the molecular environment would participate in the cycle. Thus microwaves could make possible very precise quantum control. The inducing microwaves could be emitted by the conformational transitions of proteins and other bio-molecules and this would make possible precise and selective bio-control from protein level since the thermal widths of states would be extremely narrow at $k = 151$ space-time sheet. The phase conjugates of microwaves would induce the time reversal of this process making possible healing by time reversal of the biological programs. This would boil down to a very elegant and economical control of the metabolism and homeostasis combining both many-sheeted laser physics and super-conductivity. The analysis of the findings of P. Gariaev's group [I75] suggests that biological microwave lasers are only example of bio-lasers.

Many-sheeted laser action

There is strong analogy with the functioning of laser. The transfer of ions to smaller space-time sheets is analogous to the pumping of atoms to higher energy state. The presence of coherent photons at this energy implies also the many-sheeted analog of the induced emission: the ions having only thermal energy drop back to the magnetic flux tube by emitting photon at energy corresponding to the zero point kinetic energy. If the energy obtained in the kicking is exactly the zero point kinetic energy and the smaller space-time sheet is very cold no dissipation occurs and the situation is especially favorable for laser action.

The irradiation of system with phase conjugate beam of coherent light at this frequency could help to restore the super-conductivity: this hypothesis might be tested for high T_c super-conductors, which might be based on the same mechanism as bio-super-conductors [K13, K14] .

The special role of microwave photons in homeostasis

Microwaves are certainly not the only players in homeostasis but it seems that they have a special role. Plasmoids consisting of closed magnetic flux tube structures carrying supra currents plus atomic space-time sheets associated with them, are good candidates for primitive electromagnetic life-forms. Ordinary bio-matter is assumed to self-organize around these structures and nerve circuit represents a good example of a structure resulting in this manner.

Plasma balls are known to be accompanied by microwaves. This suggests that microwave photons could induce these bridges, break super-conductivity, and induce energy feed and self-organization. A similar breaking of super-conductivity might be also involved with the driving of the super-conducting ions to the atomic space-time sheets in the living matter. It is also possible that the process does not involve much dissipation ($k = 151$ space-time sheet should be very cold and in this case many-sheeted maser would result).

There are several candidates for the source of microwaves in case of plasmoids. What makes these sources so interesting from the point of view of biology is that the frequency spectrum is almost universal.

1. For instance, the ionic currents between $k = 151$ space-time sheets and Earth's magnetic flux tubes makes possible masers. The dropping of electron Cooper pairs from $k = 157$ space-time gives rise to microwave photons with energy about 10^{-3} eV, wavelength of 1.24 mm. More generally, the frequency is $f(A, k) = 2^{157-k} \times .25$ GHz with the assumption that the size of space-time sheet is given by $L(k)$. The dropping of ion of mass number A from space-time sheet k gives rise to photons with frequencies $f(k) = 2^{151-k} \times .15/A$ GHz frequency.
2. The multiple-coiled structure of DNA is expected to give rise to a hierarchy of magnetic flux tubes, and cyclotron transitions at these magnetic flux tubes serve as sources of microwaves. Electronic cyclotron frequency, assuming p-adic scaling of the Earth's magnetic field strength ($k = 169$), is equal to $f_c(k) = 2^{163-k} \times .038$ GHz, whereas ionic cyclotron frequency is $f_c(A, k) =$

$2^{151-k} \times .8/A$ GHz. As will be found, the transitions between cyclotron states at different space-time sheets allow to understand the radio-wave emission from DNA induced by laser light.

There are also more conventional sources of microwaves.

1. Coherently occurring protein conformal transitions could generate microwaves and could be also amplified by the many-sheeted masers. Also molecular masers are possible (say OH maser).
2. The rotational transitions of clusters of water molecules could emit microwaves and perhaps mimic and amplify the microwaves generated by proteins. The clusters of water molecules forming liquid crystals can mimic the conformational and rotational spectrum of various molecules, and that the ability to reproduce the rotational frequency spectrum of the medicine molecule is an essential element of homeopathic healing. The level of self-organization of water would thus be measured by how complex mimicry it is able to perform.

Why rotational microwave energy spectrum is so important for healing, might be understood as follows. The many-sheeted current circuitry, involving atomic space-time sheets and magnetic flux tubes and also other space-time sheets, is extremely complex control structure [K57, K58]. The continual regeneration of bridges between, say, atomic space-time sheets and magnetic flux tubes by microwaves emitted by proteins is necessary to sustain this circuitry. An important category of diseases is due to the failure to generate the bridges between super-conducting and atomic space-time sheets so that this control circuitry suffers shortcuts. Perhaps the genetic expression of some proteins responsible for the microwaves generating particular bridges fails. The medicine or its homeopathic counterpart would help to generate (or even re-establish the generation of) the microwave spectrum responsible for the generation of the lacking bridges in the circuitry.

4.7.2 Combining macro-temporal quantum coherence and dissipation

The question is how the saint and sinner aspects combine. The needed piece of the puzzle comes from the scaling law of homeopathy [K36]. The law states that high and low frequencies accompany each other, the frequency ratio being $f_{high}/f_{low} \simeq 2 \times 10^{11}$ in the simplest situation when the ions leak to atomic space-time sheet from the magnetic flux tubes of Earth's magnetic field. The ratio is essentially the ratio of zero point kinetic energy of the ion at the smaller space-time sheet and the cyclotron energy of the ion at magnetic flux tube. Radiation with frequency f_{high} is produced when ions drop to the magnetic flux tube. The ions drop to cyclotron states such that the magnetic quantum number n is usually larger than $n = 0$, which in turn decay and produce cyclotron radiation with frequency f_{low} and its harmonics.

The TGD based interpretation is that ELF MEs are responsible for quantum entanglement in macroscopic, even astrophysical, length scales. Microwave MEs propagating effectively as mass-less particles along ELF MEs in turn induce self-organization by serving effectively as 'food' of the plasmonic life forms at the receiving end. This mechanism is behind both the endo- and exogenous realizations of intentions as actions, that is ordinary motor actions and phenomena like remote healing and psychokinesis. Also sensory representations at the personal magnetic canvas and magnetosphere rely on this mechanism, and in this case life-forms are mental images getting at least partially their metabolic energy from brain. The law generalizes also to pairs formed by kHz radio wave MEs and MEs corresponding to visible light.

4.7.3 Healing by time reversal

I have proposed in [K63] that time reversal is the basic mechanism of healing. The biological programs simply run backwards to the point, where the error occurred, and a new trial is made. De-differentiation is the counterpart of this mechanism at the cellular level. Stem cells are indeed increasingly used for healing purposes, leukemia being one example of this. The following arguments inspire the question whether biological rhythms could quite generally correspond to dissipation-healing (by time reversal) cycles.

Priore's machine

The TGD based model [K63] of Priore's machine [I54, I40] is based on this idea and involves phase conjugates of microwaves perhaps inducing time reversal mode of molecular machines at DNA level and thus leading to the correction of the genetic error responsible for the cancer. Irradiation by phase conjugate microwaves at critical frequencies might induce the time reversed mode and thus provide a possible general healing mechanism affecting directly the DNA level. Later an alternative interpretation for the functioning of Priore's machines as a mechanism of "stealing" metabolic energy from the cancer cells will be proposed.

Searl machine

The work with various anomalies involved with free energy phenomena has revealed a deep connection between quantum bio-control, remote mental interactions, and free energy phenomena. This connection has become especially clear during the development of a model for so called Searl machine [H11, H10] (see [K83]). Searl machine involves stationary ring magnet along which smaller cylindrical magnets spontaneously start to rotate provided the parameters of the system are in suitable range. Several anomalous effects are involved: weight loss, over unity energy production, generation of magnetic walls, generation of plasma phase, effects on radio-active decay rates, and strong parity breaking.

The TGD based model of the Searl effect is based on essentially the same mechanisms as applied in the quantum models for homeostasis and remote mental interactions (see the chapter "Homeopathy in the Many-Sheeted Space-Time").

Several new physics effects seem to be involved.

1. The rotating magnetic system develops em and Z^0 charges and experiences the classical em and Z^0 electric forces created by Earth so that the effective weight is reduced or increases (depending on the direction of rotation) as much as 35 per cent. The charging is due to the flow of electrons and neutrinos from the rolling magnets to the surrounding air induced by the radial electric and Z^0 electric fields generated by the Faraday effect inducing vacuum charge density (not possible in Maxwell's electrodynamics). The fact that critical frequencies are different for clockwise and counter clockwise spontaneous rotation implies that classical Z^0 force and neutrino currents must be present.
2. The spontaneous accelerating rotation above critical frequency can be understood as being to a Lorentz torque acting on the radial Ohmic em and Z^0 currents in rollers and roller ring. Above the critical frequency the Lorentz torque, which is proportional to rotation frequency, becomes larger than frictional torque, and spontaneous accelerating rotation becomes possible due to the positive feedback.
3. The radial ohmic current of electrons leaking from the atomic space-time sheets of rollers to the space-time sheet of environment explains the presence of plasma around the system. The ionization of the molecules is caused by the electrons from rollers gaining keV energy as they drop from atomic space-time sheets of rollers to the space-time sheets of the environment.
4. The generation of Z^0 magnetic field explains the presence of the strange magnetic walls.
5. A remote metabolism based on the emission of negative energy (phase conjugate) microwave photons and realized in terms of the generalized four-wave mechanism based on magnetostatic waves provides the energy needed by the accelerating system and explains the cooling of the air around the system.

For some time I believed that the reduction of the inertial mass gives rise to a spontaneous accelerated rotation of the rollers by pirouette effect: also the generation of gravitational mass was necessary in order to understand the qualitative behavior. The required reduction of inertial mass is however measured in kilograms and means generation of corresponding positive inertial mass outside the system: this seems implausible. This does not however exclude the generation of gravitational mass in a much smaller scale defined by the magnetic energy density of the magnetic walls appearing in the system.

A further interesting aspect is that the presence of ELF waves at 10 Hz implied by rotation of the Searl machine means that the interaction with the experimenter's brain might interfere with the

experiment. The importance of the experimenter's intention would conform with the finding that free energy effects are not fully re-producible. This only adds to the fascination of these effect if one is ready to give up the reductionist and materialistic dogmas and accept the possibility of remote mental interactions. For instance, Searl's machine might provide be ideal for studying mind-machine interaction.

Could molecular machines act as Searl machines?

One can ask whether the time reversal of the mechanism leading to the leakage of supra currents could be central also for the functioning of bio-systems, and whether the living matter might utilize Searl effect routinely. If so, the time-reversed modes of various molecular machines such as $F_0 - F_1$ machine responsible for the metabolism (and its variants suggests by the many-sheeted space-time concept) might be a routine part of the functioning of the living matter. They would induce time reversals of biological programs and thus healing. The generation of negative energy MEs would induce bound state entanglement and the liberated binding energy would compensate the lack of the metabolic energy feed during the time reversed mode. They could also induce "anti-gravitational" effects, which together with the macroscopic quantum coherence induced by negative energy MEs, could be an essential aspect of the locomotion of the living organism. Molecules, which have temporarily reduced their effective weights, would be ideal for the catalysis in the many-sheeted space-time. For instance, Coulomb wall could be easily circumvented by leaving the electromagnetic charge temporarily to the larger space-time sheet.

One can thus ask whether some molecular machines are actually Searl machines in their time reversed mode. For instance, the $F_0 - F_1$ machine driving protons to atomic space-time sheet from (presumably) magnetic flux tubes of Earth, is much like a power plant containing a rotating shaft. In time reversed mode, in which it acts like a motor, the shaft might have reduced effective weight. The parity breaking effect induced by the classical Z^0 force would also favor second direction for rotation, this is obviously essential in order to achieve a synchronous action.

As noticed, Searl machine could be sensitive to remote mental interactions induced by ELF ME induced entanglement. Interestingly, the rotation frequency of $F_0 - F_1$ machine is about 300 Hz, which is the cyclotron frequency of proton in Earth's magnetic field with nominal value .5 Gauss. The rate for translation of DNA is 20/s and also this is ELF frequency. The possibility of remote mental interaction in bodily length scales by ELF ME induced entanglement could be absolutely essential for the possibility to realize intention by using molecular machines.

Could biological rhythms correspond to dissipation-healing cycles?

The following argument leads to suggestion that biological rhythms quite generally correspond to dissipation-healing cycles involving time reversal in the healing period.

Time reversal means that the second law of thermodynamics is broken. Since p-adic topology does not allow ordering of events, it is natural to expect that time reversals can occur only below the time scale defined by n-ary p-adic time scale $T_n(k)$, $p \simeq 2^k$, k prime or power of prime. An especially important p-adic time scale is the secondary time scale $T_2(127) \simeq .1$ seconds associated with electron. There is already evidence for the breaking of the second law below this time scale [D15] .

The time reversal for the leakage of supra currents is predicted to involve anomalous radiation. Rotating magnetic systems (Searl machine in particular) generate visible light, which must be due to the transitions of excited N_2 and N_2^+ molecules to their ground state (see [K83] , [H10] . This strange radiation has no standard physics explanation. The radiation could result in a geometric time reversal of the process in which electron drops from an atomic space-time sheet by emitting its zero point kinetic energy of about 1 keV as an X ray; X ray in turn ionizes atoms of air and creates electrons, which in turn induce electronic transitions of N_2 and N_2^+ molecules to excited states. For the time reversal excitation of nitrogen molecules occurs first by emission of negative energy photons, which in turn induce geometric time reversal for the ionization process, and finally there is a single negative energy X ray inducing the dropping of electron from atomic space-time sheet to the magnetic flux tube. The system absorbs energy from the environment in this manner, breaks second law, and is able to transform thermal energy to usable energy with efficiency larger than one.

Rotating magnetic system is also found to be surrounded by a series of magnetic walls and a lowering of the temperature is observed at the magnetic "walls": a signature for the pumping of

energy from environment. Anomalous radiation usually generated by ionization of air by electrons and magnetic walls with lowered temperature might be signatures of also remote healing by time reversal.

Also metabolic cycle involves the dropping of protons to some larger space-time sheet, presumably a super-conducting magnetic flux tube of Earth, and a liberation of about .5 eV zero point kinetic energy as a usable energy (the universal "energy currency"). Buy-now pay later principle and temporary time reversal could be involved also now and provide enormous flexibility (think only how easy it is to travel abroad if you have a credit card!). The molecular system utilizing the metabolic energy quantum would emit negative energy photon being thus excited to a higher energy state, and a proton at the atomic space-time would absorb the negative energy photon and "drop" to the magnetic flux tube to be driven back by $F_0 - F_1$ machine. Thus metabolism would repeat a cycle involving dissipation and healing. Fractality suggests that other biorhythms correspond to similar dissipation-healing cycle.

Even sensory perception and motor action could be seen as time reversals of each other in a relevant time scale. Motor action would be like carving a four-dimensional statue by starting from a rough sketch and adding the details gradually. The dissipation in both ordinary and reversed direction of the geometric time would Darwinially select a final state with only a rough dependence on the details of the sketch. No detailed planning would be required. Dissipation would act as an ally instead of an enemy. Motor actions could be imagined by initiating the time reversed process, not from the muscle cells as in case of actual motor action, but from some higher level of the central nervous system and proceeding to the level of cortex. Sensory imagination would also be a process starting from some level above sensory receptors and propagate up to the cortical level: this would mean that sensory qualia would be absent. During dreaming and hallucinations sensory qualia would be assigned to the imagined experience by feedback to the primary sensory organs involving entanglement and sharing of mental images.

4.7.4 Earth's magnetic field as a structure analogous to Searl's machine

Earth's magnetic field rotates and this suggests that it is also kind Searl's machine. The frequency of rotation is one cycle per 24 hours (10 cycles per second for the Searl's machine of [H10]). If Searl's machine indeed involves a time reversal, one might expect that similar time reversal occurs in the case of the Earth's magnetic field. Therefore one expects a bio-rhythm with a period of 24 hours decomposing to dissipative self-organization period and a healing period.

Wake-sleep cycle is obvious candidate for this bio-rhythm. During sleep brains and perhaps entire organism entangles with the magnetosphere to give rise to self-organizing collective magnetospheric consciousness, which is something else than a mere passive sensory representation and draws actively energy from the biosphere by buy now -let others pay mechanism by emitting negative energy MEs.

The outer magnetosphere, in particular plasma sheet corresponds to theta and delta bands for protons from the requirement that the length of ME defines an appropriate magnetic transition frequency at a given point. Theta and delta bands indeed dominate during sleep. Alpha band is at the boundary between the inner and outer magnetosphere and dominates during hypnagogic states during which conscious experience involves transpersonal components.

The prediction is that EEG corresponds to negative energy photons and time reversed MEs during sleep. During daytime the inner magnetosphere is activated and in a role of passive computer monitor. Thus brain would generate during the wake-up period positive energy MEs inducing self-organization at magnetosphere and personal magnetic canvas responsible for the sensory representations. Night-day dichotomy would correspond to negative-positive energy dichotomy for MEs, and this dichotomy might be detectable from EEG (during night time coherent EEG laser beams would transform to their phase conjugates). That night side magnetosphere corresponds structurally and functionally to motor areas and frontal lobes, and day side magnetosphere to the sensory areas, was proposed already earlier in [K42] . Although this picture is bound to an over-simplification, it might be a good starting point.

The anomalous radiation associated with the Searl's machine should correspond to a self-organization of the magnetospheric plasma by remote metabolism using the metabolic resources of the sleeping brain and body. From the point of view of biosphere this process would be a healing process since time reversals of dissipative processes occur. Magnetic transitions of super-conducting charged particles (protons and electrons) are good candidates for generating anomalous ELF radiation. Negative energy EEG MEs carry high (negative) frequency MEs resulting when ions jump from magnetic flux tubes to smaller space-time sheets. In self-organizing plasma regions an entire hierarchy of space-time sheets

is expected to be present, and could give rise to wide range of negative energy photons, microwave photons in particular. This vision provides a tentative model for how the highly self-organization plasma sheet at the night side of the magnetosphere uses the metabolic energy from sleeping brain to self-organize and to construct sensory representation about biosphere [F2] .

Chapter 5

Bio-Systems as Conscious Holograms

5.1 Introduction

The idea about brain as hologram is very attractive but it is not easy to give precise and testable content for this notion. This chapter is devoted to the question in what precise sense living matter can be regarded as a hologram.

5.1.1 The notion of conscious hologram

At the level of quantum TGD the notion of quantum gravitational hologram emerges naturally in the sense that 3-surfaces code for data about pieces of 4-surfaces just like 2-dimensional hologram plates codes data about a 3-dimensional image. Classical non-determinism of the basic variational principle however implies that TGD based physics does not reduce to the moment of big bang. Massless extremals which are topological counterparts of light rays in TGD could provide a realization of this idea. Unfortunately, this notion of hologram is yet quite too abstract to be applicable to the concrete modelling of living matter.

Even more, the basic challenge is to generalize the notion of the ordinary hologram to that of a *conscious* hologram, about which bio-holograms would be examples. The notion of quantum gravitational hologram is defined at the level of geometric, purely physical existence whereas conscious holograms exist at the level of subjective existence defined by the sequence of quantum jumps and giving rise to the self hierarchy. Of course, these two notions of hologram must be closely related.

The notion of conscious hologram combines the saint and sinner aspects of consciousness to single concept: macro-temporal quantum coherence due to the generation of bound state entanglement and giving rise to co-operation on one hand, and the dissipative self-organization giving rise to Darwinian selection and competition on the other hand.

In nutshell, the notion of conscious hologram follows from the topological field quantization. Classical fields and matter form a Feynmann diagram like structure consisting of lines representing matter (say charged particles) and bosons (say photons). The matter lines are replaced by space-time sheets representing matter (elementary particles, atoms, molecules,...), and virtual bosons are replaced by topological light rays ("mass-less extremals", MEs). Also magnetic flux tubes appear and together with MEs they serve as correlates for bound state quantum entanglement.

The classical fields associated with MEs interfere only at the nodes, where they meet, and one has a hologram like structure with nodes interpreted as the points of a hologram. Thus one avoids the loss of information caused by the interference of all signals everywhere. This aspect is crucial for understanding the role of em fields in living matter and brain. The MEs corresponding to 'real photons' are like laser beams entering the hologram and possibly reflected from it. What is new that the nodes can be connected by 'virtual photon' MEs also analogous to laser beams. Hence also 'self-holograms' with no laser beam from external world are possible (brain without sensory input).

The hologram has a fractal structure: there are space-time sheets at space-time sheets and high frequency MEs propagating effectively as mass-less particles inside low frequency MEs serving as

quantum entangling bridges of even astrophysical length. The particle like high frequency MEs induce 'bridges' between magnetic flux tubes and atomic space-time sheets at the receiving end. This makes possible the leakage of supra currents from magnetic flux tubes to atomic space-time sheets analogous to the exposure of film producing hologram. The leakage induces dissipation, self-organization, and primitive metabolism as a cyclic flow of ionic currents between the two space-time sheets, and thus a Darwinian selection of the self-organization patterns results. Under certain conditions the leakage followed by dropping back to the larger space-time sheet can also give rise to a many-sheeted laser. The low frequency MEs are responsible for the bound state entanglement, macroscopic quantum coherence and co-operation whereas high frequency MEs are responsible for self-organization and competition.

The 3-D vision associated with ordinary holograms generalizes to stereo consciousness resulting in the fusion of mental images associated with the points of conscious hologram.

5.1.2 Time mirror mechanism

Time mirror mechanism involves reflection of laser beam in time direction. The negative energy phase conjugate photons from geometric future are time reflected as positive energy photons to the direction of geometric future. These photons could be also dark photons, or more generally, dark electro-weak gauge bosons, gluons, or even gravitons. The large values of \hbar make possible time mirror mechanism in arbitrarily long time and length scales since photon energies can be above thermal energy for arbitrarily low frequencies.

Time reflection provides a mechanism of long term memory as communications with the geometric past and a mechanism of metabolism in the case that the system of the geometric past is population reversed laser. The proposed mechanism of intentional action relies on time mirror mechanism. Dark matter hierarchy makes possible remote mental interactions in arbitrarily long time and length scales. The control of the biological body by the magnetic body (there is actually a hierarchy of them) provides the basic everyday example of remote mental interaction. The strange time delays of consciousness discovered by Libet can be interpreted as being due to the communications between biological and magnetic body.

5.1.3 Biophotons

The general vision developed in [K26] suggests how bio-systems could generate holograms in much more concrete sense than the wetty and hot and noisy character of this environment would suggest: even mechanisms generating laser beams could be there. Bio-photons are excellent candidates for the coherent light generated in living matter. An alternative identification is as de-coherence products of dark photons generated by living matter.

The findings of Peter Gariaev and collaborators [I75] provide a new support for the notion of many-sheeted DNA. The findings also lead to a concrete model for how bio-photons affect many-sheeted DNA, and in this manner induce a generation of coherent radio waves and ELF waves. Moreover, a concrete model for how bio-systems act as many-sheeted lasers at various wavelengths emerges.

5.1.4 The work of William Tiller

William Tiller in Stanford University has carried out impressive experimental work with what he calls intention imprinted electronic devices (IIED), and his results challenge that standard assumption that the intentions of experimenter do not affect the experimental apparatus [J99, J100, J101]. The analysis of the work of Tiller in the conceptual framework of TGD leads to the conclusion that four-wave interaction, which is a basic mechanism to produce phase conjugate waves (negative energy topological light rays), serves also as a basic mechanism of intentional action. When the two oppositely reference beams have slightly different frequencies. A first principle explanation for the scaling law of homeopathy, which involves a pair of high and low frequencies and an excitation moving with a sub-luminal velocity, emerges.

Time mirror mechanism involving probe wave and its phase conjugate are needed to get the energy to build this kind of hologram. The archetypal holograms defined by the standing waves resulting as interference patterns of reference waves moving in opposite directions can be regarded as basic building blocks for the symbolic representations of sensory data. Nerve pulse patterns reflect the basic aspects underlying four-wave interactions. Pairs of ELF and microwave frequencies are necessary in order to

have moving standing wave patterns serving as correlates for the neuronal synchrony: hence one can understand the role of EEG and kHz oscillations. Rate coding results from the possibility to choose the frequency of the microwaves responsible for the hologram. Also Ca_{++} waves and other ionic waves should define archetypal symbolic representations of the sensory data.

The notion of hologram generalizes. The quintessence of standing waves is that they correspond to synchronous coherent oscillations of the entire system. Ionic plasma oscillations occur with the same frequency irrespective of the wave vector and thus they define ideal holograms in the sense that the same pattern occurs repeatedly. Ordinary matter is completely Z^0 ionized and therefore Z^0 plasma frequencies are ideal for generating living holograms. As a matter fact, the observation that Z^0 plasma frequency of water corresponds to energy .44 eV, the basic metabolic energy currency, put the bell ringing. Various biologically important ions define also plasma frequencies. p-Adic length scale hypothesis predicts entire hierarchy of plasma frequencies coming as powers of $2^{3k/4}$. Thus the prediction about hierarchy of holograms is readily testable.

In the sequel the basic ideas of the many-sheeted quantum control are summarized, the notion of conscious hologram is introduced, phase conjugation and time mirror mechanism is discussed, a concrete model for bio-photons and for how living system acts as a many-sheeted laser emerging from the experimental findings of Peter Gariaev and his group [I74] is described, and the application to remote mental interactions and various tests of the concept are discussed at the general level. The chapter ends with the detailed model for the findings of William A. Tiller and vision about how four-wave interaction generalizes.

5.2 Conscious hologram

The notion of conscious hologram gives hopes about a unified description of living matter and remote mental interactions.

5.2.1 What are the basic properties of conscious hologram?

To proceed it is good to ask what are the basic features of ordinary holograms possessed also by conscious holograms.

Distributed information storage

The most fundamental and biologically attractive property of hologram is the distributed character of the information storage in the sense that a small piece of hologram represents satisfactorily the same image as entire hologram. This makes information storage very robust. This condition is very general and is satisfied by the neurons of cortex which receive information from a large number of neurons, and it would seem that neurons are good candidates for points of a 3-D conscious hologram. The fractality of the TGD universe allows an entire hierarchy of hologram structures corresponding to the hierarchies of space-time sheets and of selves.

Continuity

The neighboring points of the hologram store almost the same information. Also in the case of a primitive organisms like salamanders each neuron of brain seems to represent almost the same information (even when salamander's brain is shuffled like a pack of cards, salamander recovers and preserves its memories [J86]). This would suggest that single neuron forms a hologrammic image about a considerable part of brain. This could apply at the level of any cell and body parts to which it belongs.

The assumption that cells are like points of hologram plate would explain why cell replication is the basic architectonic principle in the living matter. Quite generally, the structures which appear as almost identical copies, say proteins, DNA triplets, cell nuclei, cells, and the millimeter sized information processing units in cortex, are good candidates for 'points' of a conscious hologram. The TGD based view about higher levels of the self hierarchy suggests that even individual organisms of a given species correspond to the points of conscious holograms representing higher multi-brained conscious entities. Also various body organs, brains, substructures of brain,...., and even the DNAs of a given species could form similar collective conscious entities.

5.2.2 Stereo consciousness and the notion of conscious hologram

Ordinary holograms are 3-dimensional. This is made possible by the preservation of the phase information achieved by the interference between reference beam and the beam scattered from the object. On the other hand, ordinary stereo vision results somehow from two slightly different views about the same visual field provided by the retinas. In TGD inspired theory of consciousness stereo-consciousness results, when different sub-selves bound-state entangle to single sub-self: each sub-self gives rise to a view about (possibly) the same object of perceptive field. The entanglement of right and left visual fields so that separate visual fields fuse to single 3-D visual field is a special case of this. When the sensory fields are too different, stereo consciousness is not sensible. In this kind of situation sensory rivalry results so that either left or right hemisphere determines the conscious-to-us percept. This is analogous to the 'alike likes alike' rule of Sheldrake [I122] characterizing morphic resonance. In particular, during sleep a large number of sufficiently similar brains could quantum entangle to give a stereo view about 'human condition'.

The question is whether the hologram mechanism understood in a sufficiently abstract sense could be consistent with the generation of stereo consciousness by bound-state entanglement. This seems to be the case. The entangling systems would correspond to the points of a conscious hologram, neurons, cells or some other structures. The survival value provided by stereo consciousness explains why populations of almost similar living systems have resulted in evolution. The geometric correlate for the bound state entanglement is the formation of join along boundaries bonds, say magnetic flux tubes and MEs. These join along boundaries bonds imply classical coherence necessary for the hologram property in the ordinary sense, as well as macroscopic and macro-temporal quantum coherence in the time scale defined by the lifetime of the bound state.

MEs are TGD counterparts of topological light rays and the classical fields propagating along them are natural candidates for generating self-hologram as a system which defines its own hologrammic image. This requires that a given basic unit is connected by join along boundaries bonds to a large number of other units and receives classical information from and quantum entangles with them in the hologrammic state. When bound state quantum entanglement is not present, system is in a 'reductionistic mode' and decomposes into separate sub-selves. Classically this corresponds to the de-coherence of the classical fields associated with the units and absence join along boundaries bonds connecting the units of the conscious hologram.

The experimental findings of Russian researchers about bio-holograms [I91] support the notion of conscious hologram. Kirlian images taken from say fingertips are studied. What is found is that the simultaneous electrical stimulation of some body part, say inner ear, affects the spectrum of visible light in the Kirlian image of the finger tip. Even more, it is possible to abstract the image of the stimulated body part from the pattern of the visible light in Kirlian image.

5.2.3 Questions

At least the proposed basic aspects seem to be worth of taking into account in an attempt to generalize the notion of hologram to that of self-hologram or conscious hologram. Several questions however remain to be answered.

How is it possible to abstract any conscious information at all from the self-hologram?

Ordinary hologram is completely diffuse and does not contain visual information as such and reference beam is needed to generate the 3-dimensional picture. In case of a self-hologram this mechanism need not work, since even the notion of reference beam is questionable. In the case of an ideal self-hologram every part of the hologram receives fields from all the other parts and there are actually large number of fields interfering at a given point of the hologram. There are two ways to circumvent the problem: hologram is not ideal and there is a symmetry breaking input from external world.

1. Self-holograms are somewhere between ordinary photo and ideal hologram

Self-hologram is not ideal one: not every unit is connected with every other unit and self-hologram is expected to be somewhere between the ordinary photo and ideal hologram. A given block of units receives information about some other blocks of units and forms a hologram about the field patterns sent by those blocks. For instance, these blocks could correspond to cortical features associated with a given sensory modality and firing synchronously. Topologically this means that these blocks of units

are connected by a large number join along boundaries bonds whereas the number of join along boundaries bonds to the other units is relatively small. Thalamo-cortical and cortico-thalamic connections provide a basic example of this. Topographical connections from sensory organs to thalamus and from thalamus to the primary sensory areas correspond to the geometric optics limit in which interference effects are minimized. Diffuse connections from brain stem responsible for controlling general alertness correspond to the second extreme.

2. Breaking of symmetry by inputs from external world

Self-hologram receives input from the external world via what might be called primary sensory organs (in generalized sense). This information is shared holographically by join along boundaries bonds connecting the primary sensory organs to other units. This breaks the symmetry between units even in the case that ideal self-hologram is in question. When some unit receives strong stimulation and self-organizes vigorously, it also sends much stronger stimuli to the other units. Hence the contribution of this unit to the experiences of other units can dominate and other units tend to experience the same experience as the strongly stimulated unit.

For instance, in the case of bio-holography [191] by Kirlian imaging the electrical stimulation of the inner ear implies that the input from the inner ear to the finger tip starts to dominate over the input from the other body parts. This picture conforms with the general facts about conscious experience. When the sensory input breaking the symmetry is absent as in case of a deep meditative state, a holistic state of one-ness in which mind is 'empty' results. On the other hand, when a highly emotional mental image is present, this mental image dominates over the other mental images. The emotional content of the mental image obviously measures how strongly it contributes to the self-hologram. The fact that information molecules responsible for emotions are scattered around the entire body, encourages to think that it is indeed the entire body which experiences emotions, and that limbic brain is more like a primary emotional organ. Emotional expression would result from the quantum communication of emotions from the limbic brain to the body which now takes the same role as brain in case of sensory input.

3. In what sense mental functions are localized?

This picture is consistent with the finding that the localization of mental functions to various parts of brain seems to make sense. As already noticed, one can divide the units of the self-hologram into two classes: those which receive primary stimulus, and those which receive only secondary stimuli. This division can be made at several levels. Primary sensory organs viz. other parts of CNS, thalamus viz. cortex, primary sensory areas viz. higher sensory areas are examples of divisions of this kind. The possibility of this kind of division means that the assumption about the localization of consciousness to brain and various mental functions to various parts of brain, although basically wrong, defines a reasonable 'as-if' theory. The units which receive the primary stimuli replace functional units in the hologrammic view about brain. Artificial stimulation of, say, cortical neurons can artificially make them the primary sensory organs and the fact that this kind of stimulation can induce memories and complex hallucinations, suggests that these neurons indeed have complex conscious experiences differing from our experiences only in that the stereo consciousness aspect is not present.

What physical process corresponds to the formation of a conscious hologram?

Ordinary hologram plate results, when the reference beam and the beam scattered from an object interfere and induce a local change in the transparency of the film. This change is proportional to the local intensity of the incoming light. In the case of a self-hologram the reference beam and the light scattered from the object are replaced by the interference of the classical radiation fields propagating along MEs and converging to a given unit like light rays to retina. Hologram results locally if one assumes that the classical radiation resulting in the interference induces some physical change proportional to the net intensity of the classical radiation field, and provided that the units are connected by join along boundaries bonds to form a macroscopic quantum bound state.

Conscious experience involves a formation of self-organizing mental images. A very general mechanism inducing self-organization is the leakage of ions from the super-conducting magnetic flux tubes to the atomic space-time sheets, where the ions dissipate their energy, and end back to the magnetic flux tubes sooner or later. In case of protons this process corresponds to the fundamental step in the metabolic ADP-ATP cycle. Very probably the process occurs for other ions and perhaps even for

molecules, and in this generates EEG waves by the mechanism proposed in [K38] .

This process occurs only if 'bridges' between atomic space-time sheets and magnetic flux tubes are somehow created. If the number of bridges formed is proportional to the total intensity of the classical radiation entering into the unit along various topological light rays converging to it, a hologram like structure results.

A concrete interpretation for this mechanism is suggested by various findings related to the role of microwaves in living matter. Microwaves with energies of quanta not too much above the gap energy of bio-super-conductor, generate 'bridges' between magnetic flux tubes and atomic space-time sheets inducing the breaking of super-conductivity and local self-organization. This mechanism gives rise to the many-sheeted ionic flow equilibrium defining dynamical control circuitry taking care of quantum homeostasis. The scaling law of homeopathy leads to the view that ELF MEs serve as quantum entanglers, em bridges connecting units of a conscious hologram, and that microwave MEs propagate along them like mass-less particles along ELF MEs, and induce self-organization at the receiving end. The interference of the classical fields associated with microwave MEs in the region with size considerably smaller than wavelength to guarantee effective point-likeness would give rise to single point of the hologram.

Both the fractality of TGD Universe and the findings of bio-holography [I91] suggest that the mechanism is much more general. Also MEs with lengths in wavelength range of visible light and radio frequency (RF) MEs in kHz range define low-high frequency pairs of MEs. The electric voltage associated with say finger tip and oscillating at about kHz frequency defines the RF ME to which RF MEs from various body parts converge and fuse with. Along RF MEs propagate the visible MEs with lengths coming as multiples of the wave lengths of visible light. The interference occurs in a region of size smaller than wavelength of visible light. When some body part is stimulated electrically, it emits a large number of visible MEs ending down to the fingertip and contributing to the Kirlian image.

As noticed, the sizes of the basic hologrammic units corresponding to a given wavelength must be smaller than the wavelength to guarantee effective point-likeness. The experiments of Gariaev [I75] demonstrate that the illumination of DNA with a visible laser light generates radio waves with frequencies up to MHz with frequencies in kHz range having especially strong intensities, which suggest that the wavelength range associated with the visible light corresponds to sub-cellular structures, DNA being the most natural candidate in this respect. Also the findings about bio-holograms [I91] , and the fact that kHz frequency corresponds to the duration of nerve pulse and to the frequency of neuronal synchrony support this identification. The units associated with microwave MEs must have sizes in the length scale range 1 mm-300 mm and millimeter sized structures in cortex (cortex has thickness of order millimeter).

Also larger structures of cortex are candidates for hologrammic units at the level of multi-brained collective consciousness. Magnetospheric sensory representations would naturally correspond to this kind of multi-brained conscious holograms and various parts of brain and also body parts could give rise to what might be regarded as a species consisting of individuals and possessing collective consciousness. Scaling law makes this hypothesis quantitative and assigns to a structure with a given size an ELF frequency responsible for the entanglement with magnetosphere.

What about the notions of reference beam and static hologram?

The view about holograms as generated by a simple reference beam and the beam representing information is too simplistic to be applied as such to conscious hologram. For instance, the number of interfering beams is large since each ME converging to given unit of self-hologram corresponds to a particular beam. However, in a situation in which single ME gives a dominating contribution, the remaining MEs collectively interfere to what might be regarded as a counterpart for a slowly varying reference beam.

Under certain conditions it is also possible to talk about quasi-static conscious hologram. There are two time scales involved: the lifetime τ_B of the macroscopic bound state defined by the hologram, and the lifetime τ_s of the 'bridges' connecting atomic space-time sheets and larger space-time sheets. If these time scales are longer than the duration of the stimulation from the active units of hologram, quasi-static hologram results. At the level of conscious experience the reference beam could be interpreted as the background whereas the dominating contribution to conscious experience would correspond to the figure.

p-Adic length scale hierarchy suggests the presence of a hierarchy of time scales corresponding to

the lifetimes of these bridges, and synaptic strengths might be seen as quasi-static conscious holograms resulting in this manner. If this is the case, the breaking of super conductivity and dissipation should be a crucial element of synaptic activity. The fact that the dendrites are responsible for most ohmic losses in the neural circuitry [E1] conforms with the idea that the breaking of super-conductivity occurs dominantly in the dendrites. The age hierarchy for quasi-static holograms would correspond to a hierarchy of supra current leakages occurring from various space-time sheets labelled by p-adic primes. The effect of various neural transmitters and information molecules might be understood as a generation of bridges between space-time sheets characterized by the duration of the effect. The more lasting the effect is, the larger the corresponding space-time sheet would be. This conforms with the fact that information molecules with long lasting effect are responsible for emotions and moods, which are indeed whole-body effects.

How to avoid the problems caused by finite temperature?

The basic objection against the notion of conscious hologram is that thermal fluctuations destroy the quantum coherence for sub-thermal photon (boson) energies. In the standard physics framework this would have fatal consequences.

Before the realization that Planck constant is most naturally dynamical and quantized in TGD Universe [K92, K25] , the hypothesis was that the sheets of many-sheeted space-time are thermally isolated in a good approximation so that the temperatures of large space-time sheets can remain very low for long periods of time. This would allow to circumvent the thermal constraint. A more elegant solution working also for the isothermal case is that large space-time sheets correspond to large values of Planck constant implying that for any given frequency there exist infinite number of levels in dark matter hierarchy such that photon energy is above thermal energy. Dark matter hierarchy would therefore make universe quite literally a conscious hologram.

The stimulus leading to the ideas about dark matter hierarchy and large \hbar came from the observations suggesting that gravitationally bound states of dark matter correspond to a gigantic value of Planck constant [K72, K25] , [E6] . This suggests that also dark gravitons are there and make universe a hologram in astrophysical and cosmological length scales. These ideas lead to a precise proposal for how the hierarchy of Planck constant is realized in terms of the book like structure of generalized imbedding space as well as to a proposal for a spectrum of Planck constants [K29] .

TGD inspired quantum biology and number theoretical considerations suggest preferred values for $r = \hbar/\hbar_0$. For the most general option the values of \hbar are products and ratios of two integers n_a and n_b . Ruler and compass integers defined by the products of distinct Fermat primes and power of two are number theoretically favored values for these integers because the phases $exp(i2\pi/n_i)$, $i \in \{a, b\}$, in this case are number theoretically very simple and should have emerged first in the number theoretical evolution via algebraic extensions of p-adics and of rationals. p-Adic length scale hypothesis favors powers of two as values of r .

One can however ask whether a more precise characterization of preferred Mersennes could exist and whether there could exist a stronger correlation between hierarchies of p-adic length scales and Planck constants. Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1 + i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241.. \}$ are expected to be physically highly interesting and up to $k = 127$ indeed correspond to elementary particles. The number theoretical miracle is that all the four p-adic length scales with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μ m). The question has been whether these define scaled up copies of electro-weak and QCD type physics with ordinary value of \hbar . The proposal that this is the case and that these physics are in a well-defined sense induced by the dark scaled up variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$.

This proposal will be referred to as Mersenne hypothesis and it leads to strong predictions about EEG since it predicts a spectrum of preferred Josephson frequencies for a given value of membrane potential and also assigns to given value of \hbar a fixed size scale having interpretations as size scale of body part or magnetic body.

5.2.4 Self-referentiality and space-time topology

The notion of self-referentiality is one of the deepest and most fascinating notions of mathematics but for some reason it has not caught the full attention of physicists. I encountered the mystic variant

of this notion during my 'great experience' (the idea about living system as a computer sitting at its own terminal) and a more mathematical variant of the idea for a year or two later while reading the book "Gödel, Escher, Bach" of Douglas Hofstadter. It took however more than fifteen years before I managed to identify a possible concrete realization of the notion in TGD based physics. Although topological self-referentiality is only loosely related to the notion of conscious hologram, it deserves to be discussed here.

Does physical system provide a representation for a theory about physical system?

MEs and magnetic mirrors play a key role in TGD based model of living matter. The connection with standard chemistry has been however lacking. It seems that some deep principle is needed to build this connection. The hints about the big principle come from the following observations related to the topological field quantization implying what might be called Bohr orbitology for the classical fields.

1. TGD predicts the existence of negative energy space-time sheets, in particular MEs. The prediction is based solely on the assumption that the space-time is representable as a 4-surface.
2. One can understand gravitational binding energy only if negative energy MEs represent this energy. This suggests that binding energy of a system has a very concrete representation as a negative energy MEs.
3. Quantum entanglement has as a geometric correlate join along boundaries bonds, in particular MEs and possibly also magnetic mirrors. Only the entanglement associated with the bound states is stable against the state preparation process leading to a maximally unentangled state in each quantum jump.
4. Classical superposition for em fields could mimic quantum superposition for states. The multiples of the fundamental frequency for ME could represent the BE condensate of bosons with energy defined by the fundamental frequency $f = c/L$.
5. The phase increments of the CP_2 coordinates around closed loops could represent phase increments of spinor fields and super-conducting order parameters around them as suggested in [K39].
6. Join along boundaries bonds can represent even half-odd integer spin topologically. The join along boundaries bonds connecting 3-surface to a larger 3-surface get entangled in 2π rotation but in 4π rotation no entanglement results : this is due to the fact that the bonds provide a representation for the homeotopy group of 3-dimensional rotation group. A good manner to visualize the situation is to think of a cube inside a larger cube with threads connecting the corresponding vertices of the cubes. An interesting question is whether also spin and statistics connection could be represented classically somehow.
7. Dark matter hierarchy would make possible the concrete realization of self-referentiality. The fact that for a given energy the size of the space-time sheet scales as \hbar suggests a hierarchical structure for self representations in the sense that given level of dark matter hierarchy provides representations of lower levels. These representations would be abstractions, space-time averages with too small details smoothed out. This is just what our brains in general and theory builders in particular are doing all the time. What is new that Nature itself would be constructing these idealizations so that the idealizations of reality provided by various levels of dark matter hierarchy would be an essential element of reality.

These observations suggests a far-reaching generalization. Perhaps many-sheeted space-time allows the system to represent in its own structure the theory about itself. All theoretical concepts usually thought to have rather ethereal existence would have a concrete topological representation. These representations would exist already at the elementary particle level. Not only bio-molecules, but even hadrons, would be accompanied by a topological representation about their theory analogous to a written language. p-Adic-to-real transition would actualize this theory. Thus not only cognition but also symbolic representations of thoughts would be present in all length scales.

This idea of self-referentiality is actually an essential part of the basic philosophy of TGD. TGD inspired theory of consciousness implies that the Cartesian division to a world and theory about it

is an illusion. Quantum histories, which are TGD counterparts for the solutions of field equations *are* the reality, there is no need to postulate any 'real' reality behind them since conscious experience is associated between quantum jumps between quantum histories rather than the 'real' reality. 'Ontogeny recapitulates phylogeny' principle states that quantum histories have geometric and topological correlates at space-time level. This is just what the idea about topological representation of a theory about the system as a part of the system itself means. System could consist of a hierarchy of levels such that $N + 1$:th level represents N :th level. Or perhaps more precisely, what results in the interaction of N :th level systems.

In atomic and molecular physics the basic implications would be following.

1. Atoms and bio-molecules would carry a representation about their own theory based on MEs. Since MEs carry light like four-momentum, they should appear as pairs of parallel MEs with opposite momenta and with frequency corresponding to one half of the binding energy: $f = E_B/2$. The frequencies associated with ME come as multiples of its fundamental frequency $f = c/L$, L the length of ME. This dictates to a high degree the lengths of the MEs associated with a given binding energy. The most natural length corresponds to the wave length defined by one half of the binding energy. In the spirit of Bohr orbitology justified by the allowing only preferred extremals of Kähler action with the property that there exists infinite number of deformations with a vanishing second variation, one can also require that ME pair has a classical energy equal to the binding energy: this requirement correlates the field strength and the thickness of the negative energy MEs.
2. Atomic binding energies would correspond to MEs with wave lengths in UV region. The binding energies of typical covalent bonds would give rise to MEs with lengths in wave length region which corresponds to UV and visible light. The binding energies of hydrogen bonds in turn would give rise to MEs with lengths which correspond to wave lengths in the near infrared, cell size would be the typical length scale.
3. In the case of a potential well, such as the one associated with a harmonic oscillator or constant magnetic field, a natural representation would be in terms of positive energy ME allowing various harmonics. Vibrational and rotational frequencies would correspond to infrared and micro-wave region and magnetic energies to ELF region. The idea that these frequencies correspond to high level representations for the system is of course already now a basic element of TGD inspired theory of consciousness and conforms fully with the idea about topological self reference.

Possible biological implications of topological self reference

The notion of topological self-referentiality, if correct, means the possibility to combine enormous amount of knowledge from biochemistry to build a concrete view about em bodies of molecules and about how living matter represents itself in its own structure. One could also try to identify the chemical counterparts for the special frequencies predicted by the p-adic length scale hypothesis. One might even hope that one could at some level understand how such very high level phenomena like written language emerge from the topological self-referentiality. What is so interesting is that the hypothesis connects various length scales. For instance, the binding energies of atoms with nuclear charges $Z \sim 10$ are in keV range and correspond to MEs with size of order nanometer. Perhaps even the structure of condensed matter is partly coded into the representation of the binding energies of atoms.

Some examples of the possible consequences in biological length scales deserve to be mentioned.

1. The many-sheeted structure associated with a molecule would provide a representation for the molecule identifiable as its electromagnetic signature introduced in the theories of homeopathy and water memory. And not only this: this structure would also serve as a 4-D dynamical hologram serving as a photograph-like template for the self-organization of matter around the molecule. This would mean effective reductionism, but obviously only effective.
2. Genetic code would be a highly developed form of this representation. It would involve the negative energy MEs associated with various atomic and molecular binding energies. Especially important negative energy MEs would be in the visible region and associated with the covalent bonds and in the near infrared associated with the hydrogen bonds connecting DNA nucleotides

together. Also the MEs associated with rotational and vibrational degrees of freedom are expected to be very important and for them liquid crystal blocks of water could serve as mimickers and amplifiers. The transparency of water to visible frequencies (covalent bonds have energies 4.7 eV in UV region) means that water is an ideal medium in the visible region for communications by MEs since coherent visible light can propagate long distances with attenuation caused only by the absorption by bio-molecules.

This picture gives a justification for the suggestion of Peter Gariaev that DNA is accompanied by laser mirror pairs [174]. The negative energy ME pairs associated with various binding energies would correspond to the laser mirror pairs. This picture differs slightly from the earlier proposal for the realization of genetic code involving orthogonal pairs of MEs associated with each nucleotide giving rise to 4 different pairs of polarizations and suggests a simpler realization in which the four polarization pairs associated with a pair of parallel MEs would realize the genetic code in a given length scale.

Topological self-referentiality allows also to understand what happens in over-unity energy production and these insights might be also crucial for the understanding of how life has evolved as a parallel development of macroscopic quantum bound states and the ability to metabolize. The components of the system can bind mutually or with the environment and negative energy space-time sheets represent binding energy. Bound state energy is liberated as a usable energy. The resulting bound states have entanglement irreducible under state function preparation process: this makes possible fusion of sub-selves to larger sub-selves. The bound states correspond to space-time sheets having typical sizes given by the p-adic length scale hypothesis and the process means basically space-time engineering. The typical wave length of the radiation emitted in the process gives estimate for the electromagnetic or gravitational size of the bound state. In ELF frequency range the electromagnetic size is of order Earth size.

Electrolytic processes are especially interesting from the point of view of over-unity energy production. For instance, the production of hydrogen molecules in the electrolysis of water might be accompanied by the formation of large bound states of water molecules and the liberation of the binding energy as a usable energy. The signature for the process is simple: the energy liberated is larger than the energy deduced from the binding energies of water and hydrogen molecules. Rather interestingly, the hydrogen bond energy deduced from the evaporation energy per water molecule is .485 eV and is very near to the photon energy $E(167) = .4844$ eV corresponding to p-adic length scale $L(167) = 256L(151)$ for $L(151) = 10$ nm: $k = 167$ is one of the four subsequent p-adic length scales $k = 151, 157, 163, 167$ which correspond to Gaussian Mersennes. Perhaps cold fusion involves both the nuclear fusion by Trojan horse mechanism and the formation of large scale bound states.

Biology provides an important area of applications and as already found the model of bio-photons leads to a concrete model for the generation of pairs of positive and negative energy MEs at DNA level. Bio-molecules and cells are indeed bound states of macroscopic size. The first form of life evolved under conditions in which electrolytic processes occurred: perhaps bound state formation led to the generation of bio-molecules and cells. What is nice that the development of long range order (negative energy MEs) would have been automatically accompanied by the development of metabolism (positive energy MEs!).

Sol-gel transition crucial for the cellular locomotion is a particular example of this process. Thus a natural path to follow in the attempts to build new energy technologies is to try to mimic what living nature has already achieved. This kind of energy production would be also wasteless and support evolution. Quantum spin glass analogy means that Kähler action has an enormous almost ground state degeneracy and only classical gravitational energy differentiates between different ground states. Thus the classical gravitational binding and also the generation of coherent gravitons by MEs might have a role to play in the quantum physics of living matter. A rough order of magnitude estimate for the gravitational binding energy for a blob of water having size $L(k)$ is

$$E_{gr} \sim \frac{GM^2}{L(k)} = G\rho^2 L(k)^5 \sim \frac{Gm_p^2}{L(137)} \frac{L(k)}{L(137)^5} \simeq 2^{-127} 2^{5/2(k-137)} \frac{1}{L(137)} .$$

Gravitational binding energy is larger than the p-adic energy $\pi/L(k)$ for $L(k = 179) \simeq .169$ mm. In the range $L(163) = 640$ nm and $L(167) = 2.56 \mu m$ gravitational binding frequency varies between 1 Hz and 1 kHz, that is over EEG range up to the maximal frequency of nerve pulses. For $k = 157$ and $k = 151$ the gravitational binding frequency corresponds to a time scale of 9 hours and 100 years

respectively so that the time scales relevant for life are spanned by the Gaussian Mersennes. Perhaps gravitonic MEs carrying vanishing em fields accompany the basic building blocks of the cell. Neither the connection with EEG is excluded.

5.2.5 Comparison of Maxwellian and TGD views about classical gauge fields

In TGD Universe gauge fields are replaced with topological field quanta. Examples are topological light rays, magnetic flux tubes and sheets, and electric flux quanta carrying both magnetic and electric fields. Flux quanta form a fractal hierarchy in the sense that there are flux quanta inside flux quanta. It is natural to assume quantization of Kähler magnetic flux. Braiding and reconnection are basic topological operations for flux quanta.

One important example is the description of non-perturbative aspects of strong interactions in terms of reconnection of color magnetic flux quanta carrying magnetic monopole fluxes [K33, K47]. These objects are string like structures and one can indeed assign to them string world sheets. The transitions in which the thickness of flux tube increases so that flux conservation implies that part of magnetic energy is liberated unless the length of the flux quantum increases, are central in TGD inspired cosmology and astrophysics. The magnetic energy of flux quantum is interpreted as dark energy and magnetic tension as negative "pressure" causing accelerated expansion.

This picture is beautiful and extremely general but raises challenges. How to describe interference and linear superposition for classical gauge fields in terms of topologically quantized classical fields? How the interference and superposition of Maxwellian magnetic fields is realized in the situation when magnetic fields decompose to flux quanta? How to describe simple systems such as solenoidal current generating constant magnetic field using the language of flux quanta?

Superposition of fields in terms of flux quanta

The basic question concerns the elegant description of superposition of classical fields in terms of topological field quanta. What it means that magnetic fields superpose.

1. In Maxwell's linear theory the answer would be trivial but not now. Linear superposition holds true only inside topological light rays for signals propagating in fixed direction with light velocity and with same local polarization. The easy solution would be to say that one considers small perturbations of background space-time sheet and linearizes the theory. Linearization would apply also to induced gauge fields and metric and one would obtain linear superposition approximately. This does not look elegant. Rather, quantum classical correspondence requires the space-time counterpart for the expansion of quantum fields as sum of modes in terms of topological field quanta. Topological field quanta should not lose their identity in the superposition.
2. In the spirit of topological field quantization it would be nice to have topological representation for the superposition and interference without any linearization. To make progress one must return to the roots and ask how the fields are operationally defined. One has test particle and it experiences a gauge force in the field. From the acceleration of the test particle the value of field is deduced. What one observes is the superposition of gauge forces, not of gauge fields.
 - (a) Let us just assume that we have two space-time sheets representing field configurations to be effectively superposed. Suppose that they are "on top" of each other with respect to CP_2 degrees of freedom so that their M^4 volumes overlap. The points of the sheets representing the field values that would sum in Maxwell's theory are typically at distance of CP_2 radius of about 10^4 Planck lengths. Wormhole contacts representing the interaction between the field configurations are formed. Hence the analog of linear superposition does not hold true exactly. For instance, amplitude modulation becomes possible. This is however not essential for the argument.
 - (b) Test particle could be taken to be fermion which is simultaneously topologically condensed to both sheets. In other words, fermionic CP_2 type almost vacuum extremal touches both sheets and wormhole throats at which the signature of the induced metric changes is formed. Fermion experiences the sum of gauge forces from the two space-time sheets through its

wormhole throats. From this one usually concludes that superposition holds true for the induced gauge fields. This assumption is however not true and is also un-necessary in the recent case. In case of topological light rays the representation of modes in given direction in terms of massless extremals makes possible to realize the analogy for the representation of quantum field as sum of modes. The representation does not depend on approximate linearity as in the case of quantum field theories and therefore removes a lot of fuzziness related to the quantum theory. In TGD framework the bosonic action is indeed extremely non-linear.

3. This view about linear superposition has interesting implications. In effective superposition the superposed field patterns do not lose their identity which means that the information about the sources is not lost - this is true at least mathematically. This is nothing but quantum classical correspondence: it is the decomposition of radiation into quanta which allows to conclude that the radiation arrives from a particular astrophysical object. It is also possible to have superposition of fields to zero field in Maxwellian sense but in the sense of TGD both fields patterns still exist. Linear superposition in TGD sense might allow testing using time dependent magnetic fields. In the critical situation in which the magnetic field created by AC current passes through zero, flux quanta have macroscopic size and the direction of the flux quantum changes to opposite.

The basic objection against TGD

The basic objection against TGD is that induced metrics for space-time surfaces in $M^4 \times CP_2$ form an extremely limited set in the space of all space-time metrics appearing in the path integral formulation of General Relativity. Even special metrics like the metric of a rotating black hole fail to be imbeddable as an induced metric. For instance, one can argue that TGD cannot reproduce the post-Newtonian approximation to General Relativity since it involves linear superposition of gravitational fields of massive objects. As a matter fact, Holger B. Nielsen - one of the very few colleagues who has shown interest in my work - made this objection for at least two decades ago in some conference and I remember vividly the discussion in which I tried to defend TGD with my poor English.

The objection generalizes also to induced gauge fields expressible solely in terms of CP_2 coordinates and their gradients. This argument is not so strong as one might think first since in standard model only classical electromagnetic field plays an important role.

1. Any electromagnetic gauge potential has in principle a local imbedding in some region. Preferred extremal property poses strong additional constraints and the linear superposition of massless modes possible in Maxwell's electrodynamics is not possible.
2. There are also global constraints leading to topological quantization playing a central role in the interpretation of TGD and leads to the notions of field body and magnetic body having non-trivial application even in non-perturbative hadron physics. For a very large class of preferred extremals space-time sheets decompose into regions having interpretation as geometric counterparts for massless quanta characterized by local polarization and momentum directions. Therefore it seems that TGD space-time is very quantal. Is it possible to obtain from TGD what we have used to call classical physics at all?

The imbeddability constraint has actually highly desirable implications in cosmology. The enormously tight constraints from imbeddability imply that imbeddable Robertson-Walker cosmologies with infinite duration are sub-critical so that the most pressing problem of General Relativity disappears. Critical and over-critical cosmologies are unique apart from a parameter characterizing their duration and critical cosmology replaces both inflationary cosmology and cosmology characterized by accelerating expansion. In inflationary theories the situation is just the opposite of this: one ends up with fine tuning of inflaton potential in order to obtain recent day cosmology.

Despite these and many other nice implications of the induced field concept and of sub-manifold gravity the basic question remains. Is the imbeddability condition too strong physically? What about linear superposition of fields which is exact for Maxwell's electrodynamics in vacuum and a good approximation central also in gauge theories. Can one obtain linear superposition in some sense?

1. Linear superposition for small deformations of gauge fields makes sense also in TGD but for space-time sheets the field variables would be the deformations of CP_2 coordinates which are scalar fields. One could use preferred complex coordinates determined about SU(3) rotation to do perturbation theory but the idea about perturbations of metric and gauge fields would be lost. This does not look promising. Could linear superposition for fields be replaced with something more general but physically equivalent?
2. This is indeed possible. The basic observation is utterly simple: what we know is that the *effects* of gauge fields superpose. The assumption that fields superpose is un-necessary! This is a highly non-trivial lesson in what operationalism means for theoreticians tending to take these kind of considerations as mere "philosophy".
3. The hypothesis is that the superposition of effects of gauge fields occurs when the M^4 projections of space-time sheets carrying gauge and gravitational fields intersect so that the sheets are extremely near to each other and can touch each other (CP_2 size is the relevant scale).

A more detailed formulation goes as follows.

1. One can introduce common M^4 coordinates for the space-time sheets. A test particle (or real particle) is identifiable as a wormhole contact and is therefore pointlike in excellent approximation. In the intersection region for M^4 projections of space-time sheets the particle forms topological sum contacts with all the space-time sheets for which M^4 projections intersect.
2. The test particle experiences the sum of various gauge potentials of space-time sheets involved. For Maxwellian gauge fields linear superposition is obtained. For non-Abelian gauge fields gauge fields contain interaction terms between gauge potentials associated with different space-time sheets. Also the quantum generalization is obvious. The sum of the fields induces quantum transitions for states of individual space time sheets in some sense stationary in their internal gauge potentials.
3. The linear superposition applies also in the case of gravitation. The induced metric for each space-time sheet can be expressed as a sum of Minkowski metric and CP_2 part having interpretation as gravitational field. The natural hypothesis that in the above kind of situation the effective metric is sum of Minkowski metric with the sum of the CP_2 contributions from various sheets. The effective metric for the system is well-defined and one can calculate a curvature tensor for it among other things and it contains naturally the interaction terms between different space-time sheets. At the Newtonian limit one obtains linear superposition of gravitational potentials. One can also postulate that test particles moving along geodesics in the effective metric. These geodesics are not geodesics in the metrics of the space-time sheets.
4. This picture makes it possible to interpret classical physics as the physics based on effective gauge and gravitational fields and applying in the regions where there are many space-time sheets which M^4 intersections are non-empty. The loss of quantum coherence would be due to the effective superposition of very many modes having random phases.

The effective superposition of the CP_2 parts of the induced metrics gives rise to an effective metric which is not in general imbeddable to $M^4 \times CP_2$. Therefore many-sheeted space-time makes possible a rather wide repertoire of 4-metrics realized as effective metrics as one might have expected and the basic objection can be circumvented. In asymptotic regions where one can expect single sheetedness, only a rather narrow repertoire of "archetypal" field patterns of gauge fields and gravitational fields defined by topological field quanta is possible.

The skeptic can argue that this still need not make possible the imbedding of a rotating black hole metric as induced metric in any physically natural manner. This might be the case but need of course not be a catastrophe. We do not really know whether rotating blackhole metric is realized in Nature. I have indeed proposed that TGD predicts new physics in rotating systems. Unfortunately, gravity probe B could not check whether this new physics is there since it was located at equator where the new effects vanish.

Time varying magnetic fields described in terms of flux quanta

An interesting challenge to describe time dependent fields in terms of topological field quanta which are in many respects static structures (for instance, flux is constant). The magnetic fields created by time dependent currents serves as a good example from which one can generalize. In the simplest situation the magnetic field strength experiences time dependent scaling. How to describe this scaling?

Consider first the scaling of the magnetic field strength in flux tube quantization.

1. Intuitively it seems clear that the field decomposes into flux quanta, whose M^4 projections can partially overlap. To get a connection to Maxwell's theory one can assume that the average field intensity is defined in terms of the flux of the magnetic field over a surface with area S . For simplicity consider constant magnetic field so that one has $B_{ave}S = \Phi = n\Phi_0$, where Φ_0 is the quantized flux for a flux tube assumed to have minimum value Φ_0 . Integer n is proportional to the average magnetic field B_{ave} . B_{ave} must be reasonably near to the typical local value of the magnetic field which manifest itself quantum mechanically as cyclotron frequency.
2. What happens in the scaling $B \rightarrow B/x$. If the transversal area of flux quantum is scaled up by x the flux quantum is conserved. To get the total flux correctly, the number of flux quanta must scale down: $n \rightarrow n/x$. One indeed has $(n/x) \times xS = nS$. This implies that the total area associated with flux quanta within total area S is preserved in the scaling.
3. The condition that the flux is exact integer multiple of Φ_0 would pose additional conditions leading to the quantization of magnetic flux if the total area can be regarded as fixed. This need not to be true.

Consider as the first example slowly varying magnetic field created by an alternating running in current in cylindrical solenoid. There are flux tubes inside the cylindrical solenoid and return flux tubes outside it flowing in opposite direction. Flux tubes get thicker as magnetic field weakens and shift from the interior of solenoid outside. For some value x of the time dependent scaling $B \rightarrow B/x$ the elementary flux quantum Φ_0 reaches the radius of the solenoid. Quantum effects must become important and make possible the change of the sign of the elementary flux quantum. Perhaps quantum jump turning the flux quantum around takes place. After this the size of the flux quantum begins to decrease as the magnitude of the magnetic field increases. At the maximum value the size of the flux quantum is minimum.

This example generalizes to the magnetic field created by a linear alternating current. In this case flux quanta are cylindrical flux sheets for which magnetic field strength and thickness oscillators with time. Also in this case the maximum transversal area to the system defines a critical situation in which there is just single flux sheet in the system carrying elementary flux. This flux quantum changes its sign as the sign of the current changes.

The notion of conscious hologram

In TGD inspired theory of consciousness the idea about living system as a conscious hologram [K11] is central. It is of course far from clear what this notion means. The notions of interference and superposition of fields are crucial for the description of the ordinary hologram. Therefore the proposed general description for the TGD counterpart for the superposition of fields is a natural starting point for the more precise formulation of the notion of conscious hologram.

1. Consider ordinary hologram first. Reference wave and reflected wave interfere and produce an interference pattern to which the substrate of the hologram reacts so that its absorption coefficient is affected. When the substrate is illuminated with the conjugate of the reference wave, the original reflected wave is generated. The modification of the absorption coefficient is assumed to be proportional to the modulus squared from the sum of the reflected and reference waves. This implies that the wave reflected from the hologram is in good approximation identical with the original reflected wave.
2. Conscious hologram would be dynamical rather than static. It would be also quantal: the quantum transitions of particles in the fields defined by the hologram would be responsible for the realization of the interference pattern as a conscious experience. The previous considerations

actually leave only this option since the interference of classical fields does not happen. Reference wave and reflected wave correspond now to any field configurations. The charged particles having wormhole contacts to the space-time sheets representing the field configurations experience the sum of the fields involved, and this induces quantum jumps between the quantum states associated with the situation in which only the reference wave is present.

This would induce a conscious experience representing an interference pattern. The reference wave can also correspond to a flux tube of magnetic body carrying a static magnetic field and defining cyclotron states as stationary state. External time dependent magnetic field can replace reflected wave and induces cyclotron transitions. Also radiation fields represented by MEs can represent the reference wave and reflected wave. If there is need for the "reading" of the hologram it would correspond to the addition of a space-time sheet carrying fields which in good approximation have opposite sign and same magnitude as those in the sheet representing reference wave so that the effect on the charged particles reduces to that of the "reflected wave". This step might be un-necessary since already the formation of hologram would give rise to a conscious experience. The conscious holograms created when the hologram is created and when the conjugate of the reference wave is added give rise to two different conscious representations. This might have something to do with holistic and reductionistic views about the same situation.

3. One can imagine several realizations for the conscious hologram. It seems that the realization at the macroscopic level is essentially four-dimensional. By quantum holography it would reduce at microscopic level to a hologram realized at the 3-D light-like surfaces defining the surfaces at which the signature of induce metric changes (generalized Feynman diagrams having also macroscopic size - anyons [K59]) or space-like 3-surfaces at the ends of space-time sheets at the two light-like boundaries of CD . Strong form of holography implied by the strong form of general coordinate invariance requires that holograms correspond to collections of partonic 2-surfaces in given measurement resolution. This could be understood in the sense that the charged particles defining the substrate can be described mathematically in terms of the ends of the corresponding light-like 3-surfaces at the ends of CD s. The cyclotron transitions could be thought of as occurring for particles represent as partonic 2-surfaces topologically condensed at several space-time sheets.

One can imagine several applications in TGD inspired quantum biology.

1. One can develop a model for how certain aspects of sensory experience could be understood in terms of interference patterns for signals sent from the biological body to the magnetic body. The information about the relative position of the magnetic body and biological body would be coded by the interference patterns giving rise to conscious sensory percepts. This information would represent geometric qualia [K32] giving information about distances and angles basically. There would be a magnetic flux tube representing the analog of the reference wave and magnetic flux tube carrying the analog of reflected wavel which could represent the effect of neural activity. When the signal changes with time, cyclotron transitions are induced and conscious percept is generated. In principle it there is no need not compensate for the reference wave although also this is possible.
2. The natural first guess is that EEG rhythms (and those for its fractal generalization) represent reference waves and that the frequencies in question are either harmonics of cyclotron frequencies or linear combinations of these and Josephson frequency assignable to cell membrane (and possibly its harmonics). The modulation of membrane potential would induce modulations of Josephson frequency and if large enough would generate nerve pulses. These modulations would define the counterpart of the reflected wave. The flux tubes representing unperturbed magnetic field would represent reference waves.
3. For instance, the motion of the biological body changes the signal at the space-time sheets carrying the signal and this generates cyclotron transitions giving rise to a conscious experience. Perhaps the sensation of having a body is based in this mechanism. The signals could emerge from directly from cells: it could be that this sensation corresponds to lower level selves rather than us. Second option is that nerve pulses to brain induce the signals sent to the our magnetic body.

4. The motion of biological body relative to biological body generates virtual sensory experience which could be responsible for the illusions like train illusion and the unpleasant sensory experience about falling down from cliff by just imagining it. OBEs could be also due to the virtual sensory experiences of the magnetic body. One interesting illusion results when one swims long time in windy sea. When one returns to the shore one has rather long lasting experience of being in sea. Magnetic body gradually learns to compensate the motion of sea so that the perception of the wavy motion is reduced. At the shore this compensation mechanism however continues to work. This mechanism represents an example of adaptation and could be a very general mechanism. Since also magnetic body uses metabolic energy, this mechanism could have justification in terms of metabolic economy.

Also thinking as internal, silent speech might be assigned with magnetic body and would represent those aspects of the sensory experience of ordinary speech which involve quantum jumps at magnetic body. This speech would be internal speech since there would be no real sound signal or virtual sound signal from brain to cochlea.

5. Conscious hologram would make possible to represent phase information. This information is especially important for hearing. The mere power spectrum is not enough since it is same for speech and its time reversal. Cochlea performs an analysis of sounds to frequencies. It is not easy to imagine how this process could preserve the phase information associated with the Fourier components. It is believed that both right and left cochlea are needed to abstract the phase difference between the signals arriving to right and left ear allowing to deduce the direction of the source neural mechanisms for this has been proposed but these mechanisms are not enough in case of speech. Could there exist a separate holistic representation in which sound wave as a whole generates a single signal interfering with the reference wave at the magnetic body and in this manner represents as a conscious experience the phase?
6. Also the control and reference signals from the magnetic body to biological body could create time dependent interference patterns giving rise to neural response initiating motor actions and other responses. Basically the quantum interference should reduce the magnitude of membrane resting potentials so that nerve pulses would be generated and give rise to motor action. Similar mechanism would be at work at the level of sensory receptors - at least retina. The generation of nerve pulses would mean kind of emergency situation at the neuronal level. Frequency modulation of Josephson radiation would be the normal situation.

Topology of fields and topological field quantization

5.3 Phase conjugation, negative energy topological light rays, and time mirror mechanism

Negative energy topological light rays having phase conjugate laser waves as standard physics counterparts provide the fundamental control mechanism in the TGD based model of living matter and appears in practically every mechanism of consciousness as a basic step. In the sequel its the relationship of negative energy MEs to phase conjugate waves is discussed in detail.

5.3.1 Do negative energy space-time sheets have counterparts in quantum field theory?

Negative energy topological light rays seem to correspond to phase conjugate laser waves. In particular, the experiments of Feinberg [D4] are consistent with the transparency of matter for phase conjugate laser beams with photon energies above thermal energy. In optics phase conjugation requires optically non-linear system [D33]. For instance, in usual hologram the matter is optically non-linear in the sense that dielectric constant depends on the external electric field so that the electromagnetic radiation induces a change of the refraction coefficient which in turn codes for the hologram.

The dynamics of classical fields is indeed extremely nonlinear in TGD: the topological field quantization is one of the most dramatic outcomes of this non-linearity. Whether the phenomenological models for phase conjugate waves and for their generation are enough in TGD framework is an open question. The mechanism based for the generation of negative energy topological light rays based on

short pulses to be discussed in this section does not seem to reduce to the framework of non-nonlinear optics.

There are also questions of principle involved.

Is phase conjugation properly understood in quantum field theories?

At the level of quantum physics negative energy photons would correspond to a system quantized in such a manner that both bosonic and fermionic annihilation and creation operators have changed their roles. Negative energy photons and fermions do not correspond to (non-existing) "anti-photons" and anti-fermions. Using the terminology of Dirac's bra-ket formalism: negative energy systems are like bras if positive energy photons are kets. Kets and bras correspond to Hilbert space and linear functionals defined in it. The space of bras is actually not equivalent with that of kets but in a well defined sense a more general concept. This conforms with the role of negative energy space-time sheets in TGD inspired theory of consciousness.

In quantum field theories time reversal transforms creation operators for fermions to creation operators for anti-fermions. Vacuum state is not changed. Time reversal in TGD sense would transform ket vacuum to bra vacuum so that the earlier creation operators annihilate the new vacuum state and genuine negative energy states result. This would suggest that negative energy states are something genuinely new and a genuine outcome of the many-sheeted space-time concept allowing either bra and ket type vacuum at a given space-time sheet. This difference might relate to matter-antimatter asymmetry whose origin is one of the deepest problems of cosmology. Perhaps dynamics favors space-time sheets containing negative energy matter instead of antimatter.

Phase conjugation and irreversibility

One interesting aspect associated with negative energy topological light rays is that they seem to be irreversible systems. On the other hand, phase conjugation can be used to eliminate perturbations on signal caused by thermal noise since the evolution proceeds from perturbed to non-perturbed signal. This could be seen as an objection against TGD based interpretation stating that topological light rays are essentially non-dissipative structures of classical physics.

The objection can be circumvented. Classical-quantum correspondence implies that space-time physics mimics also the dissipative aspects of quantum dynamics defined by quantum jump sequences. The classical non-determinism of the basic variational principle makes this possible. Classical fields are non-dissipative structures are even able to represent information about dissipation, analogous to a written text telling a story about growth, flourishing, and decay. In fact, in TGD framework space-time itself provides symbolic classical representations for quantum jump sequences determining the subjective, experienced reality. The implications of this representative aspect for biology are highly non-trivial. For instance, phase conjugate waves could provide a fundamental mechanism of healing and error correction.

5.3.2 Is the TGD view about phase conjugate waves consistent with the existent wisdom?

A priori it is not obvious that the TGD based identification of phase conjugate waves as negative energy photons/topological light rays is consistent with what is known about phase conjugate waves. The best manner to check this is to translate the standard physics description of the basic mechanisms producing phase conjugate waves to the language of TGD. This should also provide new insights about how self-organization by the emission of negative energy photons proceeds in non-linear media.

Basic mechanism producing phase conjugate waves

There are two basic mechanisms producing phase conjugate waves. The physics believed to be behind these mechanisms is summarized in an enjoyable manner in the book of D. M. Pepper [D33], and in the review article of V. V. Shunov and B. Ya. Zeldovich [D37], who are pioneers of optical phase conjugation. The mechanisms rely on four-wave mixing and stimulated Brillouin scattering. Both mechanisms can be modelled using the notion of a dynamical hologram. In TGD framework dynamical hologram can be regarded as a spontaneously generated self-organizing hologram resulting by the emission of negative energy photons. The reference laser beam is quite generally pulsed. This

raises the question whether the phase conjugate photons are produced by negative energy scalar wave pulses inducing negative energy "acceleration radiation" as the (em- or Z^0 -) charged particles are accelerated at the space-time sheets representing scalar wave pulses.

1. Four-wave mixing

Consider first four-wave mixing. The basic observation is that already in the case of ordinary hologram a phase conjugate beam is generated when the reference beam irradiating the hologram has a direction opposite to that of the original reference beam. The idea is to replace the static hologram with a dynamic hologram by utilizing reference beams moving in opposite directions simultaneously besides the probe beam coming from the object, so that the beams used to construct and read the hologram are simultaneously present. Either reference beam can be thought of as being scattered from the interference pattern created by the other beams and producing the phase conjugate wave. The resulting phase conjugate wave moves in a direction opposite to the probe beam, just as in the case of the ordinary hologram. The dynamic hologram is created in the non-linear medium whose properties are affected by the interference pattern formed by the beams.

TGD description would be that the interference of the three beams induces self-organization of the non-linear medium to a higher energy state representing the dynamic hologram and that this occurs by the emission of the phase conjugate wave having negative energy. This means the breaking of the second law of thermodynamics. The phase conjugate waves are dissipative structures but the dissipation takes place in a reversed direction of geometric time. To be precise, classical fields can be seen as symbolic representations for the dissipation at quantum level and possible by the non-determinism of Kähler action. This explains the strange features of phase conjugate waves.

2. Stimulated Brillouin scattering

Stimulated Brillouin scattering was first discovered to produce phase conjugate waves [D37] by Boris Ya. Zeldovich and his colleagues, the Russian pioneers of optical phase conjugation. Only single incoming reference beam is used and the secondary reference beam in the opposite direction appears spontaneously. In this case three-wave scattering without probe beam is in question and interference pattern is solely due to the interference of the reference beams. The dynamical hologram is realized as an acoustic wave pattern from which either reference beam can be said to scatter. The phase conjugate wave is generated only above a critical power feed for the incoming beam. The incoming beam can be distorted in the directions transversal to the primary beam by allowing it to traverse an inhomogeneous glass plate. The resulting phase conjugate beam traverses back through the inhomogeneous glass plate and turns out to be free of any distortions. Obviously this demonstrates the occurrence of the time reversal.

The standard description for what happens runs as follows.

1. The process is initiated by the scattering of photons from thermal phonons in the direction of the primary reference beam and reversing thus their direction. By energy conservation the frequency difference for the two light beams corresponds to the frequency of the acoustic wave: $\Delta\omega/\omega = v/c$, where v is the sound velocity.
2. Acoustic wave generates a periodic longitudinal density gradient such that the zones of low and high density are at a distance of *half* wave length: this follows from the fact that the scattered phonons receive *twice* the momentum of photon. In this kind of situation total reflection occurs from each layer and this amplifies the secondary light beam which in turn amplifies the sound wave. A more familiar example of total reflection is the reflection of light on water having oil layer at its surface. The varying thickness of this layer gives rise to a rainbow like appearance of the scattered light. Also a phase conjugate beam is created in the process.

In TGD framework situation can be seen as a self-organization process in which the self-organizing acoustic wave gains energy by emitting negative energy photons: obviously an over unity energy production breaking the second law of thermodynamics is in question. One could even say that non-linear medium builds a primitive sensory representation of the interference pattern.

1. At the first step the photons of the primary reference beam are scattered and generate a weak secondary reference beam in an opposite direction. The resulting interference pattern in turn excites a weak acoustic wave.

2. The acoustic wave amplifies itself when phonons emit pairs of positive and negative energy photons with energies $E_1 > 0$ and $E_2 < 0$ such that the sum of their energies corresponds to the energy E_{ph} gained by the phonon: $E_1 - |E_2| = E_{ph}$. The rate of this process is proportional to the numbers N_+ and N_- of positive and negative energy photons already present in the state: the mechanism of induced emission is at work. Positive energy photons amplify the induced reference beam and negative energy photons amplify the phase conjugate wave. Also in this case one can say that the non-linear medium builds up spontaneously a dynamical hologram about the interference pattern.

The emission of negative energy photons makes possible over unity effects claimed by free energy enthusiasts. Over unity effects need not be in conflict with the standard wisdom that phase conjugate waves utilize the energy of pumping laser or probe beam. In the case of stimulated Brillouin scattering the negative energy photons are received by the population inverted lasers producing the reference beam with the consequence that particles drop to the ground state without emission of positive energy photons. In the case of 4-wave mixing the negative energy photons could be received by the laser producing the probe beam. An interesting possibility is that negative energy beams could be produced also in the direction of reference beam and pump energy from the corresponding lasers.

Over unity effects and error correction

The emission of negative energy photons makes possible over unity effects claimed by free energy enthusiasts. Over unity effects need not be in conflict with the standard wisdom that phase conjugate waves utilize the energy of pumping laser or probe beam. In the case of stimulated Brillouin scattering the negative energy photons are received by the population inverted lasers producing the reference beam with the consequence that particles drop to the ground state without emission of positive energy photons. In the case of 4-wave mixing the negative energy photons could be received by the laser producing the probe beam. An interesting possibility is that negative energy beams could be produced also in the direction of reference beam and pump energy from the corresponding lasers.

Error correction of a signal defines a variant of the time mirror mechanism. In this case positive and negative energy signals are actually at different sides of the time mirror. The positive energy photons of the signal to be corrected annihilate with the negative energy photons of the phase conjugate signal which comes from the geometric future and is a temporal mirror image of the positive energy signal. The pulsed phase conjugate mirror would be an analog a sequence of ordinary mirrors. Pulses create a temporal sequence of time mirrors most naturally located at the ends of pulses so that positive energy photons from N :th pulse annihilate with the negative energy photons from $N + 1$:th pulse.

TGD based description for the interference of reference beams

It is interesting to find whether TGD allows the field pattern resulting as a superposition of reference beams moving in opposite direction as a solution of field equations. Topological light rays do not allow this kind of field patterns. As a special case this field pattern corresponds to a transversal standing wave of form $\cos(\omega t) \times \cos(\omega z)$ (using units $c = 1$). Waves for which the interference pattern moves (say in the case of stimulated Brillouin scattering), result when the frequencies are different. These field patterns are obtained as Lorentz transforms of the standing wave pattern.

Since the Kähler current vanishes for this kind of waves the field equations state that the contraction of the energy momentum tensor with the second fundamental form vanishes. It will be found that the field equations reduce to massless wave equation in the approximation that classical gravitational effects are negligible. It is however not clear whether this kind of solution is possible as genuinely asymptotic self-organization pattern having a precisely vanishing Kähler current.

The solution ansatz is based on the assumption that the CP_2 projection belongs to the homologically non-trivial geodesic sphere S^2 of CP_2 . Let the standard spherical coordinates of S^2 be $(U \equiv \cos(\theta), \Phi)$. Let M^4 coordinates be (t, z, x, y) , The task is to imbed the electric field representing a standing wave and having components

$$E_i = \epsilon_i \times \cos(\omega t) \times \cos(\omega z) , \tag{5.3.1}$$

as a four-surface to $X^4 \subset M_+^4 \times S^2$. The polarization vector ϵ_i lies in the (x, y) -plane.

The 4-vector potential associated with this field is

$$A_\mu = \frac{\epsilon_\mu}{\omega} \times \sin(\omega t) \times \cos(\omega z) . \quad (5.3.2)$$

Note that the scalar potential $\phi = A_t$ vanishes. The induced Kähler gauge potential is of form

$$A_\mu = U \partial_\mu \Phi , \quad (5.3.3)$$

and from this the simplest ansatz (fixed only apart from a canonical transformation of CP_2) reproducing A_μ is

$$U = a \times \sin(\omega t) \times \cos(\omega z) , \quad \Phi = b \times \epsilon_\mu x^\mu , \quad ab = \frac{1}{\omega} . \quad (5.3.4)$$

In the approximation that the induced metric is flat, action density vanishes, and the energy momentum tensor has only the longitudinal components T^{tt} and T^{zz} and is proportional to the flat metric. Field equations reduce to massless wave equation in longitudinal degrees of freedom: $D^2 u = 0$ and $D^2 \Phi = 0$, $D = \partial_t^2 - \partial_z^2$. For the proposed solution ansatz they are satisfied identically.

The fact that solution has a 2-dimensional CP_2 projection means that it represents a self-organization pattern with dissipation only due to the possible non-vanishing of the Kähler 4-current and characterized by the strength of classical gravitational interaction. Classical gravitation might imply a non-vanishing Kähler four-current.

Phase conjugate photons and dark matter hierarchy

Negative energy phase conjugate photons with energies above threshold propagate in matter virtually without any attenuation. Photons below thermal threshold are masked and phase conjugate photons with wavelengths longer than the thermal wavelength absorption becomes a problem since they are absorbed. Dark matter hierarchy allows to circumvent this problem and for given thermal energy arbitrarily long wavelengths are possible for both photons and their phase conjugate. This is of key importance since remote mental interactions between magnetic and biological body are star actors in the TGD based model of living matter. There is evidence that remote mental interactions involve even galactic length scales [J95] . Same might hold true in the case of ordinary bio-control since time mirror mechanism makes possible instantaneous control although the controlling part of magnetic body is at huge temporal distance in geometric future.

5.4 Bio-photons

MEs (massless extremals) can be carriers of light like vacuum currents generating coherent light. Bio-photons [I64, I82, I115] were the first proposed identification for this coherent light in living matter [K55] . In absence of material about bio-photons I did not develop these ideas in any quantitative detail. Situation has changed with the development of web and recently I learned from Lian Sidoroff about home page containing online articles of Fritz-Albert Popp and colleagues about bio-photons and related phenomena. I am grateful for Lian also for very useful discussions and keen questions helping me to become and stay conscious about the many poorly understood aspects of the 'great vision'. This homepage is recommended also to the reader and the data used below mostly derive from the articles therein [J55] .

5.4.1 What bio-photons are?

The web articles [J55] provide the basic facts about bio-photons and in the following I summarize my novice view about bio-photons.

Bio-photons have frequencies in the range 200-800 nm (at least). The intensity of bio-photons is extremely low: from one photon to few hundred photons/ cm^2s , which is 20 orders of magnitude weaker than common fluorescence of photophosphorence. There is evidence for coherent radiation

also at longer wave length scales. A far from thermal equilibrium situation is in question: the intensity of photons is about 10^{10} times higher than that associated with the thermal visible photons at body temperature. The spectral density $f(\nu)$ defined as the counterpart of Boltzmann weight is essentially constant. This means that the effective temperature increases linearly with frequency. The experimental work of Popp and colleagues provides support for the view that bio-photons are indeed coherent light rather than some waste radiation resulting as a by-product of biological processes [J55]. Poisson statistics for the number of photons in coherent state ($p_n = \exp(-\alpha)\alpha^n/n!$) is the basic signature for the coherent light and it is found that photon counts obey this distribution.

Since $\tau \sim 1$ nanoseconds is the characteristic time constant for emission and absorptions at visible wave lengths, one can argue that the length scale $L = c\tau \sim 10$ cm defines the length scale below which it is not sensible to speak about localized photon and thus bio-systems must be treated as macroscopic quantum systems as far as coherent photons are considered. The timescale means also that 10^9 reactions per second can in principle catalyzed by absorption and emission of single photon in single cell: the typical number of reactions is 10^5 per second inside single cell [J55]. If bio-photons Bose-Einstein condense at magnetic mirrors (ME-magnetic flux tube pairs), extremely sharp control of biological reactions could be indeed achieved. Of course, if Bose-Einstein condensed bio-photons are most important for bio-control, one cannot exclude the interpretation of the observed bio-photons as somekind of leakage radiation from living matter (of course, these bio-photons might serve communication purposes).

Even the wave length of the visible photons, which is somewhat below the cell size, implies that molecules see classical em field like boat sees the sea. One could argue that photons as CP_2 type extremals are essentially pointlike. One the other hand, if MEs are classical correlates for photons or if the classical interaction of atoms and molecules with MEs is additional aspect of their interaction with em fields, this is not the case. The situation is not conceptually completely clear in this respect.

Interference effects provide also support for the notion of macroscopic coherent states. Popp proposes that in a healthy organism constructive interference tends to occur inside cells for bio-photons whereas destructive interference takes place outside [I116, I115]. Or stating it differently, cells are able to store visible bio-photons inside them. For healthy cells the bio-photon emission and well as delayed luminescence have been found to increase as a function of cell density up to some critical density and to decrease after that. For cancer cells the intensity increases indefinitely and nonlinearly [I116]. This supports the view that in cancer cell population bio-photons leak out and do not properly participate to the bio-control.

Bio-photon emission is a signature of living matter in the sense that the presence of oxidative process accompanies always the emission. This is true also for the delayed luminescence resulting as a delayed response to electromagnetic or some other perturbation. The dependence of the delayed luminescence on temperature suggests that the activation energy for the process controlling photoluminescence is roughly .53 eV [I45]: this is rather near to the energy .49 eV stored in the ATP molecule. The experiments involving the insertion of inert molecules to DNA indicate that DNA is a source of bio-photons [I73], [J55]. The spectrum of bio-photons and delayed luminescence correlates strongly with various biological processes. For this reason bio-photons have several applications to bio-search, food quality control, cancer research, pharmacology and heal prophylaxis.

5.4.2 Some phenomena related to bio-photons

There are several interesting and theoretically challenging phenomena involving bio-photons.

1. Delayed luminescence [I124, I110] results after an exposure to an external perturbation, which can be light or ultrasound. Delayed luminescence accompanies also biological processes like cell mitosis. The intensity of the coherent light varies from few photons to 10^5 photons/cm²s. The characteristic feature of the delayed luminescence is hyperbolic ($I(t) \propto 1/(1 + \lambda t)$) decay instead of the exponential one expected if incoming light just scatters from the system. The intensity involves oscillatory modulations with respect to a variable u which depends logarithmically on time coordinate ($u = \log(1 + \lambda t)$). As a function of cell density delayed luminescence increases up to some critical cell density for a healthy cell population and begins to decrease after that. For cancer cell population there is no such critical cell density.
2. Some animal populations can 'see' each other. For instance, when populations of dinoflagellates become to optical contact they begin to flicker synchronously [I45] (also fireflies in mangrove

trees in Thailand flicker in a synchronous manner). In TGD framework this could be interpreted as evidence for magnetic mirror bridges connecting the populations such that the MEs associated with visible light propagate along them from population to another one. The bridges could also contain ELF em waves serves as synchronizers in the time scale in which flickering occurs.

3. Bacteria absorb bio-photons from nutrition media in a way that the absorption is highest for some critical cell density [I116]. Female inbred daphnia in the same developmental stage and about the same size do not display the increasing bio-photon emission with increasing number [I116]. Rather, a typical interference pattern of emission is observed showing maxima and minima of the bio-photon intensity at definite average distances between the animals. This could be seen as evidence for the hypothesis that the pattern of coherent light from DNA serves as kind of hologram representing 4-D template for the self-organization.

5.4.3 General TGD based model for coherent bio-photons

MEs with light like vacuum currents indeed generate coherent photons so that bio-photons indeed have a place in TGD Universe. ATP energy about .49 eV and near to the rough estimate .53 eV for the activation energy deduced by studying the temperature dependence of the delayed luminescence [I45]. This encourages to think that the MEs are closely related with the process transforming ADP to ATP serving as energy batteries (see [K38] for the TGD based model of ATP). This assumption conforms also with the fact that coherent light is associated with the oxidative process.

Bio-photons and MEs

The empirical data are consistent with the assumption that the MEs are associated with DNA (at least) and are perhaps responsible for the electromagnetic expression of the genetic information below cellular length scales (and corresponding scaled up dark length scales since there is no reason to exclude the dark variants of MEs).

MEs can carry Bose-Einstein condensates of parallel photons and the observed coherent photons represent leakage of the coherent light from cells. Both positive and negative energy MEs are possible and most naturally they are created in a pairwise manner: pairs (which do not form bound states) with a vanishing net energy and momenta are especially interesting since classical conservation laws do not pose any constraints on their creation and annihilation by p-adic-to-real transition. The buy now-pay later energy production by feeding negative energy to the environment might be closely related with the generation of pairs of MEs which vanishing net energy. It must be emphasized that also magnetic mirrors with positive and negative energies might be in question.

Bio-photons as a signature of dark matter hierarchy

Dark matter hierarchy allows perhaps the most plausible interpretation of bio-photons and is also in spirit with the general ideas about quantum holograms. The model of EEG (actually hierarchy of them) based on dark matter hierarchy [K26] assumes that the basic structures assignable to cell have fractal scaled up variants at higher levels of dark matter hierarchy. These higher level structures could generate dark photons with energies in the range corresponding to visible photons.

At the k_d^{th} level of the hierarchy predicted by Mersenne hypothesis the wavelength of photon is scaled up by a factor 2^{k_d} with possible values of k_d fixed by the Mersenne hypothesis [K26] so that communications using "visible dark" light become possible in arbitrarily long length scales. The model for cell membrane as a sensory receptor leads to the identification of these photons in terms of dark Josephson radiation and EEG and biophotons have identification in terms of decay products of dark Josephson photons.

MEs would have lengths of order wave length (which are below cell size for visible light), and there would be a constant distribution of MEs with respect to the direction and length of ME in the scaled up length scale interval corresponding to wavelengths of visible light. The scaled up wavelengths would correspond to the distances between source and receiver of bio-photons and $k_d \equiv 0$ would correspond to intracellular bio-photons assignable to MEs connecting sub-cellular structures having distance distribution which is more or less constant. The higher level contributions would tend to smooth out the wavelength distribution even if this is not strictly the case.

The general vision about quantum control of motor actions and sensory representations is consistent with the interpretation of positive energy MEs as space-time correlates for the emission of photons responsible for communications and negative energy MEs as correlates for phase conjugate photons involved with generalized motor control. In this framework bio-photons could result from the de-coherence of $k_d > 0$ dark photons and also as a leakage of $k_d = 0$ photons from cell interior. The synchronous flickering of dinoflagellates suggests $k_d > 0$ bio-photons are indeed present.

About the anatomy of dark MEs

MEs at the k_d^{th} level of dark matter hierarchy correspond to $r = 2^{k_d}$ -fold covering of M^4 , which are analogs of multi-sheeted Riemann surfaces (note that the meaning of "sheet" in this context is different from that in the context of many-sheeted space-time). Each sheet of the covering corresponds to scaled up variant of the space-time sheet associated with ordinary photon with r -fold size scale and classical energy E/r . This allows to interpret the formula $E = \hbar(k)f = r\hbar_0 f$ at space-time level.

r -fold MEs could be generated by r -sheeted magnetic flux sheets containing Bose-Einstein condensates of bosonic ions in quantum coherent manner such that each sheet is responsible for one sheet of r -fold ME.

The decay to ordinary photons can occur in two manners.

1. In de-coherence a downwards scaling of the structure by a factor $1/r$ and collapse to a single sheeted structure with energy E representing ordinary photon occurs. Since frequency is replaced with rf and \hbar by \hbar_0 , energy does not change.
2. The multi-sheeted structure could also decay to r single sheeted structures with energy E/r .

Constraint to the intensity of the vacuum current

The decomposition of dark MEs to r ordinary MEs cannot correspond to the generation of coherent photons by vacuum current since the frequencies involved would be much lower than the frequencies $\sim 10^{14}$ Hz associated with the visible light. Thus one can restrict the consideration to $k_d = 0$ case. This process might however also occur as the experimental findings of Gariaev [I75] about laser light induced radio-wave emission to be discussed in the next section indicate.

The source of photons at the second end of ME is responsible for the Bose-Einstein condensate of photons associated with ME. These photons are not observed unless some kind of leakage occurs at the receiving end of ME: suppose that this does not happen. Physical intuition suggests that the light-like vacuum currents associated with MEs generate coherent states of ordinary photons and that these photons leak out and give rise to the observed bio-photons. MEs lose their energy in the process and become eventually vacuum extremals.

These assumptions allow to deduce a constraint to the intensity of the vacuum current associated with ME.

The interaction Lagrangian of the vacuum current with the vector potential of the quantized photon field is given by

$$L_{int} = e \int d^4x j \cdot A \quad (5.4.1)$$

where the indices of the second quantized vector potential and vacuum current have been dropped away for simplicity and the units $\hbar = c = 1$ are used and e denotes the electromagnetic coupling.

This interaction term describes an infinite number of harmonic oscillators coupled to an external oscillatory force. In each Fourier mode initial vacuum state is transformed to a coherent state which is an eigenstate of the corresponding annihilation operator. By standard calculations [B3] one can deduce the expression for the effective classical vector potential defined by the eigenvalues of the annihilation operators is given by

$$\begin{aligned} A(x, t) &= \frac{ie}{(2\pi)^3} \int d^3k \frac{1}{2\omega(k)} \exp[-ik \cdot x - i\omega(k)t] j(k, \omega(k)) \ , \\ \omega(k) &= |k| \ . \end{aligned} \quad (5.4.2)$$

The eigenvalues $\alpha(\epsilon, k)$ for the annihilation operator $a(\epsilon, k)$ associated with polarization ϵ is given by the expression

$$\alpha(\epsilon, k) = \frac{ie}{2(2\pi)^3\omega(k)}\epsilon \cdot j(k, \omega(k)) . \quad (5.4.3)$$

$\alpha(k)$ indeed has the dimension length to $3/2$ as it should be on basis of the commutation relations in the continuous momentum basis. If finite quantization volume with a discrete momentum basis is used, $\alpha(k)$ contains additional $1/\sqrt{V}$ factor guaranteeing that the eigenvalues are dimensionless.

The eigenvalues characterizing the coherent states are proportional to the massless Fourier components of the vacuum current so that the intensities of bio-photons determining the values of the parameters $\alpha(k)$ allow to deduce the on mass shell Fourier components of the light like vacuum current. Of course, the coherent field of photons is superposition of several interfering contributions coming from MEs with light like currents and only the sum of these contributions appears in the detected field.

Sucking force in TGD framework

The mechanism by which sun flowers turn towards Sun as well as the attraction between cells are not very well well-understood processes. Popp and Chang introduce as an explanation an interaction which they call sucking force [I116]. The notion is inspired by the assumed analogy with the vacuum cleaner which is a particular kind of a pump. The pressure gradient along the tube of the vacuum cleaner generates airflow towards the tube. Since pumping is always done when dissipative processes are present, a process involving essentially the dynamics of quantum jumps is in question and the force does not have counterpart at the level of the irreversible classical dynamics.

In case of em fields radiation pressure gradient replaces the ordinary pressure gradient. The counterpart of the tube of vacuum cleaner is naturally a ME along which Bose-Einstein condensed photons propagate and are absorbed at the second end of the tube, most naturally cell in case of visible photons. The pumping implies an attractive force between living systems connected by MEs. This force would be present at all levels of the length scale hierarchy. The force is only between systems having common characteristic frequencies so that they can be connected by MEs. For instance, this force could explain why tRNA carrying aminoacids finds the corresponding mRNA in the translation of DNA to proteins.

The sucked MEs can propagate along larger ME serving as an em bridge to the receiving system and the absorption most naturally corresponds to the annihilation with MEs of opposite energy. Both negative and positive energy MEs can be sucked. The sucking of negative energy MEs makes possible very flexible buy now-pay later type energy consumption: the user (say DNA) generates pairs of positive and negative energy MEs and utilizes the positive energy MEs, whereas the negative energy MEs are received by the payer, most naturally mitochondria where they annihilate with the positive energy MEs produced by ATP process.

5.4.4 The interpretation of biophotons and EEG as decay products of dark Josephson radiation

The foregoing considerations have been classical in the sense that MEs have been taken as a model for biophotons. The model of EEG [K26] leads to the prediction that cell membranes act as Josephson junctions generating Josephson radiation. If the cell membrane is assumed to be almost vacuum extremal which brings in classical Z^0 field proportional to em field and raises the energy scale of Josephson junction from .07 eV for neuron to UV range. The electromagnetic charge of ion must be replaced with effective charge which is non-vanishing also for neutral atoms and molecules.

The energies of dark photons involved are in visible and UV range for most ions in the range of resting potentials just as the energies of bio-photons. The model also predicts correctly the peak frequencies of maximal sensitivity for the four kinds of photoreceptors. The frequencies are inversely proportional to the value of Planck constant characterizing the cell membrane. Quite generally, the value of Planck constant characterizes the evolutionary level of neuron.

Both EEG photons and biophotons can be identified as decay products of dark Josephson photons producing either a bunch of EEG photons or single biophoton. The frequency modulation of Josephson

frequencies provides a general coding of sensory percepts and other information in terms of Josephson radiation communicating this data to the magnetic body. This modulation could also explain the observed periodic modulations.

5.4.5 TGD based model for the delayed luminescence

The TGD based model for the delayed luminescence is based on two mathematical observations:

1. The intensity of coherent photons must be proportional to the number of positive energy MEs and hyperbolic decay results naturally if MEs annihilate pairwise. The most natural possibility is that positive and negative energy MEs annihilate in a pairwise manner, possibly by p-adic-to-real phase transition.
2. Oscillatory behavior in the variable $u = \log(1 + \lambda t)$ results if there is a feedback mechanism generating or destroying MEs or MEs with a rate which is the time derivative dF/dt of a periodic function $F(u)$. The interaction with supra currents via magnetic induction could be the mechanism in question.

The essential difference as compared to the models of Popp and Yan [I117], whose TGD variant will be also considered below, is that quantum coherence for photons is not assumed in the time scales of order seconds characterizing the decay of the delayed luminescence.

Basic observations

Before going to the analytic formulation, it is good to work through the basic mathematical and physical ideas of the model first and connect them with the general vision about homeostasis as many-sheeted ionic flow equilibrium.

1. Negative/positive energy ME is a correlate for photon absorption/emission. Thus the distribution of the coherent photons reflects the kinetics for MEs with lengths corresponding to the wave lengths of visible light. MEs and ME pairs are generated by the interaction with the external perturbation, say electromagnetic field. The annihilation of positive and negative energy ME pairs is energetically very natural mechanism changing the number of MEs. There must be an interaction between supra currents and MEs and magnetic induction is very attractive interaction mechanism. The induction current LdI/dt associated with super conducting circuit should generate or destroy MEs or ME pairs with rate which on dimensional grounds must be proportional to $eLdI/dt$.
2. At the level of frequencies hyperbolic decay law predicts a $1/f$ power spectrum for frequencies $f \ll \lambda$. $1/f$ noise is almost [E3] [D1] and I have already earlier proposed that the dynamics of the mind like space-time sheets, for instance MEs, might explain it [K57, K58].
3. Hyperbolic decay suggests that the interaction involving two MEs is involved since $dI/dt = kI^2$ gives $1/(1 + \lambda t)$ behavior. The basic reaction would be the annihilation of positive and negative energy MEs with rate proportional to $n_+ \times n_-$. The essential assumption is that in the absence of an external perturbation MEs are generated or annihilated only in pairs. It is essential that given positive energy MEs can annihilate with *any* negative energy ME: hence positive and negative energy MEs cannot appear as only self-annihilating tightly bound pairs. If only annihilation occurs the assumption implies that the difference of $n_+ - n_- = n_0$ for the numbers n_+ and n_- of positive and negative energy MEs is a constant of motion. This can be also interpreted as stating that absorption and emission cancel each other in homeostatic equilibrium. In the asymptotic stationary state only n_+ is non-vanishing.
4. A correction periodic with respect to the variable $\log(1 + \lambda t)$ to the decay rate result if there is additional mechanism generating ME pairs. The rate for the generation of ME pairs must be of the general form

$$\frac{dn(\text{ME pair})}{dt} = \frac{dF(u)}{dt}, \quad (5.4.4)$$

where $F(u)$ is a periodic function of the variable $u = \int(n_+ + n_-)dt$

Concrete physical model

One can develop the physical model further by utilizing the general ideas related to DNA, to the model of nerve pulse and EEG and fractality.

1. The events preceding delayed luminescence

The general view about how magnetic bodies control biological body and receive sensory data from it suggests how external perturbation induces delayed luminescence. External perturbation induces sensory communications to a relevant magnetic body at some level of dark matter hierarchy. Magnetic bodies react and induce generalized motor action which at DNA level means expression of some genes requiring the unwinding of some portions of DNA. Delayed luminescence is associated with this portion and corresponds to Josephson radiation of photons at various levels of dark matter hierarchy.

2. How delayed luminescence is induced?

Popp and Yan have proposed two models of the delayed luminescence based on time dependent harmonic oscillator in time dependent driving force [I117]. Both models are constructed by hand to produce the hyperbolic decay law using the flexibility of harmonic oscillator Hamiltonian. The objection is that the frequency parameter in the first model producing the hyperbolic decay law is in ELF range whereas photons have frequencies in the visible range. The authors consider also a model based on two coupled harmonic oscillators reproducing the oscillatory behavior. The problem now is that the model does not seem to approach to the first model at any limit.

Dark matter hierarchy allows to invent a modification of the harmonic oscillator model so that it overcomes the worst difficulties of principle associated with the models [I117] and allows also a concrete physical interpretation.

1. The presence of dark matter hierarchy justifies the assumption that the coherence of the harmonic oscillators at visible frequencies (with a natural time scale of 10^{-14} seconds) is maintained in time scales of minutes: nanosecond would look the maximally optimistic assumption about coherence time in the standard physics context. For instance, coherence time of 2 minutes would correspond to the dark matter levels with $r = 2^{k_d}$, $k_d = 56$.
2. Bio-photons would result as an outcome of the de-coherence of dark Josephson photons associated with MEs corresponding to frequencies $1/f \sim$ few minutes to a single-sheeted MEs corresponding to visible ordinary light. The hyperbolic decay rate and its logarithmic oscillatory behavior are still put in by hand but the model to be discussed can explain these features.
3. A possible TGD based interpretation for the frequency modulation is that frequency corresponds to a voltage over Josephson junction. The variation of the voltage over Josephson junction is in turn analogous to that occurring during nerve pulse and the change of sign for the voltage would have a natural interpretation in terms of the generation of negative energy MEs. Josephson radiation would thus generate both positive and negative energy dark MEs.

This would mean that the basic frequency $\omega_J = Q_{eff}eV$ of Josephson would vary slowly and induce a variation of the fundamental frequency of Josephson radiation over the range of visible frequencies (actually also lower frequencies can be present but with smaller intensity). This frequency would in turn define the fundamental frequency associated with the coherent light emitted by MEs and the variation would explain why the spectrum covers smoothly over the range of visible frequencies.

4. The connection with nerve pulse generation suggests that an analog of nerve pulse propagating along DNA double strand accompanies the unwinding of the double strand. The general model for the quantum control by magnetic body [K26] would suggest that the magnetic body generates W ME inducing charge entanglement between magnetic body and DNA double strand (or either of the strands). When the state function reduction of this entanglement leads to a state in which double strand (or either strand) has an anomalous em charge, double strand becomes unstable against unwinding and in this process positive and negative energy neutral MEs are generated.

5. The unwound portion of DNA double strand acts as a Josephson junction at $k_d = 0$ level of hierarchy and generating visible Josephson radiation for which MEs are space-time correlates. Bio-photons correspond to coherent photons generated by the vacuum currents associated with $k_d = 0$ MEs. The Josephson junction has scaled up dark variants just as the cell membrane and similar process occurs also at the higher levels of dark matter hierarchy just as in the case of cell membrane [K26]. Dark variants of visible photons at various levels of dark matter hierarchy are generated.

3. *Josephson radiation has positive and negative energy MEs as space-time correlates*

During gene expression period when unwinding of DNA double strand occurs, both negative and positive (inertial) energy MEs must be generated and negative energy MEs could be assigned with the change of the sign of voltage over the Josephson junction.

If MEs carry constant transversal electric and magnetic fields, they must carry effective charges at their boundaries. The rotating wormhole throats at the boundaries of MEs and connecting them to larger space-time sheets serve as sources of the electric and magnetic field. These larger space-time sheets could but need *not* be MEs with opposite energy.

The annihilation of MEs (ME pairs) must occur dominantly by collisions of MEs (ME pairs) moving in opposite directions. Annihilation would mean at the level of photons (CP_2 type extremals) that positive and negative energy CP_2 type extremals would fuse to wormhole contact by topological sum. The resulting two light-like causal horizons assignable to the wormhole contact would carry quantum numbers of photon and its phase conjugate. The resulting ME pairs cannot generate appreciable coherent light since it could be regarded essentially as a dipole like structure with the distance between currents of order CP_2 length.

MEs should be parallel and in very regular spatial configuration in order that their contributions to the coherent light interfere constructively. If MEs are associated with unwound DNA, this might be implied by the regular structure of unwound DNA. The simplest guess is that MEs are orthogonal to the DNA strands. Hence a constructive interference occurs only when DNA is in an unwound state and is thus active. This is certainly the case when DNA is transcribed. The prediction is that also the intronic portions of DNA expressed only electromagnetically must be unwound in the active state. Similar constructive interference is expected in the case of axonal MEs generating coherent light at ELF frequencies.

Interesting questions relate to the interpretation of the positive and negative energy MEs. One possibility is that negative energy MEs suck energy from metabolic sources. At $k_d = 0$ level the sources would be mitochondria. If positive energy MEs are interpreted in terms of sensory communications. What comes in mind are communications with basic building bricks of RNA molecules needed in the transcription and cyclotron frequencies of DNA and RNA nucleotides could serve as their signatures.

4. *Could magnetic induction generates or destroy MEs?*

Magnetic induction is the fundamental mechanism for the interaction of MEs and supra current circuits. That magnetic induction should generate MEs is a rather natural assumption since changing current induces radiation and MEs represent topologically quantized counterparts of the classical radiation fields. Periodic oscillations in variable $\log(1 + \lambda t)$ result if the magnetic induction (generation of emf in the circuit) for the current is accompanied by generation of MEs such that the number of MEs generated per unit time is proportional to $eLdI/dt$, where I is Josephson current. This is possible only if DNA double strand is unwound and has Josephson junctions only at the other end or both ends. If Josephson currents are the only currents in the circuit one obtains precisely the required type of term to the differential equation for the numbers of the positive and negative energy MEs. Since Josephson current is sinusoidal and has constant intensity, the prediction is that the amplitude of the oscillatory perturbation is constant unless the density of the supra current carriers varies also.

Hyperbolic decay

The kinetic equations for n_0 and n_- are

$$\frac{dn_+}{dt} = \frac{dn_-}{dt} = -kn_+n_- \quad . \quad (5.4.5)$$

This gives

$$n_+ - n_- = n_0 = \text{constant} . \quad (5.4.6)$$

Thus the difference for the numbers of positive and negative energy MEs is conserved. Using this condition, one can write the equations in the form

$$\frac{dn_+}{dt} = \frac{dn_-}{dt} = kn_+ \times (n_0 - n_+) . \quad (5.4.7)$$

The solution of this equation is

$$n_+(t) = n_0 A \frac{1}{A - \exp(-u)} , \quad n_-(t) = n_0 \left[\frac{A}{A - \exp(-u)} - 1 \right] , \quad (5.4.8)$$

$$A = \frac{n_+(0)}{n_+(0) - n_0} , \quad u = n_0 k t .$$

What is nice that the solution approaches asymptotically automatically to $(n_+ = n_0, n_- = 0)$. If n_0 is negative the roles of n_+ and n_- are changed and the solution approaches to $(n_+ = 0, n_- = n_0)$. There are reasons to believe that n_0 defines the number of *positive* energy MEs in the normal situation for the living matter and generating the coherent bio-photons.

The small values of the parameter u correspond to

$$t \ll \frac{1}{n_0 k} ,$$

and since the intensity of coherent light is proportional to n_+ one has in this region the hyperbolic decay

$$n_+(t) = n_0 \times \frac{A}{A-1} \times \frac{1}{1 + \lambda t} ,$$

$$\lambda = \frac{k}{A-1} . \quad (5.4.9)$$

The non-vanishing of the intensity of the coherent light in the absence of external perturbations requires symmetry breaking in the sense that one has $(n_+ = n_0, n_- = 0)$ in the stationary situation. This corresponds naturally to the symmetry breaking associated with the functioning of DNA. Only the strand is expressed (chemically or electromagnetically) and the conjugate strand serves as the source of energy. The conjugate strand can give part of the negative energy to the environment, most probably to the mitochondria, and the strand is the only user of the positive energy.

Periodic corrections to the decay rate

One should understand also the logarithmic oscillations [I117] in the time scale of seconds from first principles. This variation must correspond to an endogenous feedback which generates ME pairs just like the exogenous perturbations generate ME pairs. The existence of this kind of process is consistent with the observation of a delayed luminescence associated with various biological functions such as mitosis.

On basis of previous considerations suppose that there is small feedback term at the righthand side of the equation for dn_+/dt of the general form

$$\frac{dn_+}{dt} = \frac{dn_-}{dt} = -kn_+n_- + \epsilon \frac{dF}{dt} , \quad F = F(\int (n_+ + n_-) dt) . \quad (5.4.10)$$

Here ϵ is assumed to be a small parameter. For $n_+ \gg n_0$ one has in good approximation $n_+ + n_- = 2n_+$. For small value of ϵ one can integrate the perturbation in good approximation to give

$$\begin{aligned}\Delta n_+(t) &\simeq \epsilon F(\int (n_+ + n_-) dt) \simeq \epsilon F(\int 2n_+ dt) , \\ \int 2n_+ dt &\simeq K \times \log(1 + \lambda t) , \quad K = 2 \frac{n_0}{\lambda} \times \frac{A}{A-1} .\end{aligned}\tag{5.4.11}$$

If $F(u)$ is a periodic function then also a periodic logarithmic term results.

The general vision about many-sheeted ionic flow equilibrium in which MEs can act as Josephson junctions allows to make guesses about the origin of the feedback term. Suppose that the differential equations for n_+ and n_- contain a term proportional to the net voltage eV over a Josephson junction:

$$F\left(\int (n_+ + n_-) dt\right) = eV .\tag{5.4.12}$$

The motivation for this assumption is the conviction that there must be a coupling between the dynamics for MEs and many-sheeted ionic current circuits. Note that the dimensions are same for dn_+/dt and voltage eV in the natural units $\hbar = c = 1$.

The model already discussed indeed produces the required oscillatory behavior.

1. Suppose that the Josephson junctions are at the ends of the unwound DNA double strand current loop traversing transversally all n_+ positive energy MEs transversal to DNA strand and n_- negative energy MEs transversal to the conjugate strand. Assume also that that both positive and negative energy MEs contributes constant potential difference $-eV_0$ along strand besides oscillating contribution. Note that MEs are not assumed to act as Josephson junctions between strands.
2. Assume that the potential differences over the Josephson junctions are same. The net irrotational potential difference through the junction at the end is thus $(n_+ + n_-)eV_0/2$.

Under these assumptions the Josephson current through the junction is given by

$$I = I_0 \sin\left(\frac{eV_0}{2} \int (n_+ + n_-) dt\right) .\tag{5.4.13}$$

This current runs through the entire circuit and induces to the net electric potential difference through the junction a rotational magnetic induction term $\Delta V = LdI/dt$. Also Ohmic and capacitance terms can be present but for simplicity let us assume that they are absent. Under these assumptions one has

$$F\left(\int (n_+ + n_-) dt\right) = eI_0 \sin\left(\frac{eV_0}{2} \int (2n_+ - n_0) dt\right) .\tag{5.4.14}$$

This term has the required dependence on time and gives in a good approximation a periodic logarithmic term. The prediction is that the amplitude for the intensity of oscillation is constant.

TGD inspired modification of the model of Popp and Yan for the delayed luminescence

As discussed earlier, the basic objection against the model of delayed luminescence proposed by Popp and Yan [I117] is the long coherence time of order few minutes. For instance, $k_d = 56$ level of dark matter hierarchy allows 2 minute time scale. The hyperbolic decay law can in turn be understood in terms of annihilation of positive and negative energy MEs, and the annihilation of MEs induced by magnetic induction interaction having interpretation in terms of absorption of photons explains logarithmic oscillations as a signature of Josephson current.

This picture suggests that a modification of the model of Popp and Yan [I117] could make sense also in TGD framework. The physical picture of the model is that the frequencies of the visible photons are frequency modulated slowly in ELF time scale and the modulation function depends logarithmically on time. Physically this would correspond to the modulation of the lengths of the MEs which generate the coherent visible light so that frequency scale varies. The amplitude of the

frequency modulation must be below measurement resolution. This model predicts that the temporal behavior of the intensity is same for all visible frequencies.

Frequency modulation means the addition of a small and slowly varying part to the visible frequency. The modulation is a logarithmic function

$$u(t) = \log(1 + \lambda t)$$

of time. The parameter λ characterizes the hyperbolic decay rate and is of order few Hz typically. The functional form of the modulation is adhoc.

The frequency modulation of the visible frequency ω_0 reads as

$$\begin{aligned} \omega(t) &= \omega_0 + \omega_1 \times F(u) , \\ F(u) &= u + f(u) . \end{aligned} \quad (5.4.15)$$

where $f(u)$ is periodic function: also this assumption is ad hoc. $\omega_1 \ll \omega_0$ guarantees that modulation is small: the variation of the frequency ω_0 should be below the experimental frequency resolution.

Consider now a quantitative model for this based on the modification of the discussion in [I117]. The Hamiltonian for the time dependent harmonic oscillator driven by time dependent force and having time dependent vacuum energy $\beta(t)$ reads as [I105]

$$H(t) = \omega(t)a^\dagger a + fa^\dagger + \bar{f}a + \beta(t) . \quad (5.4.16)$$

Standard commutation relations are satisfied and coherent states are eigen states of annihilation operator ($a|\alpha\rangle = \alpha|\alpha\rangle$) and the eigenvalues of annihilation operator satisfies same equation of motion as the annihilation operator:

$$\frac{d\alpha}{dt} = i\omega(t)\alpha + f(t) . \quad (5.4.17)$$

The general solution of this equation is

$$\begin{aligned} \alpha(t) &= \exp(-i\phi(t)) \left[\alpha(0) + \int_0^t f(t_1) \exp(i\phi(t_1)) dt_1 \right] , \\ \phi(t) &= \int \omega(t) dt = \omega_0 t + \omega_1 \int F(1 + \lambda t) dt . \end{aligned} \quad (5.4.18)$$

Energy is constant of motion for coherent states (homeostatic equilibrium), that is $\omega n = \omega_0 n_0$ which gives

$$n(t) = n_0 \frac{\omega_0}{\omega(t)} . \quad (5.4.19)$$

This gives for the intensity of the light in delayed emission

$$\begin{aligned} I(t) &\propto \frac{dn}{dt} = -\frac{n_0 \omega_0}{\omega^2} \frac{d\omega}{dt} \\ &= -\frac{n_0 \omega_0 \omega_1}{\omega^2} \frac{dF}{du} \frac{1}{1 + \lambda t} \end{aligned} \quad (5.4.20)$$

The amplitude of frequency modulation should be below experimental resolution so that one has $\omega(t) \simeq \omega_0$ in excellent approximation. This gives the approximate expression

$$\frac{dn}{dt} \simeq -\frac{n_0 \omega_1}{\omega_0} \frac{dF}{du} \frac{1}{1 + \lambda t} \quad (5.4.21)$$

The simplest choice for $F(u)$ is $F(u) = u$ and gives hyperbolic decay. If $F(u)$ is of form $F(u) = u + \lambda_1 \sin(u)$, an oscillatory behavior

$$\frac{dn}{dt} \simeq -\frac{n_0 \omega_1}{\omega_0} [1 + \lambda_1 \cos(\log(1 + \lambda t))] \frac{1}{1 + \lambda t} \quad (5.4.22)$$

results.

5.4.6 Kirlian effect

Kirlian effect [I62] is a candidate for one particular instance of the proposed $f_{ELF} \rightarrow f_h$ transformation. Kirlian photography uses high voltage in kV range alternating at frequencies of order kHz. The frequency is 1024 Hz in so called gas discharge visualization method (GDV) developed by Korotkov [I96]. The Kirlian response of living matter differs from the response of non-living matter in that it varies in much wider limits and correlates with the state of organism. Thus it seems that the explanation as a mere passive coronal discharge cannot be correct. The presence of water is essential for the effect and for some reason this has led to skeptics to announce that effect involves nothing which would not be understood by standard skeptic science.

Korotkov [I96] believes that GDV involves a holistic psycho-physiological rather than a purely local biological response which should be same for living and non-living matter. Korotkov has developed GDV as a diagnostic tool using the hypothesis that GDV picture is kind of a hologram reflecting the state of the entire organism. GDV seems to indeed serve as a rough diagnostic tool allowing to deduce with certain reliability whether organism is healthy or not [I62]. The idea about DNA as a hologram is consistent with Korotkov's vision.

The frequency used in GDV is very near to the resonance frequency of synchronous neuronal firing. This suggests that the process involves neural activity and genetic expression as assumed also in the model for the discovery of Gariaev that laser light at 2 eV photon energies induces delayed emission of radio-waves. In this case the emitted light could be bio-photons resulting from the de-coherence of dark photons, for instance ELF photons at $k_d = 47$ level of dark matter hierarchy for 5 Hz frequency [K26]. This would conform also with the continuum of the emitted spectrum.

5.5 Bio-photons, radio waves, and genetic regulation

Bio-systems could generate holograms in much more concrete sense than the wetty and hot and noisy character of this environment would suggest: even mechanisms generating laser beams could be there. The findings of Peter Gariaev and collaborators described in the article "The spectroscopy of bio-photons in non-local genetic regulation" [I75] provide a new support for the notion of many-sheeted DNA. The findings also lead to a concrete model for how bio-photons affect many-sheeted DNA, and in this manner induce a generation of coherent radio waves and ELF waves. Moreover, a concrete model for how bio-systems act as many-sheeted lasers at various wavelengths emerges.

In polarizing laser-radio wave spectroscopy (PLR-spectroscopy) laser light scatters from the target substance. In the experiments of Gariaev *et al* red light ($\lambda = 632.8$ nm, 1.9595 eV) generated by He-Ne laser is used. There are two orthogonal polarizations correlated in intensity in such a manner that the total intensity remains constant. After the interaction of one mode with the target substance, the reflected light is returned to the optical resonator, where the re-distribution of the intensity of these modes occurs. One of the laser modes, at a certain mode of generation, is able during the interaction with the target substance to induce modulated radio waves of a wide spectrum correlated with the modulations of the optical modes of the laser radiation. The modulation depends on rotational fluctuations of micro-structural components (say, domains of crystals) and of their optical activity. The PLR-spectrum is present also for in-organic materials. For biological targets there is spectral memory effect present, which means that the radio wave radiation continues even when the laser beam is not present anymore.

The general situation is very similar to that encountered in the case of delayed luminescence [I124], and an attractive assumption is that laser light acts as an external perturbation inducing gene expression requiring unwinding of DNA which involves generation of dark photons at various levels of dark matter hierarchy as Josephson radiation. Also cyclotron radiation from magnetic bodies is

expected to be present just and the interpretation in terms of scaled up variants of EEG [K26] might make sense. Dark photons at $r = k_d^{th}$ level of dark matter hierarchy correspond to 2^{k_d} -sheeted MEs and their decay to single-sheeted MEs representing ordinary coherent light with frequency $f(k) = f/r$ yields ELF and VLF photons.

5.5.1 Frequency spectrum of radio waves

The frequency interval of the radio emission settles down at the 1 MHz. The PLR-spectrum is depicted in figures 1 and 2 of [I75] for apofillit crystal. The frequency spectrum for the radio waves has a modulated fractal structure suggesting that spectrum is superposition of spectra which consist of harmonics $n_1 f_h - n_2 f_l$ of higher frequency f_h modulated by harmonics of scaled down frequency $f_l = x f_h$. Almost identical copies of a piece of length about

$$\Delta f \sim 100 \text{ Hz}$$

appear in a sequence as the pictures 1 and 2 of [I75] for the spectrum of apofillit crystal in 1560-1860 Hz range demonstrate. This suggests the presence of harmonics of basic frequencies perhaps shifted by a constant amount. Cyclotron and spin flip transitions in magnetic field suggest itself.

There is also gross structure consisting of peaks in scale of kHz suggesting harmonics of frequency of order kHz. For wheat seed (picture 3 of [I75]) the strongly expressed frequency ranges are identified as 800-900 Hz (to my personal opinion the band is 300-900 Hz), 1700-1900 Hz, 2400-2600 Hz, 3600-3800 Hz (to my personal opinion a wider frequency range 1700-2200 Hz is strongly expressed). There is also strongly expressed frequency band below 300 Hz. Also the spectrum of high polymerization DNA sample from calf thymus (picture 4 of [I75]) shows a clear peak at 2400-2600 Hz and less pronounced peaks at lower frequencies.

The radio wave radiation from DNA samples is accompanied by specific effects on bio-systems such as ab-normally fast germination and re-vitalization of seeds. Thus it seems that the radio wave radiation is able to restore the genetic control apparatus and the vitality of the seeds.

5.5.2 Basic questions

The model proposed by Gariaev *et al* [I75] for the PLR effect is based on the phenomenological notion of photon localization dating back to the experimental findings made 1985 [D32] suggesting that photon beam can be concentrated in a narrow tube under some circumstances. This is strongly reminiscent of ME (massless extremal), which is essentially 'topological light ray' along which photons propagate. MEs are the basic element in TGD based quantum model of living matter.

Concerning the modelling of the PLR effect, the basic questions to be answered are following.

1. How could one understand the modulated fractal like spectrum of the radio waves radiation? What is the origin of the frequency scales present in the spectrum and what gives rise to modulatory structure?
2. How does the scattering of coherent light on DNA induce the radio wave emission and how one can understand the correlation between polarizations?
3. How does the spectral memory effect result and what is the mechanism causing the biological effects accompanying the radio waves?

In the following TGD based answers to some of these questions are discussed.

5.5.3 How to understand the spectrum?

The finding that the width of the basic unit of the spectrum is about $\Delta f = 100$ Hz would suggest that the mechanism involves magnetic transitions in Earth's magnetic field, whose nominal value can taken to be $B_E = .5$ Gauss for definiteness. The corresponding space-time sheet would be $k = 169$ and correspond to p-adic length scale $L(169) \simeq 5$ micrometers.

1. *Miracle length scales and the coiling hierarchy of DNA*

Above this p-adic length scale are four miracle length scales $k = 151$ (cell membrane thickness of about 10 nm), $k = 157, 163$, and $k = 167$ related by scaling $L(k) = 2^{(k-169)/2} \times L(169)$ to $L(169)$. These p-adic primes correspond to the so called Gaussian Mersennes $G_k = (1 + i)^k - 1$, $|G_k| \simeq 2^k$, which are complex counterparts of ordinary Mersenne primes. Since ordinary and Gaussian Mersennes are fundamental for TGD based elementary particle physics, one expects that the same is true in biological length scales. The coils inside coils inside... structure of the chromosomes could correspond to a quantum control hierarchy of these four space-time sheets, and the transitions of ions between cyclotron (magnetic) states at these space-time sheets would generalize ordinary cyclotron (magnetic) transitions.

If these space-time sheets are also magnetic flux tubes carrying magnetic field satisfying flux quantization condition the corresponding field strengths are obtained by scaling $B(k) = 2^{169-k} B_E$. Cyclotron frequency scales are scaled up in the same manner: $f_c(k) = 2^{169-k} f_c(169)$.

1. For $k = 167$ the cyclotron frequencies are scaled up by a factor 4. What is interesting is that for bosonic Mg_{++} ion cyclotron frequency is $f(169) = 25$ Hz so that for $k = 167$ the cyclotron frequency would be 100 Hz. Mg^{++} is indeed important biological ion, especially so for the functioning of DNA [I72] . Hence the 100 Hz approximate fractal periodicity might relate to the cyclotron harmonics of Mg_{++} ions. There are also other cyclotron frequencies present and for bosonic ions many of these frequencies are in alpha band so that 40 Hz periodicity would also suggest itself. Different frequency scales imply a super-position of the scaled up harmonics spectra.
2. For $k = 163$ the factor is 64 and frequency range 10 – 100 Hz for ionic cyclotron frequencies is scaled up to 640 – 6400 Hz. These transitions could explain the large scale features of the spectrum with characteristic scale of kHz.
3. For $k = 157$ the factor is $2^{12} \simeq 4000$, which means that the frequencies for ions are in MHz range, which corresponds to the upper bound for the frequency range of radio waves.
4. For $k = 151$ the factor is $2^{18} \simeq 10^6/2$ and the cyclotron frequency for proton is about .15 GHz and in microwave range. Microwaves are in a fundamental role in TGD based view about bio-control.

2. *Is the radio-wave spectrum a superposition of many-sheeted magnetic transition spectra?*

The simplest hypothesis is that the radio-wave spectrum is a superposition of relatively simple magnetic spectra for several ions and having the same general shape.

1. The spectrum of a given ion results, when the ion drops from a cyclotron state n_1 at $k > 169$ magnetic flux tubes to cyclotron states n_2 at $k = 169$ magnetic flux tube such that the longitudinal momentum along tube is conserved or is very small. If the magnetic flux tube is of finite length L , the longitudinal energies are given by $E_n = n^2 \pi^2 / 2mL^2$, L the length of the magnetic flux tube. If the length of the magnetic flux tube is considerably longer than the magnetic length, magnetic energy gives only a small contribution to the energy and can be neglected unless Δn is very large.
2. The frequencies of the photons resulting in this manner are given by

$$f(k) = n_1 f_c(k) - n_2 f_c(169) = [2^{169-k} \times n_1 - n_2] \times f_c(169) .$$

Here $f_c(169)$ varies in the region 1-100 Hz for ions other than proton and for proton one has $f_c(169) = 300$ Hz. Quite generally one has $f_c = 300Z/A$ Hz, where A is the mass number of ion and Z its charge. Effectively the harmonics of the ionic cyclotron frequencies at Earth's magnetic field modulate the scaled frequencies at $k < 169$ magnetic flux tubes.

3. A more general model allows the variation of the magnetic field strengths from their nominal values, so that one has the formula

$$f(k) = [a(k)2^{169-k} \times n_1 - a(169)n_2] \times f_c(169) .$$

Here $a(k)$ characterizes the scaling relating the actual value of the magnetic field value to its nominal value.

Under these assumptions it could be possible to understand the basic fractal like characteristics of the spectrum. There is a killer test for the model: one should be able to identify individual lines of the PLR-spectrum as differences $S(k_1, A) - S(k_2, A)$ of the magnetic spectra $S(k_i, A)$ for various ions (A denotes the atomic number). PLR in principle means a possibility to do many-sheeted spectroscopy and might provide the Golden Road to many-sheeted physics.

5.5.4 Many-sheeted radio-wave laser excited by ordinary laser light

The idea of many-sheeted laser allows to consider several mechanisms explaining the findings.

1. The visible laser light beam could pump the ions from the magnetic flux tubes to cyclotron states at $k < 169$ space-time sheets wherefrom they drop to $k = 169$ space-time sheet and generate coherent photons at radio wave frequencies.
2. Alternatively, laser light might stimulate directly the dropping of pre-existing ions from space-time sheet $k < 169$ to $k = 169$. The emitted light can indeed give rise to stimulated emission just like in the case of the ordinary laser. Entire many-sheeted cascades $k_1 \rightarrow k_2 \rightarrow \dots \rightarrow k = 169$ of emissions analogous to cascades of emissions from the decay of excited atomic states are possible.
3. The analogy with the delayed luminescence forces to ask whether the same basic mechanism is behind both phenomena. If so, the connection between laser irradiation and radio wave generation is less direct involving the reaction of magnetic body. The motor action of the magnetic body would induce gene expression and unwinding of DNA strand and generation of Josephson radiation responsible for the communications to the magnetic body at frequencies $nf_c \pm f_J$: this radiation would give rise to bio-photons as already discussed. The correlation of its polarization with the polarization of laser light is not plausible. If the part of the generalized EEG involving harmonics nf_c of cyclotron frequencies responsible for the control of DNA by magnetic body results as a direct response to the laser irradiation, the correlation between the polarizations of laser light and radio waves is conceivable.
4. The fact that the radio wave radiation is accompanied by biological effects suggests that radio-waves result from dark photons for which energies are above thermal threshold at room temperature. The mechanism would be the decay of r -sheeted ME to r separate MEs with energy determined by frequency in the usual manner. Biological effects would not be produced by the radio-waves but by high energy dark photons with energies in UV range (300 Hz corresponds to ~ 5 eV).

He-Ne laser produces miracle wave length

The wavelength of laser photons corresponds to about 632.48 nm, which is quite near to the p-adic length scale $L(163) = 640$ nm in the approximation $L(151) = 10$ nm. This is one of the p-adic miracle frequencies. This observation suggests that the laser light interacts resonantly with $k = 163$ space-time sheet and somehow generates radio waves in this process. Therefore the general rule of thumb for how to make many-sheeted-ness manifest would be simple. A radiation with wavelength of order p-adic length scale induces resonantly a flow of ions to space-time sheets for which the zero point kinetic energy is of the order of magnitude of the photon energy. This hypothesis is in principle testable by looking whether the laser beams with wavelengths given by p-adic length scales are in a special position.

The energy of photons from He-Ne laser corresponds to the zero point kinetic energy of electron at $k_2 = 73$ space-time sheet

The space-time sheet corresponding to the secondary p-adic length scale $L_2(k = 73) = L(146) \simeq 10/32 \simeq 3.12$ Angstroms, is rather near to the length of single DNA base (10 DNA triplets correspond to the length of 10 nm). In this case electron's zero point kinetic energy is $\simeq 2$ eV and is the same as the energy of photons in the laser beam used in the experiments. This suggests that the kicking

of electrons from $k = 163$ space-time sheet to $k = 73$ secondary space-time sheet is the first step of the process. After this step electron drops back to $k = 163$ space-time sheet and emits essentially the original wavelength so that laser action results. The probability for the occurrence of this step is amplified by the presence of coherent laser light (stimulated emission mechanism).

The correlation between the polarizations of radio-waves and laser photons

The polarizations of the radio waves correlate with the polarization of the laser light. This is the case if the radio waves result in a process, which kicks electron from $k = 163$ space-time sheet to $k = 73_2$ space-time sheet. The simplest possibility is that the kicking process involves a coherent interaction with the other ions at $k = 163$ magnetic flux tube inducing the dropping of these ions to $k = 169$ magnetic flux tube accompanied by the radiation at frequency corresponding to the difference of the magnetic energies. One can imagine also a second possibility. Since the electron is kicked to a super-conducting space-time sheet associated with the DNA base, the information about polarization is not lost into a thermal noise, and the electron dropping back to $k \leq 169$ space-time sheet still carries it. Therefore the dropped electron could induce the dropping of ion to $k = 169$ space-time sheet generating still polarized radio waves.

Quantum coherence produces intense radio wave and ELF laser beams

Because of the presence of a large number of Cooper pairs/bosonic ions in the same state at $k \leq 169$ space-time sheet, the process occurs coherently and the rate is proportional to the square N^2 of the number N of the bosonic ions/Cooper pairs in the system.

The radio waves and ELF radiation produced in ordinary magnetic transitions at $k = 169$ space-time sheet is quantum coherent in the length scale defined by wavelength at least and propagates inside the tubes defined by ELF or VLF MEs. This radiation is obviously ideal for biological communication and control purposes. This suggests that bio-photons propagating inside low frequency MEs with frequencies in kHz range act just like a laser beam and induce emission of radio waves in the proposed manner.

Also $k > 169$ space-time sheets can be involved and produce radiation ULF wave lengths. For instance, maser beam could resonantly interact with structures in the size range of roughly 1 mm-1 m (microwave wavelengths) and kick electrons to $k = 157$ magnetic flux tubes (say) where cyclotron energy scale is of correct order of magnitude. Thus a very complex many-sheeted spectroscopy analogous to atomic and molecular spectroscopies is predicted.

Phantom DNA effect

A further mysterious looking effect involved with the experiments is phantom DNA effect. There is also an elastic scattering of the coherent from irradiated DNA and the simplest mechanism is the kicking of electrons to the $k_2 = 73$ space-time sheet and dropping back so that they regenerate laser photons with essentially the original wave length. When one removes the DNA from the chamber containing it, and irradiates it by laser light, a weak pattern of scattered light is still produced: as if there were a kind of phantom DNA there.

A possible explanation for the effect is that the removal of DNA is not complete but leaves some non-atomic space-time sheets associated with the DNA to the chamber. If $k_2 = 73$. $k = 163$ and $k = 167$ space-time sheets are left besides the $k = 169$ space-time sheets associated with the magnetic field of Earth, the proposed model indeed predicts scattering. Sooner or later however the ionic densities from these space-time sheet should leak from the volume of the chamber and the scattering is not observed anymore. A killer test for the model is whether the removal of the Earth's magnetic field artificially destroys the effect (and also PLR effect).

5.5.5 Is the radio wave band structure for wheat seed a scaled-up version of the band structure of EEG?

In the model for the hierarchy of EEGs (and generalizations of EEG) based on dark matter hierarchy the band structure of EEG can be understood in terms of resting voltage of cell membrane and cyclotron frequencies in the magnetic field of Earth [K26] . Same ions should contribute to the radio wave spectrum also if it corresponds to a scaled up version of the the cyclotron frequency part of

EEG. Therefore it is interesting to look at the band structures of the radio-wave spectrum for wheat seed represented in the figure 3 of [I75] assuming that $k = 163$ magnetic flux tubes are in question.

1. By scaling the frequency bands of figure 3 of [I75] one finds that the lowest band below 250 Hz can be identified as the counterpart of delta band in EEG ($f < 3.9$ Hz).
2. The region 300 – 900 Hz corresponds to the range 4.7 – 14 Hz covering theta and alpha bands. Actually the band extends to about 1300 Hz so that it contains also beta frequencies up to 20 Hz. In the figure 4 representing the spectral memory there is minimum of intensity at about 700 Hz which corresponds to about 11 Hz so that alpha and beta bands separate from each other.
3. The band 1700 – 2100 Hz corresponds to the range 26-32 Hz and also to beta frequencies. 2400 – 2600 Hz band corresponds to 40 Hz thalamo-cortical resonance band 37.5 – 40.6 Hz.
4. 3600 – 3800 Hz band corresponds to the range 56.3 – 59.5 Hz. The DNA spectrum of figure 4 of [I75] contains also a band around 4800 Hz: this frequency corresponds to 75 Hz and to the cyclotron frequency of ${}^4\text{He}_+$ ion, which is not bosonic ion unless it is an exotic one. This is somewhat questionable interpretation. For $k = 157$ it could be identified as scaled up variant of delta band around 1 Hz which corresponds to DNA cyclotron frequencies. There are no further peaks visible in the figures of [I75]. Protonic cyclotron peak should be visible at frequency of 19.2 kHz not represented in the figures.

As already noticed, the 100 Hz periodicity visible in the spectrum of apofillit crystal (figure 2b) could be due to the harmonics of the Mg_{++} cyclotron frequency $f_c(167) = 100$ Hz at $k = 167$ space-time sheet. There is also 50 Hz periodicity and a weaker 25 Hz periodicity and these periodicities could correspond to even and odd cyclotron harmonics of Mg_{++} at $k = 169$ space-time sheet. Even harmonics for ordinary cyclotron transitions are suppressed by parity conservation.

5.6 Conscious hologram and remote mental interactions

The notion of conscious hologram allows also a unified description of remote mental interactions.

5.6.1 Big vision

The notion of conscious hologram, which is based on the generalization of the notion of Feynman diagram, provides a general view about remote mental interactions.

1. Brain can be seen as a part of a gigantic dynamical and fractal brain consisting actually of the entire universe. The same mechanisms that work at the brain level work also at larger length and time scales. Brains/bodies serve as 'neurons' for the magnetospheric selves receiving information from several brains/bodies. In particular the fusion of the mental images defined by similar structures can give rise to stereo-consciousness, and the notion of species consciousness and even multi-organ consciousness associated with various kinds of organs makes sense.
2. The notions of super-genome and hyper-genome provide a concrete view about how transpersonal levels of self-hierarchy are realized. Super genes are magnetic flux sheets containing sequences of genes like text lines at the page of book. Hyper genes are flux sheets containing sequences of super-genes belonging to different organisms as genetic text lines. This picture conforms nicely with and generalizes Sheldrake's species memory and 'alike likes alike' rule. It also suggest a concrete realization of remote biological mental interaction based on activation of gene expression and nerve pulse activity.

The flux sheets associated with super-genome and hyper-genome have fields strengths of magnetic field of Earth. The correlation of the quality of remote cognition performance with sidereal time [J95] leads to the hypothesis that also the flux quanta of galactic magnetic field couple somehow to living matter.

3. Besides time mirror mechanism charge entanglement realized in terms of W MEs is a basic mechanism of remote mental interaction. The simplest model for the generation of nerve pulse

is based on quantum jump leading to a state in which Bose-Einstein condensate of Ca^{++} and/or Mg^{++} becomes exotically ionized and generates charge flow through cell membrane. Quite generally, charge entanglement would be part of the ordinary bio-control realized in terms of Ca^{++} waves. Charged entanglement provides also a mechanism for the sharing of mental images between magnetic body and biological body. There is no reason why this mechanism could not work also at the level of other remote mental interactions than those that we are too familiar with to realize that remote mental interactions are in question. The typical time 13-15 seconds associated with the remote realization of intentions by Qigong masters [J53] could correspond to a typical duration of W entanglement.

The models for bio-photons bio [I64] and Gariaev's findings [I75] suggest a tentative model for how remote mental interactions proceed. Charged entanglement via W MEs makes possible sharing of mental images. After a reduction of entanglement the generation of positive and negative energy MEs occurs and involves time mirror mechanism making possible remote metabolism and communications of declarative memories. In the case of ordinary bio-control magnetic body utilizes the metabolic energy resources of biological body.

4. Association mechanism works also for remote mental interactions and is even in the case of brain based on MEs and magnetic flux tubes with neuronal firing and metabolic activities being side products of the this mechanism.
5. One of the strange findings about remote mental interactions is that remote viewer can receive information about an object for which she knows only coordinates, which as such are meaningless numbers to her. It is also commonly reported that erroneous readings or interpretations of the target tend to propagate to other viewers. These findings suggest that magnetospheric (earthly or galactic magnetosphere could be in question) dynamical multi-brained selves act as kind of relay stations mediating the remote contact between remote viewer and object. If some brain knows the meaning of the coordinates of the target, this is enough to connect remote viewer to the correct target.

Empirical support for the notion of multi-brained collective levels of consciousness comes from the experiments of Mark Germaine [J59]. An operator and a subject person were involved. The stimulation of the subject person consisted of a sequence of identical sounds containing now and then an odd-ball stimulus (now silence). The odd-ball stimulus generated an event related potential (ERP) visible in EEG and reflecting the conscious reaction. The operator was in a second room and by simple toss of coin decided whether to observe the stimuli in the computer monitor or not. The stimuli appeared in the computer monitor one second before they were heard by the subject person.

What was found that when the operator saw the odd ball stimulus from the computer monitor, the ERP was weaker on the average. An 11 Hz periodicity was the major component in the difference profiles.

The simplest explanation is that the brains of both the operator and of the subject person belong to a larger multi-brained self and that the evoked response represented partially the reaction of this self. When this multi-brained self had already seen the stimulus through the operator's eyes, it was not so surprised to hear this stimulus again through the ears of the subject person, and ERP was weaker.

The appearance of the 11 Hz periodicity suggests that this frequency is an important correlate for the entanglement of the subject person's mental images with those of some multi-brained magnetospheric self. The cyclotron frequencies of most bosonic ions in Earth's magnetic field are in alpha band so that the finding is consistent with the vision about a fractal hierarchy of generalized EEGs associated with the dark matter hierarchy [K26]. The notion of hyper-genome provides a detailed model for how transpersonal levels of self hierarchy control the behavior of groups of individuals. The hypothesis could be tested by looking whether the gene expressions of individuals having close personal relationship but not in a direct personal contact correlate.

5.6.2 Sketch for what could happen in a typical remote viewing experiment

Consider a situation in which a system consists of remote viewer A, person B knowing the position of target T and the coordinates XYZ for it. B gives the coordinates XYZ for person C in turn giving them to the remote viewer A. The following simplified sketch assumes that communication channels

are permanent and that the intentions involved with the process are realized as p-adic space-time sheets in the brain of A, and very probably involve p-adic MEs as representations of the intentions.

1. Remote viewer A, person B knowing having target-XYZ association as two mental images in his brain, and target T have permanent bridges to a magnetospheric multi-brained self M. Therefore M knows the target-XYZ association via the brain of B.
2. Remote viewer A is a client of the multi-brained self M using the remote sensory services provided by M. A-M contact is more or less permanent: this is what it means to have the ability to remote view. Minimum requirement is the existence of magnetic flux quanta connecting A to M. The sharing of mental images requires generation of entanglement, say charge entanglement by W MEs. This would correspond the most primitive passive mode of remote viewing. W mode allows to share also mental images of primitive living systems like plants, and even those assignable to system regarded usually as in-animate. The reduction of charge entanglement makes possible remote mental interaction since resulting charge non-equilibrium generates currents: generation of nerve pulse and Ca^{++} waves would represent basic example of this kind.
3. One can imagine also active mode of remote viewing and this could be involved with telepathy: in this case M would not be involved. This mode involves intentional action (p-adic MEs are transformed to their real variants) and classical communications with the geometric past/future using neutral negative/positive energy MEs could realize declarative memories/"declarative" precognition as well as motor action based on classical communications using symbolic representations. The model for bio-photons suggests that Z^0 and em MEs are generated after the reduction of charge entanglement. The ability to predict reasonable well the personal future could rely on "declarative pre-cognition". The evolution from bicameral mind to modern consciousness [K71] could have proceeded from a mere sharing of mental images by W MEs to complex classical symbolic communications involving also neutral MEs.
4. Since M cannot be assumed to have anything comparable to a nervous system, A-M communications should rely on sharing of mental images. That is, the intention of A (p-adic space-time sheet in brain of A perhaps) to remote view and the questions of A about the target would be shared by M. T-M communications could involve classical communication with light velocity generating magnetospheric sensory representation about the target by self-organization. The 13-17 second delay of remote mental interactions [J53] could correspond to the typical duration of charge entanglement. Target could be also "non-living": it is quite possible that magnetospheric selves form sensory representations also about "non-living" matter. The finding that meteor sounds have frequency spectrum in the 40 Hz band of thalamocortical resonance frequencies, rather than in the predicted 20-20.000 Hz band, supports the view that magnetospheric sensory representations at 40 Hz resonance band are associated also with the non-living matter [K40] , [F1] . Also the vision about dark matter hierarchy conforms with the idea about Earth's magnetosphere as a living organism.
5. Remote viewing by the sharing of mental images means that there are no sensory receptors associated with the passive mode of remote viewing: no such receptors have been identified [J42] . Various physiological correlates (say EEG patterns) of remote viewing should be reactions to the shared mental image rather than direct correlates of it. If primary sensory qualia are at the level of sensory organs, remote viewing differs from hallucinations in that there is no feedback to the retinas from cortex responsible for "qualiafication": this could provide be a clear-cut test. At least in the case of living targets the laws that govern the ordinary sensory perception should hold true for the remote viewing. For instance, the known correlation of the AC performance with the spatial and temporal entropy gradients of the target should hold true for living targets. Even in the case of a non-living target similar correlation holds true if the sensory perception of magnetospheric selves obeys same laws as that of ours: there is some evidence for the correlation of the entropy of non-living target with the AC performance [J42] .

5.6.3 Why it is so difficult to take remote mental interactions seriously?

By the fractality of consciousness the anatomy of quantum jump represents the general structure of the life cycle of any self. First totally entangled multi-verse is generated, then state function reduction

and preparation by self measurements occur and the end result is a maximally un-entangled state. This is what analysis following the birth of an intuitive idea is. By the fractality of consciousness same process occurs also in longer time scales since the sequences of quantum jumps effectively integrate to single quantum jump and the sequences of these effective quantum jumps have similar structure.

This somewhat pessimistic vision is based on the standard Shannonian notion of entropy. For algebraic entanglement, which is the only possible entanglement between different number fields, number-theoretic entropies can be non-negative and Negentropy Maximization Principle does not force de-entanglement in this case. Thus it might be possible to avoid the unavoidable looking decay, and living systems might apply it routinely.

Dark matter hierarchy provides justification for the hierarchy of moments of consciousness with increasing averaging geometric durations and for the idea of quantum parallel dissipation. The simplest view is that life cycle corresponds at the highest level of the personal dark matter hierarchy single moment of consciousness and lower levels would define the mental images as sequences of quantum jumps. This would explain why we 'know' that we existed also yesterday. Entropy growth would apply only to the sequences of lower level quantum jumps defining sub-selves so that mental images would age but could also reincarnate.

Depending on whether one believes in Shannonian world order or takes seriously the notion of number theoretic entropy, one ends up with two almost diametrically opposite visions: evolution as an emergence of selfish *resp.* unselfish selves. Both views explain in their own manner why it is so difficult for a modern man to take remote mental interactions seriously.

Pessimistic view: evolution as a gradual de-entanglement?

From the Shannonian view point and assuming no dark matter hierarchy, the evolution of self at any level is also a decay process leading to alienation and loneliness at the level of mental images. What is consoling is that selves can lose consciousness and wake-up into new childhood. One can say that a healing sleep after a hard day is possible at all levels of self hierarchy.

Ancient myths inspire to think that this vision applies to the evolution of modern subjective consciousness from more collective consciousness. Jaynes has proposed a vision about how bicameral consciousness [J67], in which the voices of Gods talking to people were talking to everyone, gradually transformed to the modern subjective consciousness. TGD based articulation of Jaynes's views based on the notion of semi-trance is discussed in the last chapters of this book.

The basic theme of the pessimistic view about evolution would be the gradual de-entanglement. The ancient world has survived in fairy tales. In this world remote mental interactions like telepathy, remote healing, and witchcraft were every-day life. Incredible-to-us physical feats like building of pyramids might have been made possible by the liberation of energy and coherent momentum in the formation of collective bound state entanglement. The rhythmic work songs helping to generate body synchrony are a remnant from this period, but are not sung in modern IT companies. Also the strange intra-terrestrial creatures and spirits of magnetosphere; fairies, trolls, eagle-headed humans, dreadful snakes,..., populated this world. Shamans talk completely seriously to the anthropologists about these creatures without any doubt about their reality. The human sacrifices for Gods, which look extremely cruel to us, were not experienced as such since these people were not individuals with ambitious plans for a lifelong career.

This development has a parallel at the level of personal life. Fairy tales are told to children, who themselves are living the period of oneness. Then these children grow, become more and more rational and analytic. After the days of willpower, intentional resources re depleted and they gradually lose their ability to make choices and there is not much to choose anymore, and become often also lonely and separated. Gradual physical decay adds its own flavor to this process.

The entire evolution could be seen as wake-ups or re-births, bursts of potentialities from which only few are selected during gradual de-entanglement accompanying self-organization, with dissipation serving as the Darwinian selector. Huxley's view about brain as a filter makes sense: our brains would minimize the sharing of mental images, which does not aid controlled behavior and survival, and thus make us modern individuals. For instance, the mysterious ability of birds and fishes to migrate back to their birth places might actually involve quantum entanglement.

Inhibition by various neurotransmitters could be seen as a measure for the degree of de-entanglement. Inhibition would act as the filter, which de-entangles the brain from other brains and the body from the bodies of other life forms. During hallucinatory experiences, generated by say drugs, inhibition

would "fail". The degree of inhibition indeed increases, as one climbs along evolutionary tree and in human brain most of the neural activity is inhibition, a rather strange finding difficult to understand in the framework of the ordinary neuroscience.

In accordance with ontogeny recapitulates phylogeny principle, this evolution could be seen as an increasing dominance of inhibition during the development of individual leading from spontaneous children to well-behaved and highly controlled adults. Only in some periods of life inhibition fails: during puberty, in physical death and in great turning points of life. Indeed, puberty and physical death are sometimes accompanied by poltergeist phenomena. Physical death may also be accompanied by telepathic phenomena.

Optimistic view: evolution as an emergence of un-selfish selves?

If the notion of the number-theoretic entropy makes sense and the view that life cycle itself corresponds to a single moment of consciousness at the highest level of personal dark matter hierarchy, the view about the growing role of inhibition as an indication of continual de-entanglement is incorrect.

Rather, the increasing dominance of inhibition would indicate the increasing role of an entanglement during which neuron receives negative energy MEs, and thus provides energy for some another system by buy now and let others pay mechanism. This would mean a gradual emergence of un-selfish neurons making possible increasing flexibility and co-operativity. This of course applies also at higher levels like family and society. The increasing role of inhibition could also reduce the remote mental interactions having negative effects (witchcraft might involve genuine remote mental interactions). The Jaynesian view about the evolution of subjective consciousness could be seen as a gradual development from a child like selfish self sending negative energy to an adult unselfish self able to receive negative energies and co-operate.

The primitive society as an analog of single muscle becomes a flexible system in which responsibilities are maximally delegated to the individuals and God's voice does not anymore give direct commands and advice. The evolution of social structures and culture is essentially evolution of hyper-genome coding for the transpersonal levels of consciousness. The irony is that the replacement of God's voice with symbolic communications leads to the illusion that there is nothing but the lonely individuals although the emergence of complex social structures suggests just the opposite.

In this picture the loneliness of the post-modern man might be seen as a degeneration, a return to a selfish child like behavior paralleling the disappearance of transpersonal levels of consciousness. In entanglement either party is the one who gives energy, and the refusal of the average market economy self to entangle by receiving negative energy or sending positive energy makes it hard to entangle at all. A society of lonely skeptics is the outcome. In this view, the failure of inhibition is a degeneration phenomenon, a return to childhood, and involves strong fluxes of negative energy to the environment generating irreversible phenomena like poltergeist and inducing telepathic experiences.

5.6.4 About the physiological correlates of anomalous cognition

In the article "Physiological correlates of Psi cognition" of Charles Tart [J97] some apparently contradictory findings about physiological correlates of anomalous cognition are described besides the experimental findings of Tart. Changes in EEG, galvanic skin response, finger pulse, and basal skin resistance are examples of possible candidates for the physiological correlates of remote mental interactions.

The findings are following.

1. The first class of experiments involves two persons: subject and agent. The agent is subjected to various kinds of stimuli inducing emotional response: sudden sounds, painful stimuli as in the experiments of Targ, etc.. Subject person is typically in a sound proof room and tries to remotely cognize when subject person experiences these stimuli. Various candidates for the physiological correlates are measured. The physiological correlates typically express a heightened arousal. For instance, in the experiments of Tart [J97] galvanic skin response occurred more frequently, and EEG became more complex with more beta waves and fewer alpha, theta, and delta waves.
2. In the second kind of experimental arrangement remote viewing or telepathy is involved but the second person, if present at all, is not subject to any stimuli inducing emotional reaction. Now

the physiological correlates tend to be characteristic for a relaxed state of mind. The increase of the basal skin resistance is one such correlate.

At first these findings might seem to be contradictory. The paradox disappears if sharing of mental images is in question and if the mental images induce same emotional response in the subject person as in the agent.

The remotely perceived (possibly sub-conscious) stimulus or remote anticipation of the stimulus induces in the subject person an emotional reaction having as a correlate the reduction of skin resistance. In the experiments of Tart [J97] both the real electrical stimulus experienced by the agent and the electrical stimulus guide by the operator to an electrical resistance instead of the agent, generates the arousal in the subject. This requires that both the operator, agent, and subject belong to the same multi-brained self so that the reaction of the subject can be interpreted as a kind of conditioned reaction of the multi-brained self expressed via the body of the subject.

5.6.5 Local sidereal time, geomagnetic fluctuations, and remote mental interactions

The article of J. Spottiswoode [J95] discusses two strange findings about remote mental interactions.

1. There is a statistical tendency of the anomalous cognition (AC) performance to concentrate in a 2 hour period around 13.30 of the local sidereal time (ST), which is the time measured using as a reference distant stars and thus running at a slightly different rate than the solar time: the lag is $\Delta T = 24/365$ hours ~ 3.7 minutes during 24 hours.
2. The anticorrelation between the level of geomagnetic fluctuations and AC performance has also a maximum during 2-hour period around ~ 13.30 ST.

The fact that AC performance is associated with the same sidereal hour suggests the identification of the galactic magnetosphere as a conscious involved with remote cognition. For interstellar and galactic magnetic fields cyclotron time scales correspond to the time scales of human consciousness so that also these magnetic flux quanta could receive sensory input from biosphere and control it.

Support for the role of magnetospheric consciousness

The so called ap index measures the intensity of the fluctuations of the Earth's magnetic field. If the magnetosphere is a conscious entity, ap index can be interpreted as a measure for the level of arousal of the magnetospheric mind. The negative correlation between ap and AC performance tells that AC is most probable, when the magnetosphere is in a "calm state of mind". This is natural since only in this kind of situation the noise masks minimally the signals from the galactic magnetosphere.

The local magnetic noise produced by the modern high tech environment is much stronger than the geomagnetic noise but this does not matter. If artificial magnetic fields correspond to $k_d = 0$ level of the dark matter hierarchy, they have no effect on higher levels of dark matter hierarchy.

Is there an ELF signal from the special direction masked usually by the geo-magnetic noise?

The obvious question is why the anticorrelation between anomalous cognition effect size and ap index is highest at 13.30 ST? What this finding means that a particular portion of the sky defined by a definite longitude is above the head of a successful anomalous cognizer independently of the time of year. Thus there should be something special in a direction at this longitude.

The simplest explanation for these findings goes as follows.

1. Suppose that there is a higher level conscious entity at the direction 13.30 ST at the galactic magnetic body such that various cyclotron frequencies involved with the communications with this entity correspond to a typical time scale of the anomalous cognition. This conscious entity could have size of galaxy or it could correspond to a flux tube of galactic magnetic body using the cognizer and target as sensory receptors and motor instruments just as our magnetic body might use neurons of our brain or our body parts.

2. Anomalous cognition could involve positive and negative energy signals to this magnetic body and back so that essentially instantaneous AC events would be possible.
3. The information transfer between two kinds of flux tubes is made possible by the topological condensation of the flux tubes of B_E or its dark variant at those of the galactic magnetic field or its dark variant and would be maximal when both are nearly vertical. Also geomagnetic noise would be transferred via wormhole contacts to the flux tubes of the galactic magnetic field and perturb these communications. Both AC and its anticorrelation with geomagnetic noise would be maximal when the flux tubes of magnetic fields in question are approximately parallel. Since the flux tubes of B_E are approximately vertical, this the case when the galactic center is directly above the head. This would explain the special value of sidereal time. One can say that the magnetic flux tubes of the interstellar magnetic field define kind of cosmic umbilic cord which might serve as a correlate for the tunnel experience associated with NDEs.
4. If signals to geometric past and back are involved the time and length scales would measured using 10^5 years as unit. The signals themselves would be coded using frequencies characterizing time scales of neural consciousness as kinds of ripples to the very slowly oscillating background signal just as perturbations due to nerve pulses interfere with EEG rhythms. Since remote psychokinesis and anomalous cognition should rely on the same mechanism, the first guess for the time scale involved with these signals is as the time lag of 13 to 17 seconds involved with the remote realization of intentions by Qigong masters [J53] : the interpretation as a typical duration of charge entanglement was already proposed. It would not be surprising if the time scale of entanglement would determine also the scale of cyclotron frequencies. This would mean the importance of the frequencies in the range .06 to .08 Hz for anomalous cognition.

The following scenario suggests a possible manner to understand the time scale of remote PK.

1. If protonic cyclotron transitions generate the low frequency MEs in the range $f_1 = .06$ Hz to $f_2 = .1$ Hz, the strength of magnetic field must be in the range 13 to 17 nT (nanotesla). The magnetic flux tubes of an interstellar magnetic field in a direction with a longitude defined by 13.30 ST should be in question.
2. The ends of the magnetic flux quanta attached to structures within the inner magnetosphere co-rotate with Earth. The resulting twisting presumably tends to induce additional noise to the interstellar magnetic field or Earth's magnetic field or both.
3. The strengths of the typical disturbances of Earth's magnetic field are in the range 50-200 nT [J95] . The average strength for a given frequency component for the fluctuating part of the Earth's magnetic field increases at low frequencies. At the alpha band the strength of the Fourier component of fluctuations is about $\sqrt{B^2(f)} \simeq 1 pT/\sqrt{Hz}$ at alpha frequencies. Interestingly, the magnetic perturbation produced by brain at alpha band has a peak, which is slightly above the fluctuations of the Earth's magnetic field. This is perhaps not an accident in light of the expected role of the alpha band in remote mental interactions. The strength for the Fourier component $B^2(f)$ for the fluctuations of $B^2(t)$ [J16] is roughly $\sqrt{B^2(f)} \simeq .1 nT/\sqrt{Hz}$ at $f_2 = .01$ Hz, and about $\sqrt{B^2(f)} \simeq 10 nT/\sqrt{Hz}$ at frequency $f_1 = .06$ Hz.

What puts bells ringing is that the noise level 50-200 nT is by a a factor 4 to 15 higher than the required interstellar static magnetic field at the lower limit corresponding to the 17 second period. These findings suggests that magnetic fluctuations tend to mask the positive effect of the interstellar magnetic field on AC. Only when the strength of the fluctuations of the Earth's magnetic field at the cyclotron frequency of the interstellar magnetic field reduces sufficiently below the strength of the interstellar magnetic field, the masking effect is small enough.

What is the origin of the interstellar magnetic field?

The idea about the magnetic umbilic cord connecting distant astrophysical objects to a single quantum coherent whole is sensible in the many-sheeted space-time. The TGD based model for the galaxy formation assumes that the ordinary matter results from the decay of cosmic strings, which are objects carrying extremely strong magnetic fields (magnetic flux tubes and these objects belong to the same

solution family of field equations). These cosmic strings form a complex network. For instance, this model explains gamma ray bursters [K73] .

The huge energy production of gamma ray bursters is consistent with their huge distance only if one assumes that the energy is liberated in jets. In TGD framework the gamma ray bursts can be identified as jets resulting in the decay of split cosmic strings giving rise to the ordinary matter. The bursts are indeed known to originate in the regions, where new stars are born. This picture supports the idea about the existence of a fractal magnetic flux tube network connecting different astrophysical objects, and left as a remnant from cosmic strings, when their magnetic energy transformed to the ordinary matter and gave rise to the birth of stars. This network could give rise to galactic nervous systems in turn combining to the central nervous system of the Universe.

Surprisingly, this picture might be consistent with the constraints on the direction and magnitude of the interstellar magnetic field.

1. According to the online lecture of S. Oliver [E5] , the measured values of the interstellar magnetic fields depend somewhat on the method with which they are measured (this might be a signal of the many-sheetedness). The interstellar magnetic fields vary in the range $B_u = 1$ mGauss– $B_l = .1$ μ Gauss [E7] , which means that both electronic and protonic cyclotron time scales for all interstellar magnetic fields correspond to time scales relevant for human consciousness. The minimal values of k_d are $k_d = 53$ for B_u and $k_d = 66$ for B_l from thermal stability: .1 second time scale of alpha band is mapped to 50 s for B_u and to ~ 3 days for B_l .
2. The synchrotron radiation associated with the diffuse emission from the whole sky but concentrated towards galactic plane corresponds to a field strength $\sim .6$ nT. Zeeman splitting for hydrogen 21 cm line from condensing clouds gives fields in 1-2 nT range. In the plane of the galaxy the field is roughly parallel to spiral arms and its strength is .1-1 nT and too weak to correspond to the proposed magnetic umbilic cord. Also the direction of the spiral arm is different from the direction of the required magnetic umbilic cord.
3. The second guess is that the magnetic umbilic cord is orthogonal to the galactic plane. The direction of the galactic North Pole has the right ascension (identifiable as the sidereal time at the meridian of the rotating observer) RA=12.49 $\delta = 27.4$ degrees: RA is not too far from 13.30 so that this guess might make sense. Taking into account that the rotation axis of is tilted by 23.5 degrees towards Sun this would mean that the direction of the magnetic umbilic cord is with accuracy of 3 degrees in the plane defined by the orbit of Earth around Sun. Interestingly, the magnetic field associated with the solar wind varies in the range .2 – 80 nT and average value is 6 nT.

According to [E7] , galactic center carries a dipole like field with a strength of order 100 nT, not too far from 10-30 nT. Also this field has filament like structures (flux tubes), which might extend to long distances [E7] . The flux tubes of this field should intersect the galactic plane orthogonally. If the strength of the magnetic field inside the flux tubes stays constant rather than varying like dipole field strength, these flux tubes could give rise to the magnetic umbilic cords connecting us directly to the center of the galaxy. Galactic center, perhaps the immense black-hole region there, could be an monstrous brain having galaxy sized central nervous system! That the model for magnetospheric consciousness would generalize to the scale of entire galaxy would conform with the fractality of consciousness.

4. According to [E7] , supernova remnants are accompanied by radial filament like structures carrying magnetic field in 1-10 nT and it seems that supernova wind might carry this field around galaxy: very natural if flux tubes carry the field. According to [E5] , for individual sources such as supernova remnants like Cas A Minor, the field strength is 10-30 nT. This corresponds to the interval 5.6 to 17 seconds. That the field strength is of the same order of magnitude as the dipole field at the galactic center conforms with the idea about magnetic nervous system of galaxy connecting the center of the galaxy to the stars. This magnetic field would be easy to observe in case of supernovae because super nova explosion has packed magnetic flux tubes to a very dense bundle.

Connections with other effects?

There might be fascinating connections with other strange findings.

1. In Comorosan effect [K93] , [I59] the irradiation of a bio-matter with a laser irradiation lasting for a multiple of 5 seconds has anomalous effect on a catalyst action. 5 seconds corresponds to $n = 3$ cyclotron transition for proton in a magnetic field of 10 nT. Comorosan effect occurs also in a non-living matter and suggests that the magnetic umbilic cord serves as a kind of cosmic clock.
2. The strength of the Earth's magnetic field in far-away in the plasma sheet is about 10 nT. Could this cosmic magnetic umbilic cord be connected with the plasma sheet and be in a synchrony with what happens there? Plasma sheet is known to be highly self-organizing structure containing in the velocity distributions of charged particles features like "wings" and "eyes" [F2] . In [K42] I have proposed that plasma sheet defines the "self model" of magnetospheric brain and is thus in a role analogous to the insula in the human brain. It would rather natural for the cosmic umbilic cord to couple with that part of the magnetospheric brain which corresponds to the highest level in the self hierarchy associated with the magnetic Mother Gaia.
3. Lungs contain magnetic particles giving rise to magnetic field of about 10 nT. The theory of magnetospheric sensory representations inspires the speculation that the moment of physical death is decided by magnetospheric self sending to lungs stopping signal at proton's cyclotron frequency associated with 10 nT magnetic field.

5.6.6 DelaWarr camera

One can ask how the information about the body part is coded into the fields associated with the transversal MEs. The most naive guess is that the representation is simply a 4-dimensional photograph about body part, that is dynamical hologram, and that the DNA in the cells which express the formation of a given body part contain this kind of representation. The cells in which the genes are expressed could contain this kind of representation serving as a template and biological control command. Thus body part would contain its own image in each of its cells. The time reversal (phase conjugate) of the 4-D hologram would in turn naturally act as a time reversal of the control command and provide a universal mechanism making possible healing and self repair.

Entire hierarchy of representations in various length scales might be involved providing dynamical photographs about the planned evolution or various bio-molecules, subcellular structures, cells, etc... This sounds utterly simplistic but one can ask what else? The representation for the development body structure must be based on very simple and concrete code since the cells building it during morphogenesis are very simple creatures and see only the light telling where to go and what to do!

This naive guess might have some truth in it as following arguments suggest. In CASYS2001 symposium Peter Marcer [I104] told about the British engineer George DelaWarr built a remote imaging camera in the 1950s. Using only a test object provided from the subject such as a small blood, sputum, or hair sample, this device photographically images the subjects internal conditions at a distance, with a high degree of accuracy.

A unique feature of the DelaWarr system is claimed to be that it is able to detect diseases in the pre-clinical stages prior to detection by conventional techniques such as physical examination, X-ray, CT scan, or Magnetic Resonance Imaging. The photographs taken by DelaWarr camera were treated by Susan Benford by modern image processing techniques and she claims that these photographs contain the information needed to reconstruct three-dimensional holograms. The proposed explanation was that the test object (adjunct) contains a hologrammic representation about the patient.

The functioning DelaWarr camera looks highly mysterious even when one takes seriously the idea that DNA generates holograms of the body parts it codes for. Therefore it is better to introduce the ingredients of the model by making questions.

1. Was the intent of the photographer all that was needed and did other levels levels of the self hierarchy take care of the rest as they do when I make the decision to raise my hand? Could the intent of the photographer have generated a reference wave at some very special frequency acting on the adjunct and activating a hologram giving rise to a photograph about the desired body part or inducing a sequence of events leading eventually to the generation of the photograph?
2. Was the visible light giving rise to the photograph generated in the adjunct? Does the DNA of each cell of body and thus also of the adjunct contain electromagnetic representations for the

body parts and are these representations more or less equivalent with holograms? Certainly direct hologrammic images about body parts would provide the simplest manner to realize the field part of the genetic code as proposed.

3. Did the adjunct serve as a relay station (much like thalamus in brain) mediating the information from the patient via magnetic flux tube-ME pairs to the camera projecting it to the camera as a coherent light generating an ordinary photograph? Was the image realized as a coherent light propagating along the MEs connecting adjunct and patient serving as bridges?

5.7 The experimental work of William Tiller about intentional imprinting of electronic devices

William Tiller in Stanford University has carried out impressive experimental work with what he calls intention imprinted electronic devices (IIED), and his results challenge that standard assumption that the intentions of experimenter do not affect the experimental apparatus [J99, J100, J101] .

5.7.1 Experimental arrangement

The goal was to try to imprint a specific intention into a simple, low tech electronic device so as to influence the companion, specific, well-designed, target experiment. The intentional imprinting was attempted in a meditative state. The intentionally imprinted device, IIED, was sent to a laboratory located at distance of about 1500 miles where colleagues had set up the experiment. The device was placed about 6 inches from a continuously running and computer-monitored target experiment and switched on (total electrical power rate was less than 1 microwatt). Over a time period of about 1-4 months the recorded results from the target experiment changed in the directions of the specific intention and the change eventually reached the selected magnitude of the specific intention. Also an identical, but not intention imprinted device was used and the results were compared in order to achieve more objective measurements about the effects of human consciousness on electric devices.

The targets used were purified water, some bio-molecules, and larvae of flies. These targets were either unshielded or shielded from radiation. For the latter purpose they were closed inside a grounded Faraday cage (FC), which screened rather effectively the radiation coming at microwave frequencies whereas for ultra low frequency (ULF) fields the screening is virtually absent (skin depth behaves as $1/\sqrt{\pi\sigma f}$ at low frequencies and $f = 2\pi\sigma$ (in units $\hbar = c = 1$) defines kind of critical frequency above which screening occurs effectively). The targets could be affected by control device (CD) or by identical IIED generating microwave radiation. Radiation was generated either at single frequency (7.3 MHz) or at three frequencies (5.0, 8.0 and 9.3 MHz) [J106] .

In the case of purified water the spatial distributions of physical parameters like pH, temperature, and conductivity were measured as a function time. In the case of bio-molecules the possible effect on thermodynamical activity, which measures the thermodynamical energy of single molecule, was measured. In the case of fly larvae the effect on the larval development time was studied. The results from various arrangements were compared with control targets (no FC, no CD, no IIED).

5.7.2 Basic experimental findings

The basic experimental results were two-fold. First of all intended effects were achieved. Secondly, the "conditioning" of the laboratory resulted as an unexpected effect and continued even after the removal of the target and IIED.

Direct effects of the intentional action

1. IIED imprinted by intention to increase/decrease the pH of water gradually induced a shift in the pH of purified water to the intended value, increased the in vitro thermodynamic activity of bio-molecules, and a reduction of larval development time.
2. For bio-molecules and larvae four simultaneous side-by-side treatments were tested: i) an unshielded sample, ii) a shielded sample, iii) a shielded sample with an "on" control device, iv) a

shielded sample with an "on" IIED. Just the shielding of em radiation affected the thermodynamic activity of the bio-molecules, and just adding less than about 1 microwatt of microwave radiation via control device reduced the thermodynamical activity and lengthened the developmental time. Thus the microwave radiation acted as a stressor having entropic effect. When the control device was replaced with IIED, the degradation caused by microwave radiation was overcome.

"Conditioning" of the laboratory

Quite unexpected phenomena arose from a repeated conduct of IIED in a given laboratory space. By simply continuing to use IIED in the laboratory space, it became "conditioned in some very fundamental way". Three signatures heralded the onset of the "conditioning" process.

1. Oscillations of air and water temperature, and of pH and electrical conductivity of water with large amplitudes with the periods of oscillations in 10-100 minute range developed. The amplitudes of pH- and temperature oscillations was $\sim \Delta pH = .1$ pH-unit and $\Delta T \sim 1 - 3$ K units respectively. Even more remarkably, the oscillations were sustained in the locale even after the removal of the IIED suggesting kind of phantom effect analogous to phantom DNA effect. Oscillation amplitude had peaks at the harmonics of fundamental frequency $f_l = 1/T_l$, $T_l = 36.6$ minutes with three lowest harmonics being very clearly visible [J101]. Also $T_l = 51.2$ minutes appears as fundamental period in some experiments. The ratio of these periods is 1.4 and rather near to $\sqrt{2} = 1.41$, which might relate to p-adic length scale hypothesis.
2. When an pH-increasing IIED with intention to increase pH by one unit was turned on in an almost unconditioned space located several hundred feet away from a strongly conditioned space, a well-defined pattern of pH-oscillations in an unconditioned space emerged. This pattern was accompanied by a highly correlated pattern of oscillations in strongly conditioned space. This kind of highly correlated oscillations were not observed in several unconditioned spaces - also located several hundred feet away.
3. The targets were subject to the action of a vertically aligned magnetic field in the range of $10^{-2} - 5 \times 10^{-2}$ Tesla, such that the direction of the field could be reversed. In an unconditioned space the change of the direction of the magnetic field did not affect the pH. In the strongly conditioned space the effect on pH was different for the opposite directions of the applied field and the difference in pH values was about .6 units. One can say, that the target had become sensitive to the effects of external magnetic fields.

5.7.3 Explanation of the pH oscillations in terms of the general model of intentional action

The findings described above support the notion of magnetic body as a mediator of the intentional action, and provide a connection with the general TGD based vision about pre-biotic evolution. The following general model for the effects suggests itself.

Intentional action induces magnetic self-organization of the control device and target

The magnetic body of IIED becomes a part of the intentional agent. Also the magnetic body of the target (purified water, etc...) partially fuses with that of IIED. Even more, the general model for the pre-biotic evolution [K31] suggests that the intentional action mediated via the IIED induced a self-organization of a p-adic hierarchy of topological field quanta of magnetic field in the target system. This kind of hierarchy is associated also with DNA in the TGD based model for the effects of laser radiation on DNA observed by Gariaev [I75]. The generation of magnetic structures in shorter length scales is what one expects the intentional action to generate since intentional "growth" proceeds quite generally from long to short length and time scales.

The simplest candidate for the time scale of oscillations varying in 10-100 minute range is as the time scale associated with the cyclotron frequency of magnetic field quanta responsible for the intentional action. The cyclotron period of proton lies in 10-100 minute range for a magnetic field strength varying in the range of 27.8-278 pT. For $T_l = 36.6$ minute period the field strength would be

75.9 pT. The corresponding magnetic length is 4 mm and near to $L(188) = 3.7$ mm. The harmonics of the fundamental f_l could correspond to the quantized values of the magnetic flux coming as integer multiples of the basic flux with the strength of magnetic field quantized to integer multiples. Similar quantization of the Z^0 magnetic field strength is assumed in TGD based model of hearing [K61] .

Cyclotron oscillations in the magnetic field could induce by some mechanism a periodic flow of protons between the magnetic flux tubes and the atomic space-time sheets of water and in this manner affect pH. pH-fluctuations would in turn induce temperature and conductivity fluctuations as side effects. Both $T_l = 51.2$ min and $T_l = 36.6$ min appear and have ratio very near to $L(k+1)/L(k) = \sqrt{2}$. If this finding is taken at face value, the magnetic flux quanta must be magnetic sheets for which magnetic flux scales as the inverse of the thickness $d = L(k)$ of the flux sheet having constant size in the second transversal dimension.

Scaling law of homeopathy and frequencies of pH-oscillations and microwaves

The experiment involves two frequencies: the ULF frequencies associated with the pH-oscillations and the frequencies associated with the microwaves generated by the control device. Since intentional action compensates for the entropic effect of microwaves, these frequencies should relate to each other and generalized scaling law is an excellent candidate in this respect.

The TGD based model explains and generalizes the scaling law of homeopathy, which states that low and high frequencies having ratio $f_h/f_l = 2 \times 10^{11}$ accompany each other. Cyclotron oscillations with frequency f_l would result when charged particles drop from smaller space-time sheets and liberate the increment of zero point kinetic energy as a radiation with frequency f_h . Also the reverse of this process could occur with generation of negative energy photons at frequencies f_h and f_l . The emission of two photons is needed to guarantee momentum conservation since the momenta of charged particles are so small as compared to photon momenta.

The generalized scaling law predicts

$$f_h/f_l = \Delta E_0/E_c(k_2) ,$$

where $\Delta E_0 = E_0(k_1) - E_0(k_2)$ is the zero point kinetic energy increment when a charged particle drops from the space-time sheet labelled by k_1 to the sheet labelled by k_2 . $E_c(k_2)$ denotes cyclotron frequency at the magnetic flux tube labelled by k_2 .

The factor f_h/f_l varies but does not depend on the mass of the charged particle and by the quantization of the magnetic flux are apart from a numerical factor proportional to the ratio $p_2/p_1 = 2^{k_2-k_1}$ defined by the p-adic primes $p \simeq 2^k$ for the two space-time sheets in question. The scaling law of homeopathy in its basic form and p-adic length scale hypothesis suggest that f_h/f_l is related by a power of two to $f_h/f_l = 2 \times 10^{11} \sim (200/256) \times 2^{38}$ so that one has

$$f_h/f_l = 2 \times 10^{11} = (200/256) \times 2^n ,$$

where the integer n varies.

The generalized scaling law suggests that the frequency of pH oscillations corresponds to f_l . The frequencies of microwaves would correspond to f_h identifiable as the zero point kinetic energy of proton liberated when it drops from space-time sheet generated by the intentionally induced magnetic self-organization.

The mechanism of intentional action

The control device generates microwaves, and the intentional action should compensate the effect of the control device. The model of the intentional action based on the time mirror mechanism supports the view that negative energy MEs and photons are involved. Phase conjugation means essentially time reversal, and it could compensate the entropic effect of the ordinary microwaves generated by IIED and acting as a stressor in case of fly larvae. This also conforms with the fact that phase conjugate microwaves inside MEs can penetrate the Faraday cage.

The longitudinal Fourier expansion of the fields inside ME contains besides high and low frequency Fourier components and also constant component. The constant component represents intentional action and grows quantum jump by quantum jump to a value realizing gradually the desired effect, say change of pH.

The microwave radiation at frequencies f_h could induce a flow of protons between $k = 167$ space-time sheets and larger space-time sheets by providing the needed zero point kinetic energy to kick protons to $k = 167$ space-time sheet. Negative energy (phase conjugate) microwave photons would induce the reverse process. By the basic mechanism of induced emission (now induced dropping) this in turn could induce the flow of protons from atomic space-time sheets to smaller space-time sheets as a kind of domino effect, and lead to a new flow equilibrium would result with different pH. The pre-requisite of this mechanism is that the hierarchy of the magnetic flux tubes characterizing also DNA is present in the target. The IIED affected by the intentional action would give rise to this magnetic hierarchy unless it already exists. IIED would play a role similar to an object received by the person to be healed from the healer (or vice versa) in remote healing.

A more detailed space-time description for what happens might be as follows.

1. Constant field representing intention, ULF and microwave fields are coherently superposed inside MEs (incoherence would mean microwave MEs inside ULF MEs) so that the corresponding transversal magnetic and electric fields are precisely parallel by the highly non-linear properties of MEs. ULF frequencies correspond naturally to the harmonics of cyclotron frequency because of the strong coupling to cyclotron phase transitions of the Cooper pair Bose-Einstein condensate.
2. MEs serve as temporary bridges connecting the boundaries of $k = 169$ and $k = 188$ space-time sheets and the oscillating electric field of ME is orthogonal to the boundaries. By quantum classical correspondence the microwave frequencies associated with ME as well as the voltage along the bridge correspond to integer multiples for the energy of a microwave photon. The same mechanism based on Z^0 MEs underlies the TGD based model of nerve pulse.
3. The superposed ULF and microwave frequency electric fields inside ME induce a periodic flow of the protonic Cooper pairs forth and back between the super-conducting flux tubes of the Earth's magnetic field ($k = 169$) and magnetic flux tubes of the field B_I ($k = 188$). Microwave part induces a rapidly oscillating force superposed to the slowly varying ULF part and constant part of the force. The oscillatory flow of protons from atomic space-time sheets to larger space-time sheets affects the proton density at atomic space-time sheets causing pH oscillations.

Do the three peak frequencies for pH-oscillations correspond directly to three microwave frequencies by scaling law?

Scaling law would suggest that the three peak frequencies coming as harmonics of $f = 1/T_l$, $T_l = 51.2$ min, correspond to three frequencies f_l identifiable as cyclotron frequencies corresponding to the quantized values $n = 1, 2, 3$ for the magnetic flux. The frequencies produced by control device producing microwaves in 1-10 MHz range are non-trivial [J100, J101] and the first bet is that the frequencies given by the generalized scaling law must be in this range to compensate the entropic effects. The generalized scaling law $f_h/f_l = (200/256) \times 2^n$ with $n = 33$ gives the frequencies $f_h = 3.1$ MHz and its two harmonics 6.2 MHz and 9.3 MHz as counterparts of f_l and its harmonics. The frequencies produced by the control device are 5.0, 8.0 and 9.3 MHz and not harmonics of each other. Note however that the highest frequency corresponds exactly to the third harmonic of f_l .

Rather remarkably, $f_h = 3.1$ MHz corresponds to the zero point kinetic energy of a protonic Cooper pair at $k = 169$ space-time sheet associated with the magnetic flux tubes of the Earth's magnetic field. Thus protonic Cooper pairs could drop from the super-conducting flux tubes of the Earth's magnetic field to the magnetic flux tubes of ~ 76 pT magnetic field having $k = 188$. This in turn would generate a cascade like dropping of protons from the atomic space-time sheet so that pH is changed.

Correlation between pH and temperature oscillations and protonic zero point kinetic energy

In the case of water at temperature $T = 300$ K the amplitudes of oscillations are $\Delta T = 3$ K and $\Delta pH \simeq .1$. If the density of protons satisfies $n = n_0 \exp(-\Delta E/T)$, where ΔE is most naturally the zero point kinetic energy .4 – .5 eV of protons at the atomic space-time sheet, one has

$$\Delta pH = \frac{\Delta E}{T} \times \frac{\Delta T}{T} .$$

$\Delta pH = .1$ would require $\Delta E \simeq .3$ eV, which is quite near .4 – .5 eV.

The fact that the exponential $\exp(-\Delta E/T)$ happens to be near to the number $n/n_{H_2O} = 10^{-pH}$, gives further support for the idea that the zero point kinetic energy at $k = 137$ space-time sheet determines pH, or more generally, that the densities of various ions are determined by many-sheeted chemistry and by zero point kinetic energies. If this interpretation is correct, $n(137)$ can be identified as the net density of protons including also protons bound to hydrogen atoms. The net density of protons at a given space-time sheet involves a degeneracy of states factor $g(k)$ so that one would have

$$n(137) = \frac{g(137)}{g(169)} \times n(169) \ ,$$

where $k = 169$ refers to the super-conducting flux tubes of the Earth's magnetic field. p-Adic fractality and p-adic length scale hypothesis imply that $g(k)$ scales as $1/L^3(k)$. This gives $g(169)/g(137) \sim (L(137)/L(169))^3 = 2^{-48} \simeq 4 \times 10^{-15}$.

Sensitivity to the external magnetic field

The effect of the pH values depends on the direction of the external magnetic field B_{ext} . This could be understood if B_{ext} interferes with the magnetic field at some level of magnetic hierarchy induced by the magnetic fields in .1 nT range which mediate the intentional action. pH is changed if the change of the magnetic field at these space-time sheets in the cellular length scale range affects the flow of protons between atomic space-time sheets and larger space-time sheets when .1 nT flux tubes with thickness around 100 μm are present. This is expected to be the case if the thickness of the flux tubes is affected by the external magnetic field. The flux tubes in a given p-adic length scale could even disappear as a result of destructive or constructive interference.

Concerning the detailed model there are two options.

1. If the magnetic field consists of flux sheets so that one has $B(k) \propto 1/L(k) \propto 2^{-k/2}$. In this case the external field strength corresponds to p-adic length scale $L(k)$ related to the length scale $L(169) \simeq 5 \mu\text{m}$ by a scaling of $.5 \times 10^{-2} - 10^{-3}$ the length scale varies between $L(149) = .5 \text{ nm}$ (thickness of the lipid layer of cell membrane) and 25 nm. This option is supported at the level of DNA magnetic hierarchy by the findings of Gariaev about effects of laser light on DNA, and also by the fact that the ratio of $T_l = 51.2 \text{ min}$ and $T_k = 36.6 \text{ min}$ is very near to $\sqrt{2}$. This situation would result if the flux quanta at various p-adic length scales are quite generally obtained by scaling the flux tubes of the Earth's magnetic field in one direction by keeping the flux as constant.
2. If the magnetic field consists of flux tubes ($B(k) \propto 1/L^2(k) \propto 2^{-k}$) $L(k)$ is related to $L(169)$ by a scaling by a factor .1 - .03 so that it is in the range 1.6 - .5 μm .

Phantom effect

A further strange finding is that the removal of both IIED and target does not eliminate the temperature oscillations of the air although their amplitude is reduced by a factor of about ten. The phantom effect can be understood if the magnetic flux tubes associated with $k = 188$ magnetic field are present also in the air volume, and are not affected by the removal of IIED and target, so that the oscillatory flow of protons between $k = 169$ and $k = 188$ space-time sheets with cyclotron frequency continues and induces the oscillation of the proton density of air.

The effects on random number generators

Also the computers might be affected by the "conditioning". Tiller has tested also this [J106] and found clear evidence that this indeed occurs. In the experiment the computer produced a sequence of pseudo-random numbers in a conditioned environment with a rate of one random number per minute. Both processes produced one random number, call it n , per minute. First of all 200 bits are generated 100 times every minute.

1. The first process computes the sum of these 200 bits and calculates the average of the 100 sums resulting in this manner. One expects the average result to be $\langle n \rangle = 100$ and maximum result to be $n_{max} = 200$.

2. The second process picks the second one of the 200 random numbers and compute the sum of the hundred numbers picked up during minute. In this case the average result should be $\langle n \rangle = 50$ and maximum $n_{max} = 100$.

The Fourier transformation of the distribution of these random numbers taken with respect to real time was found to display peaks at frequency $f = 1/T$, $T = 113.778$ minutes and at its harmonics. The presence of precise harmonics is not easy to explain if random numbers are in question.

The mechanism producing the peaks could be the same as the one producing pH oscillations. The representation of the resulting random numbers involves sequence of bits and the number of bits depends on the accuracy used. Since maximum is 200 in the first case and 100 hundred in the second case, the storage of the integer parts of these numbers requires 8 bits in the first case and 7 bits in the second case. The most significant bit is often zero. Cyclotron oscillations could induce a flow of protons from atomic space-time sheets to larger space-time sheet also in the computer and in this manner affect (say) the voltage representing the zero bit so that it changes from 0 to 1 when the amplitude of oscillation is maximum and from 1 to 0 when the amplitude is minimum since the sign of the electric field is different in these two cases. This effect tends to widen the distribution of the random numbers and is enough to explain the emergence of Fourier components coming as harmonics of the cyclotron frequency.

This model predicts that the mechanism tends to increase the mean from the expected value. Consider the case when the expected mean is 100 and maximum is 200. Let $p(i)$ be the probability of the 8:th bit to be $i = 1, 0$. p_0 is the probability that the integer part of n is in the interval $(0, 127)$ whereas p_1 the probability of the random number to be in the interval $(127, 200)$. Since the probability distribution for the resulting pseudo-random numbers is Gaussian around mean value $\langle n \rangle = 100$, one has $p_1 > p_0$. Hence the flip $0 \rightarrow 1$ occurs with a higher probability than the reverse process and tends to increase the mean from $\langle n \rangle = 100$.

Of course, the realization of the mechanism depends on the precise representation of the numbers but the general expectation is that mean increases somewhat and harmonics of cyclotron frequency appear in the spectrum.

5.7.4 The effects caused by the quartz crystal

In some experiments the removal of the target and IED was followed by the addition of quartz crystal [J106]. The quartz crystal was made of natural quartz (in order to avoid undesired intentional imprinting!) and had height $h = 15.24$ cm and minimum diameter $d = h/2 = 7.62$ cm. The crystal was asymmetric in the vertical direction having apex pointing upwards.

The findings were following.

1. When the crystal was in a vertical direction, its presence sharpened the existing spatial phantom profile for temperature oscillations of air and somewhat amplified it.
2. When the crystal was turned to a horizontal direction, its presence immediately increased the temporal frequency of T-oscillations by a factor slightly larger than two. The spatial profile became first almost flat and the amplitude weakened.

The interpretation of the stimulates several ideas and questions.

Does the spatial profile of T-oscillations correspond to a standing wave resulting as an interference pattern of microwaves?

The spatial profile for the temperature oscillations is measured using spatial resolution $D = h = 15.24$ cm, where h is the height of the quartz crystal. The profile is quasi-periodic with a period of $\lambda = 2D = 2h$. Of course, experiments with a better spatial resolution would be required to deduce reliably the profile but the measurements are consistent with a spatial oscillation having period $\lambda = 2D = 2h$. This kind of profile could result as an interference of two classical microwave beams propagating in two opposite directions and generating a standing wave with wave length $2h$. This kind of interference pattern is involved with the four-wave interaction producing phase conjugate waves: the interfering waves correspond to the reference beam and a beam opposite to it. The two additional beams correspond to beam and its phase conjugate, either of them generating the other one.

Does the quartz crystal act as an amplifier?

The orientation of the crystal is obviously important. This encourages to think that the incoming signal enters from a vertical direction and is amplified by the quartz crystal so that the vertical dimension determines the resonantly amplified wave lengths. Perhaps magnetic flux tubes of B_I and the Earth's magnetic field B_E are in this direction. It could be that the light-like vacuum current of ME generates positive or negative energy coherent photons with an intensity distribution having maximum in the directions orthogonal to MEs and that the presence of the quartz crystal amplifies the vacuum current inside ME. Alternatively, it could be enough that quartz crystal amplifies the classical fields associated with MEs.

The height h of the quartz crystal is one half of the microwave wavelength. Hence it could act like an absorbing or emitting half wave antenna. The fundamental frequencies associated with the microwaves would correspond to $f_1 = c/2h \simeq 1$ GHz for the vertical crystal and $f_2 = c/2d = 2f_1 \simeq 2$ GHz for the horizontal crystal. For the vertical crystal $\lambda_1 = 2h = 2D = 30.48$ cm would be the wavelength of the spatial profile which conforms with observations. For the horizontal crystal period would be $\lambda_2 = 2d = 15.4$ cm. The observed spatial profile immediately after the turning of the quartz crystal to horizontal position is flat in consistency with this prediction. It should be easy to check out whether the oscillatory pattern is present by improving the resolution.

Are population inverted many-sheeted masers involved?

The frequencies f_1 resp. $f_2 = 2f_1$ are rather near to the zero point kinetic energies of a protonic Cooper pair for $k = 153$ resp. $k = 152$. In the case of electronic Cooper pairs one has $k = 164$ and 163 (the ratio of proton and electron masses is near to a power of 2: $m_p/m_e \simeq 2^{11}$). Perhaps many-sheeted population inverted micro wave lasers are involved and time mirror mechanism induces dropping of protons to large space-time sheets or the reverse process. $k = 152$ and $k = 153$ correspond to length scales $\sqrt{2} \times L(151)$ and $2 \times L(151)$, where $L(151) = 10$ nm corresponds to the thickness of the cell membrane. The four-wave interaction suggested by the interpretation of the spatial profile would presumably involve many-sheeted laser mechanism at the microscopic level.

Scaling law of homeopathy is satisfied

The approximate doubling of the ULF frequency of T-oscillations when the quartz crystal is turned to a horizontal position is consistent with the generalized scaling law of homeopathy. The ratio f_h/f_l of frequencies of microwave and ULF oscillations occurring at 51.2 min period is 3.1×10^{12} for $f_h = f_1$ and 6.2×10^{12} for $f_h = f_2$. In a good approximation this ratio differs by a factor 2^4 resp. 2^5 from $f_h/f_l = 2 \times 10^{11}$.

5.7.5 Relating Tiller's hypothesis to TGD framework

Tiller makes the hypothesis that intentional action induces a transition of the system to a new phase in which $U(1)$ gauge group of electromagnetic interactions is extended to $SU(2)$ of electro-weak interactions. In this phase magnetic monopoles would be present besides ordinary charges. Although this proposal sounds rather far-fetched, it has an analog in TGD framework.

Are electro-weak and color symmetries exact for classical gauge fields in living matter?

In TGD $SU(2)_L \times U(1)$ gauge symmetry could be exact at the level of *classical* electro-weak fields above cell length scale since the classical electro-weak fields are indeed long ranged and become important in biological length scales. This predicts exotic phenomena such as charge entanglement made possible by classical W^\pm fields. Also classical color fields unavoidably accompany any classical em field. The color associated with color rotational degrees of the freedom of space-time sheet could be also important and analogous to rigid body angular momentum. TGD based model of color qualia relies on classical color fields.

Classification of phases of matter by the dimension of CP_2 projection

The proposal of Tiller relates interestingly to the classification of the phases of matter according to the dimension D of the CP_2 projection of the space-time sheet. This classification emerges naturally in the

study of the general solutions of field equations when one assumes that absolute minimization of Kähler action corresponds to second law so space-time sheets correspond asymptotically to self-organization patterns for which Lorentz four-force representing dissipation vanishes. $D = 2$ is analogous to a ferromagnetic phase consisting of simple magnetic flux tubes. $D = 3$ is analogous to a critical spin glass phase between magnetized and de-magnetized phases, is possible only in a finite temperature range, is highly complex but organized, and corresponds to the living matter. $D = 4$ corresponds to the chaotic demagnetized phase and "dead" matter.

For $D = 2$ the induced gauge fields are Abelian and both electro-weak and color holonomy groups reduce to $U(1) \times U(1)$. For $D = 3$ electro-weak holonomy group is the electro-weak group itself whereas color holonomy group is $U(2)$ or $SU(3)$. Classical color fields would be essential for the colors as qualia (sounds like a joke at first). $D = 3$ is indeed the minimum dimension of CP_2 projection allowing color vision whereas black-white vision is possible for $D = 2$ as has been found already earlier.

Does intentional action generate wormhole magnetic fields and homological monopoles?

TGD allows pseudo-monopoles (having no meaning in single sheeted space-time) as wormhole throats through which magnetic flux flows between space-time sheets. An extremely small dipole of magnetic charges defined by the wormhole throats at a distance of about CP_2 length is in question. At a given space-time sheet the structure gives rise to a radial magnetic field in the immediate vicinity of the wormhole throat.

The homological magnetic monopoles could be common in condensed matter systems in many-sheeted space-time (note however that also join along boundaries bonds can mediate the magnetic flux between space-time sheets). Magnetic flux tubes in superconductors might well flow to larger space-time sheet via this kind of throats. Also ferromagnets could feed their flux to larger space-time sheets through wormhole contacts. Solar magnetic fields are modelled using this concept in [K72]. The detection of the homological monopoles could be regarded as a direct support for the many-sheeted space-time, for the notion of homological monopole, and thus for the physical reality of the imbedding space $H = M_+^4 \times CP_2$. There is quite recent experimental evidence for magnetic pseudo-monopoles [D8] in condensed matter systems suggested also theoretically in [D18]. These monopoles are however monopoles of the Berry phase connection in momentum space so that they need not have anything to do with homological monopoles.

The magnetic self-organization by intentional action could involve creation of wormhole magnetic field consisting of pairs of positive and negative energy magnetic flux quanta: at least this is energetically an optimal mechanism. The flux between the two sheets flows along wormhole contacts acting as effective magnetic monopoles. In [K65] I have proposed that the changes in the qualitative character of EEG in transitions to altered states of consciousness involving emergence or disappearance of EEG bands might relate to the generation or disappearance of wormhole magnetic fields. New bands would emerge when charged particles dropping to the newly emerge magnetic flux tubes drop to ground state by cyclotron radiation in the EEG band in question.

5.7.6 A model for the findings based on hierarchy of large Planck constants

The hierarchy of Planck constants suggests an improved and conceptually simpler model for intentional imprinting. Basic ideas are however more or less the same as above.

1. The intentional imprinting means that flux tubes connecting the electronic device with mediators magnetic body are formed. The length of these flux tubes corresponds to the cyclotron time scale, which is between 10-100 minute time scale, which gives could idea about the size scale of the layer of the meditator's magnetic body involved.
2. IIED acts on the target by sending microwave photons part of which travel along the flux tubes to the magnetic body of the meditator as dark photons and are reflected back as negative energy phase conjugate photons and travel now to the target where part of them are transformed to negative energy microwave photons and part induces oscillations in time scale defined by the length of flux tube. This explain pH oscillations and their time scales. Negative energy microwave photons in turn have a syntropic effect compensating for the entropic effect of ordinary positive energy microwave photon generated by the control device. This explains the increase of the thermodynamical activity of bio-molecules and the shortening of the development time

of larvae. One can say that the system affecting the target is not IIED but the system IIED + mediator's magnetic body.

3. The values of Planck constant involved correspond to the ratios of times scales 10 – 100 minutes to the time scales of microwave frequencies 5,8, 9.3 MHz. Order of magnitude is in the range $r = 3 \times 10^{10} - 5.4 \times 10^{11}$. The scaling law of homeopathy claims that $r = 2 \times 10^{11}$ is a preferred value of this ratio.
4. The conditioning of the laboratory can be also understood. In the new unconditioned position the IIED sends microwave photons to the magnetic body of mediator and this sends part of them to the previous target so that synchronized oscillations result. The flux tubes from the magnetic body to the target continue to exist also after the removal of IIED. It is not clear to me whether the effect is present also when IIED is not functioning in the new position. One can of course imagine that the flux tube connection continues to carry large \hbar photons even after the removal of the target and the frequency is determined by the length of flux tube. This would mean that the target would possess a primitive analog of EEG.
5. The action of vertically aligned magnetic field with strength in the range $200B_E - 1000 \times B_E$ could be understood in terms of topological condensation of flux tubes of this field to vertical flux tubes of the magnetic field connecting the target and IIED to the mediator's magnetic body. The wormhole contacts would affect the value of this magnetic field in a manner depending on the direction of the magnetic field and also transmit the magnetic noise associated with the flux tubes of this field. Situation could resemble that encountered in the explanation of the correlation between anomalous cognition and sidereal time.
6. The effects on number generators would rely on a similar mechanism. The dark cyclotron frequency associated with the magnetic flux tubes connecting computer to the magnetic body of the mediator and corresponding to a period of 113.778 minutes would induce the deviation from the random behavior. Planck constant would be $\hbar/\hbar_0 \simeq 1.3 \times 10^{10}$ for 5 MHz microwave radiation in this case. The mechanism inducing bit flips could rely on low energy dark photons with large Planck constant but energy above thermal threshold. Dark frequencies above 10^2 Hz would correspond to ordinary IR frequencies and define photon energies above thermal threshold. The 1 kHz frequency characterizing synchronous firing of neurons might be involved.

5.8 Formation of holograms by time mirror mechanism as a key mechanism of intentional action?

The findings of Tiller suggest that four-wave interaction [?]r its suitable generalization could provide a basic mechanism of intentional action. In this section this proposal is discussed in detail. The basic statement is that probe and conjugate waves are responsible for the remote metabolism allowing to build the hologram which only in a special case reduces to a standing wave formed by reference beams. In general case the hologram corresponds to a synchronously oscillating field pattern, say an "energy eigen state" of a super-conducting order parameter or plasma wave pattern at plasma resonance frequency.

5.8.1 Four-wave interaction as a mechanism of intentional action

There are however several open questions about four-wave interaction. Could four-wave interaction or its generalization provide a deeper understanding of the scaling law of homeopathy? Could the basic function of probe and conjugate beams be the amplification of the standing wave interference pattern by remote metabolism? Does the standing wave formed by the reference beams serve as a kind of standardized hologram? Is it possible to generalize the notion of hologram in order to get rid of the reference beams?

Are probe and conjugate beams responsible for remote metabolism needed to construct standardized holograms?

The standing wave interference pattern represents a synchronous oscillation of the entire system and would be an excellent physical correlate for the ability of living organisms to act as coherent wholes. The standing wave resulting as the interference pattern of waves propagating in opposite directions would serve kind of a standardized hologram parameterized by the wavelength λ_h . The interference pattern can be also kicked into a motion by Lorentz boost, and the propagation velocity of the interference pattern is an additional characteristic of the pattern.

Probe and phase conjugate beams in four-wave interaction could in turn be interpreted in terms of remote metabolism. System sends negative energy MEs to the geometric past and receives as a response positive energy MEs, and amplification can occur in this process so that negative energy signal serves only a role of control signal. Its generation would utilize the energy provided by the remote metabolism. The emission of negative energy ME would switch on the positive energy laser of the geometric past generating probe beam. The energy source could be system in its geometric past or some system in the environment.

Scaling law and the role of low frequency MEs as inducers of moving standing wave patterns

The degenerate variant of the four-wave interaction does not require low frequency field components. A more general variant involving also them would allow also moving interference patterns so that pattern could represent parameters: f_h and velocity v . This leads to a new interpretation for the scaling law of homeopathy involving the excitations moving with low velocity.

Suppose that the light-like four-momentum vectors of the opposite reference beams are slightly different, such that the frequencies are $f_1 = f_h + f_l$ and $f_2 = f_h - f_l$. In this situation the interference pattern can be regarded as a Lorentz boost of the pattern at rest and thus moves with a finite velocity $v = x/\sqrt{1+x^2}$, $x = f_l/f_h$. If f_l comes as harmonics of a cyclotron frequency, the velocity is quantized for given f_h and coming as powers of 2 if zero point kinetic energy is utilized as metabolic energy.

The simplest realization of the Lorentz boost would be as quantum jump giving a boost to the entire field pattern representing standing wave and somehow the interaction of low frequency ME with the space-time sheet representing standing wave should realize this boost. The boost would result in the direction of standing wave only if f_l ME has momentum in this direction and the velocity would be $(f_l/f_h)\cos(\theta)$, where θ is the angle between f_h and f_l ME. For the spatial patterns of T-oscillations in air the maximum value of the velocity would be $v = (f_l/f_h)c \simeq 1$ mm/s. For the detected T-oscillations the spatial pattern does not move. The interpretation would be that vertical ULF MEs are in a good approximation orthogonal to the horizontal microwave MEs.

A moving pattern could result also in other manners: in stimulated Brillouin scattering generating also phase conjugate waves, the moving pattern corresponds to classical sound induced in TGD Universe by driving Z^0 ME.

What the interference of reference waves really means?

What the interference of reference beams actually means, is not at all trivial question. TGD allows imbedding of standing wave interference patterns as space-time surfaces [?]ut for these field patterns Lorentz 4-force vanishes only modulo effects caused by the classical gravitation so that in a strict sense they do not correspond to asymptotic self-organization patterns.

A less probable possibility is that the interference pattern is not a field pattern at all but a hologram resulting as a response to the presence of two MEs which are spatial mirror images of each other and represent field patterns moving in opposite directions. The force experienced by particles at material space-time sheets could be mediated by wormhole contacts and in a good approximation superposition of forces generated by MEs, and would thus create same effect as genuine standing wave.

5.8.2 Plasma oscillation patterns as generalized holograms

Standing wave pattern is the quintessence of a hologram. Probably everyone has childhood memories about swinging a rope. Suddenly it requires hardly no effort to keep the oscillation going on and it is difficult to say whether the rope moves or not.

The interference of two reference waves is only one manner to achieve a standing wave pattern and there is no need to stick to the idea that reference beams are necessary to produce the pattern. What is essential is that there is a synchronous spatial oscillation present. A moving standing wave represents kind of elementary hologram: the information content is coded by the wavelength and velocity of propagation for the interference pattern.

One can go however to other extreme and ask how one might achieve maximal representational power. This obviously requires that the frequency of the Fourier components of the wave does not depend on the wave vector at all:

$$f(k) = f_p = constant . \quad (5.8.1)$$

Plasma oscillations, which correspond to density oscillations of the number density associated with a given ion, have this property. The plasma frequency is given by

$$\omega_p \equiv 2\pi f_p = \sqrt{\frac{q^2 e^2 n}{\epsilon_r m}} , \quad (5.8.2)$$

where n is the number density of ions, q is the charge of the particle using e as a unit, m is its mass, and ϵ_r is the relative permeability. Each ion is characterized by its own plasma frequency.

Examples of plasma oscillations

There is extremely rich palette of plasma oscillations in living matter.

1. Every biologically important ion, such as Ca_{++} , Na_+ , K_+ , Cl_- defines its own plasma frequency. During nerve pulse various plasma frequencies vary but the variation is slow in the time scale defined by the plasma frequency. This would provide a further reason for why ions are so important for the living matter. Also ionosphere and entire magnetosphere contain plasma which supports earlier vision about magnetosphere as a living system.
2. Since atomic nuclei are completely ionized Z^0 ions, every atom and molecule is characterized by a plasma frequency possibly modified by the neutrino screening which can be characterized in terms of Z^0 dielectric constant. Rather remarkably, the Z^0 plasma frequency $f_Z(H_2O)$ of water corresponds to the energy .44 eV, which is the fundamental metabolic energy quantum so that basic metabolism could be related to the formation of holograms defined by Z^0 plasma oscillation patterns of water molecules. Z^0 plasma frequencies are associated also with the electromagnetically neutral matter.
3. Each space-time sheet has its own plasma frequency for every charged particle present at it. Strict p-adic fractality predicts that the densities of the charged particles scale as $n \propto 1/L^3(k) \propto 2^{-3k/2}$ for 3-dimensional structures, which would mean that plasma frequency would scale as

$$\frac{f_p(k)}{f_p(k_0)} = 2^{3(k-k_0)/4} , \quad (5.8.3)$$

so that plasma frequencies would come as 1/4:th octaves. One can consider also structures which are effectively d=1- or d=2-dimensional (say cell membrane). In this case the plasma frequencies would come as

$$\begin{aligned} \frac{f_p(k)}{f_p(k_0)} &= 2^{(k-k_0)/4} \text{ for } d = 1 , \\ \frac{f_p(k)}{f_p(k_0)} &= 2^{(k-k_0)/2} \text{ for } d = 2 . \end{aligned} \quad (5.8.4)$$

For 1- and 3-dimensional structures plasma frequencies can correspond to zero point kinetic energies coming as powers 2^k if $k - k_0 = n \times 4$ is satisfied so that the preferred p-adic length scales would come as powers of 4. For $d = 2$ the condition is $k - k_0 = 2$. Both lipid layers of cell membrane and cell membrane itself satisfy this condition.

Metabolic synchrony

The condition that plasma frequencies correspond to zero point kinetic energies, quantizes the values of the ion densities for which time mirror mechanism allows to build plasma oscillation patterns. Ionic system becomes "living" only for quantized values of the ion density. This quantization could play a role in bio-control. The variation of neutrino densities responsible for the screening of the Z^0 charge provides one manner to control particle densities.

Ions with charges q_i and masses m_i can utilize the same metabolic source if the ratio of their number densities satisfies the condition

$$n_i = \frac{m_i}{q_i^2} \times n_0 \quad (5.8.5)$$

holds true. For instance, Na_+ and Mg_{++} have $A=22$ so that the condition gives $n(Na_+) = 4n(Mg_{++})$. K_+ and Ca_{++} have $A = 39$ and $A = 40$ so that one would have $n(K_+) = 4 \times \frac{39}{40} \times n(Mg_{++})$.

A more general condition for the metabolic synchrony is that the number densities satisfy the condition

$$n_i = 2^{n_i} \times \frac{m_i}{q_i^2} \times n_0, \quad (5.8.6)$$

where n_i is an integer. Now the metabolic sources correspond to different space-time sheets.

Since nuclei are completely ionized Z^0 ions and Z^0 charge is in good approximation determined by the neutron number $A - Z$, metabolic synchrony requires in this case

$$n_i \simeq 2^{n_i} \times \frac{A_i}{(A_i - Z_i)^2} \times n_0, \quad (5.8.7)$$

The densities would be in a reasonable approximation inversely proportional to neutron number if same metabolic source is used.

Plasmoids as life forms

The idea about plasma oscillation patterns as generalized holograms and symbolic representations provides a further support to the idea that plasmoids consisting of magnetic flux tube structures plus ions define primitive life forms. The original motivation for the idea came from the notions of magnetic body, universal metabolism based on zero point kinetic energies, and some experimental findings which deserve to be discussed in the recent context.

1. The first strange empirical finding that I learned of was the discovery that the velocity distributions of electrons in the plasma sheet at the night side of the Earth's magnetosphere contained features like "wings" and "eyes" [?] Note however that velocity distributions are in question, and it is not clear how directly they correlate with plasma waves at plasma frequency.
2. Towards the end of the year 2003 came the finding that plasmoids created in laboratory have basic characteristics usually assigned to living systems [?] Plasma oscillation patterns as primitive symbolic representations of external world would be a further characteristic of this kind. Time mirror mechanism would also make possible primitive memory and intentional behavior (also plasmoids have magnetic bodies).
3. The findings of Kozyrev [?] have natural explanation terms of phase conjugate waves associated with plasma oscillations at magnetic or Z^0 magnetic flux tube structures of astrophysical size. One certainly cannot over-emphasize the importance the possibility of of quantum coherence in astrophysical length scales.
4. The spatial T-oscillation pattern of air discovered by Tiller could correspond to either em plasma oscillations of protonic Cooper pairs or to Z^0 plasma oscillations of water.

Protons are favored for obvious reasons. The scaled down electromagnetic plasma frequency for proton Cooper pairs is $f_p = 2^{-3(k-137)/4} \times x \times f_Z(H_2O)$, $x = (3e/2g_Z)$ and $f_Z(H_2O) = 1.45 \times 10^5$

GHz and should be equal to $f_p \simeq 1$ GHz suggested by the properties of the spatial pattern of T-oscillations. This gives $2^{3\Delta k/4} \simeq 10^5$ implying $\Delta k = k - 137 = 22$ with the error of 8 per cent so that the plasma oscillations of proton Cooper pairs should occur at $k = 159$ space-time sheet.

For the Z^0 plasma frequency $f_Z(H_2O) = 1.45 \times 10^5$ GHz of water the scaling $2^{3\Delta k/4} \sim 1.45 \times 10^5$ is required to get $f_p \simeq 1$ GHz. $\Delta k = 23$ gives a correct result with a 7 per cent error. Since $k = 169$ is the space-time sheet at which the nuclei feed most of their Z^0 electric gauge flux, this would give $k = 169 + 23 = 192$ whereas $k = 188 < 192$ is the space-time sheet of magnetic flux tubes supported by Tiller's findings. This option does not look realistic.

5. Crop circles [?]ight provide the most fascinating example of plasma wave patterns. Symbolic representations of "sacred geometry" based on rational numbers, some simple algebraic numbers, and π could be in question, and identifiable as an attempt to communicate about the fundamental importance of rational numbers and their extensions defining finite extensions of p-adic numbers concerning the understanding of cognitive consciousness [?]

There are strong indications that the circles are produced by microwaves, and BOLs ("balls of light") have been repeatedly reported in the vicinity of circles [?] Plasmoids would naturally generate the microwaves and the geometry of the crop formation would reflect the geometry of the plasma pattern at some larger space-time sheets. The scale of the smallest microwave patterns is about 15 cm and same as for Tiller's T-oscillation patterns for 2 GHz oscillations. That the same space-time sheets would be responsible for the smallest crop circle structures and T-oscillation patterns provides support for the general vision. The largest crop formations have a size of about 100 m. $\lambda = 75$ m corresponds to $f = 4$ MHz and $k = 171$ assuming that protonic Cooper pairs are responsible for these structures. The magnetic flux tubes of Earth having $k = 169$ would correspond to $\lambda \sim 27$ m.

In the chapters [?] rather radical proposal, which could have been inspired by Kozyrev's findings besides Chilbolton and Crabwood crop formations [?, ?] that crop circles could correspond to the communications of the descendants of human kind or of highly self-organized magnetic or Z^0 Mother Gaia from the geometric future of Earth.

5.8.3 Nerve pulse generation and holograms

The model for the nerve pulse generation discussed in [?]ssumes that nerve pulse is generated by Z^0 ME connecting the boundaries of space-time sheets and drifting along the axon in such a manner that the effective phase velocity of the Z^0 field pattern is reduced to the nerve pulse velocity. Four-wave mechanism suggest a modification of this mechanism involving interfering Z^0 microwaves acting as reference waves running in opposite axonal directions, and having frequencies differing by twice the frequency characterizing rate of nerve pulses plus transversal probe and conjugate Z^0 MEs containing also the frequencies f_l responsible for remote metabolism.

Is f_l variable or not?

The simplest possibility is that f_l corresponds to a single fundamental frequency and only the angle θ is a variable parameter. The guess $f_l \simeq 1$ kHz promotes itself as the basic frequency of neuronal synchrony and as the time scale for the duration of the nerve pulse. The spatial length per single the nerve pulse in a long axon is about $L = vT_p$, where T_p is the time interval between nerve pulses. Nerve pulses naturally correspond to the maxima of the standing wave so that $\lambda_h = L$ is a natural identification and gives $v = \cos(\theta) \times f_l \lambda_h = \cos(\theta) \times f_l v T_p$ giving $\cos(\theta) = T_l/T_p$ but leaving the value of v free. $v = x \times 10$ m/s and $T = 2$ ms give $f_h = 15/x$ GHz which represents an upper bound for this value of conduction velocity. For this option the angle θ would be the only control parameter and would control both the conduction velocity and frequency of nerve pulses.

It is of course possible that f_l could be varying and expressible as harmonics of some fundamental frequency f_0 . $f_0 = 10$ Hz is the most natural guess since 20 Hz defines the lower bound for audible frequencies and 10 Hz is the alpha frequency beginning to dominate in the absence of sensory input.

Two manners to achieve rate coding

Rate coding could result in two manners.

1. Rate coding could rely on the dependence of the angle $\cos(\theta)$ on the intensity I of the sensory stimulus: the stronger the stimulus the smaller the value of θ . Nerve pulse rate cannot correspond directly to $\Delta f_h = f_l \cos(\theta)$ but would relate to it in a statistical manner like the rate for hopping between the states of bi-stable system relates to the frequency of the driving force in stochastic resonance (for the possible role of the stochastic resonance in nervous system see [?]).
2. If f_l can have also the harmonics of the fundamental frequency as preferred values, as one might expect if cyclotron frequency is in question, the experienced intensity of the stimulus would be constant and change in a stepwise manner every time when the frequency f_l is replaced by its next harmonic. In this case 1 kHz frequency would represent upper bound for f_l . $f_0 = 10$ Hz could define the value of f_l producing no stimulus and $f_l \leq 1$ kHz would correspond to maximal alertness. If various frequencies are in one-one correspondence with memetic code words, 64 frequencies are needed and maximum value would correspond to 650 Hz.

Is the pulse rate quantized?

There is some evidence for the quantization of the experienced stimuli [?] When over-learning occurs in tasks involving temporal discrimination, the memory images about the intensity of sensation as a function of stimulus deviates from smooth logarithmic form in small scales by becoming a piecewise continuous function [?] such that the plateaus where response remains constant are octaves of each other. This suggests that the memory image about the sensation depends only on the 2-adic norm of the 2-adic image of the ratio I/I_0 of the intensity of the stimulus to the threshold stimulus under canonical identification. There two two explanations.

1. For fixed value of θ the integer valued function $\log_2(|I/I_0|_2)$ would correspond directly to the harmonics of the frequency f_l/f_0 determining the rate of nerve pulses,
2. $\cos(\theta)/\cos(\theta_0)$ can have only integer values: geometrically this would mean that the x-axis projection of the allowed points of a unit circle would be integer-valued using $x_0 = \cos(\theta_0)$ as a unit. This option makes sense from the point of view of p-adic physics of cognition and intention.

The identification of the standing wave in the case of nerve pulse

There is a considerable freedom concerning the identification of the standing wave representing nerve pulse hologram and there could be (and probably are) several representations since space-time is indeed many-sheeted. The frequencies involved are below $15/x$ GHz for $v = x \times 10$ m/s if one takes the previous estimate seriously.

Z^0 plasma waves are one possible candidate for the standing waves in question. Using value of Z^0 plasma frequency for water, $x = 1$ gives $\Delta k = 17$ giving $k_{min} = 186 < 188$. If Cooper pairs of protons correspond to the plasma waves, one would have $\Delta k = 16$ and $k_{min} = 153$. The variation range for k is $(k_{min}, k_{min} + 7)$ from the assumption that the range for frequencies f_l is $(7, 10^3)$ Hz.

The order parameters characterizing macroscopic quantum phases are good candidates for quantum holograms. In the case of super conductor the stationary states of the complex order parameter characterizing BE condensation to a given quantum state would define holograms since there is a complete synchrony in the spatial degrees of freedom.

The first variants for the model of nerve pulse were based on the idea that the solitonic Josephson currents associated with the system defined by the Josephson junctions between the lipid layers of the cell membrane could cause the nerve pulse. It became however clear that solitonic Josephson current is too weak for this purpose. One can however consider the possibility that Josephson currents have a representative role. Idealizing the Josephson junctions with a single continuous Josephson junction between the lipid layers, the Sine-Gordon for the phase difference over Josephson junction reads as

$$(\partial_t - qeV)(\partial_t \Phi - qeV) - \nabla^2 \Phi = -m^2 \times \sin(\Phi) . \quad (5.8.8)$$

Here qe is the charge of the super-conducting charge carrier, V denotes the membrane potential ($eV \simeq .05$ eV), and m is a parameter with dimensions of mass and determined by the details of the Josephson junction. V corresponds to membrane potential and is slowly varying.

The right hand side represents a very rapidly oscillating source term, which can be neglected in the lowest approximation and treated as a source term giving rapidly oscillation corrections to the basic lowest order approximation. Since the time scale of oscillations is $T = 2\pi/eV \simeq .8 \times 10^{-13}$ s, the variation of the membrane potential during the nerve pulse can be treated as an adiabatic variation. In the adiabatic approximation $\partial_t \Phi_0 = qeV$ the solutions are standing waves

$$\Phi_0 = qe \int V dt + kz . \quad (5.8.9)$$

Thus the phase factor $\exp(i\Phi) = \exp(i \int eV dt) \exp(ikz)$ represents a standing wave. The wavelength $\lambda = 2\pi/k$ should correspond to the wave length $\lambda = vT$ associated with the nerve pulse.

Intentional action, memory, and holograms

The detailed realization of intentional action at brain level could involve generation of holograms involving synchronous oscillation of the brain region, and gradual quantum jump-by-quantum jump evolution of constant components of electric and magnetic field inside MEs responsible for the control of ion flows between space-time sheets in turn responsible for their concentrations. Standing waves and there moving variants would be one possible manner to realize the holograms.

The negative energy signals to the geometric past would make possible association mechanism in geometric past as a completion of a piece of hologram to a full hologram. Negative energy signal would correspond to only a part of the neural pattern representing the entire memory and would induce in the geometric past the generation of the entire memory mental image communicated back to the geometric future. This would make it un-necessary to do use brain capacity to store associations of past. This could be of utmost importance also for the realization of motor actions: only an incomplete signal to the geometric past would be needed to realize a complex motor action.

5.8.4 Generalized four-wave interaction in relation to some other anomalies

Four-wave interaction combined with time mirror mechanism might explain many seemingly unrelated anomalies.

1. The standing wave patters associated with rotating magnetic systems and accompanied by magnetic wall structures [?]ould also be involved with the four-wave interaction and remote metabolism explaining the claimed over unity energy production in these systems.
2. Four-wave interaction could explain Kozyrev's findings about three signals coming from distant astrophysical objects [?] one signal from the future, one from the past, and one effective signal travelling with infinite velocity. The negative energy signal from the geometric future would be accompanied by a positive energy signal from Earth to the object and instantaneous "signal" would correspond to the standing wave representing the interference pattern of reference beams.
3. The phantom effects it Tiller's experiments relate to pH, temperature, and conductivity. One can however ask whether there is any evidence for mechanical phantom effects. The Russian physicist N. A. Kozyrev has indeed demonstrated mechanical "after-effects" caused by the presence of what he calls irreversible process, typically an vibrating torsion pendulum [?]

The experiments of Kozyrev deserve a more detailed discussion. In the experiments with a vibrating torsion balance, the forces at the support points did not disappear even when the vibration had ceased. The effect did not depend on the mass of the body but was dependent on its density. Most significant effects resulted for porous materials. According to Kozyrev: "Also when a system which had been in the vicinity of a periodic process and then brought to a torsion balance, yielded the same effect on it as the process itself... aluminum showed no memory. The largest memorizing effect for processes of both signs has been shown by sugar".

These findings bring in mind poor Donald Duck who once again has run over the verge of the cliff and defies the force of gravity until he realizes how Newtons's laws require him to behave. The second reminiscence is a personal experience. I love swimming and spend long times in sea during summer

time. In windy days, completely free floating with empty mind is especially enjoyable. When I return to shore, the experience about being in free floating motion continues for long time after swimming.

The general model for the formation of conscious holograms could explain also the continuation of oscillatory force response in the support points of the torsion pendulum when the oscillation itself has ceased. Every physical system has magnetic body, also the system consisting of torsion pendulum and the support for it. Brain has tendency to entrain to various kinds of oscillations. The entrainment is based on magnetic homeostasis implying that the values of local magnetic fields at some space-time sheets change so that cyclotron frequencies for some ions become equal to the entraining frequency. Same is expected to happen in the case of support system of the torsion pendulum. Also the well-known tendency of clocks to synchronize could be based on the direct contact of magnetic bodies of these systems and thus be an example of learning in its simplest form.

In the case of Tiller's experiment cyclotron oscillations induce pH-, T-, and σ -oscillations and even oscillations in series of pseudo-random numbers produced by a computer by inducing the flow of protons from magnetic flux tube to larger space-time sheets and back. Forced oscillations for the support of the pendulum induced by cyclotron oscillations of the magnetic body of the support system would be the desired item representing mechanical phenomenon in this list. In Tiller's experiments the oscillations continue when IIED and water sample are removed: in Kozyrev's experiments force oscillations in the support continue after the removal of the pendulum. The reason would be that magnetic body does not react so rapidly as physical body and can preserve the sensory memory hologram about oscillations by utilizing time mirror mechanism and generalized four-wave interaction.

When an object which has been in the vicinity of the oscillating system is brought near to the support system, the oscillatory force appears. This would be the counterpart for the conditioning induced by IIED in Tiller's experiments. The magnetic body of the support system would fuse with the part of the magnetic body of the "learned" system that has become entrained with the oscillations.

One can apply the model inspired by Tiller's observations at quantitative level.

1. Porosity favors the effect. Therefore the entrainment could occur dominantly with the mediation of the acoustic waves created by the oscillating pendulum. The learning is most effective when sound oscillations spend maximal time in the material. The sound waves are indeed caught in pores of the porous material: this is the reason why porous materials are used to absorb sound.
2. Plasma wave holograms at super-conducting space-time sheets are the best candidates for the symbolic representations of the oscillations associated with the support system. A pair (f_h, f_l) of high and low frequencies is involved. In accordance with the scaling law of homeopathy, the ratio of these frequencies defines the velocity of the moving standing wave pattern via the formula $v/c = f_l/f_h$ resulting when the reference waves with frequencies $f_h + f_l$ and $f_h - f_l$ move in opposite directions have frequencies. f_h is the frequency of the probe and conjugate waves making possible to get the energy needed by the formation of the hologram by utilizing time mirror mechanism.
3. In the recent case f_l is naturally the vibration frequency of torsion pendulums since the pendulum induces acoustic oscillations with the same frequency f_l and its harmonics. v is sound velocity in the air filling the pores of the material. This fixes f_h completely: $f_h = f_l \times (c/v)$.

f_h must be the plasma frequency f_p of protonic Cooper pairs at some non-atomic space-time sheet of air. The magnetic body might be able to vary the protonic Cooper pair density n in order to tune to the plasma frequency $f_p = (e/\pi)\sqrt{n/m}$ so that it coincides with f_h . The simplest manner for the magnetic body to achieve this is to change the local thickness of the flux tube so that charge density and also magnetic field intensity changes.

f_h must also correspond to a zero point kinetic frequency of some particle so that the oscillations can occur by time mirror mechanism using remote metabolism based on the dropping of particles to larger space-time sheets from some space-time sheet in p-adic length scale hierarchy. Since three conditions must be satisfied, the effect favors certain oscillation frequencies f_l of the pendulum.

4. A concrete example helps to get some perspective to the problem. For sound velocity $v = 300$ m/s and $f_l = 1$ Hz, one would have $f_h = 1$ MHz and radio wave with wavelength of $\lambda = 300$ m. The protonic plasma frequency corresponds roughly to p-adic length scale $L(k = 168) \simeq 3.5$

μm , whereas the magnetic flux tubes of the Earth's magnetic field correspond to $k = 169$. It might be that for suitable sizes of pores also the sound resonances inside pores couple to plasma oscillations: this would however require very special conditions to be satisfied. For millimeter sized pores the lowest resonance frequency would be around .3 MHz.

5.9 How to test the basic vision?

In the following some proposals for testing the basic vision are discussed. Possible tests distinguishing between remote viewing and hallucinatory experiences have been already discussed.

5.9.1 Leakage of supra currents as basic mechanism

The basic element of the proposed vision is remotely induced leakage of supra currents from magnetic flux tubes to atomic space-time sheets. This same mechanism works for both endogenous biological self-organization and remote mental interactions which would form a routine part of our sensory representations. The most economic experimental strategy would be a direct verification of this basic mechanism.

An especially dramatic effect would be the appearance of ions from magnetic flux tubes to the target of remote mental interaction not present in the target initially. Sue Benford has found evidence for the appearance of S, Mg, and Al in X ray films which were exposed to the radiation coming from so called torsion generator [I56]. Intentional effort was involved with the experiment. What happened was that dots and tracks with typical size scale of one millimeter appeared in the X ray film. The dots and tracks did not allow identification as tracks of charged particles, and the exposed regions contained S, Mg and Al not present elsewhere. The leakage of energetic super-conducting ions to atomic space-time sheets dissipating their energy by emitting electromagnetic radiation and ionizing the atoms is the natural explanation for the effect [I56, I104]. Keith Fredericks has found that similar effect happens in nuclear emulsion when the emulsion is near to finger tips, and interpreted the tracks as tachyons [I84]. Note that both X ray films and nuclear emulsions contain gelatin which is an organic compound and might increase the sensitivity of the system.

5.9.2 Time reversal for the leakage of supra currents

The time reversal of the mechanism generating the leakage of supra currents could be especially important for healing. This mechanism is consistent with the presence of remote bound state entanglement and anomalous production of metabolic energy when binding energy is liberated.

The mechanism would be accompanied by a mysterious disappearance of marker ions in the tissue, and manifest as time reversed function of various molecular machines certainly detectable. Phase conjugates of (that is time reversed) microwaves at critical frequencies could induce the healing process. For instance, de-differentiation of cells might be induced in this manner.

As explained earlier, geometric time reversal could typically involve generation of anomalous radiation by excitation of atoms or molecules by emission of negative energy photons. Rotating magnetic systems (Searl machine) would be especially interesting for proving that time reversal indeed occurs. One could try to demonstrate that biological rhythms correspond to dissipation-healing cycles (wake-up sleep period and metabolic cycles being basic examples).

5.9.3 Controlling metabolism by IR laser beams and DNA functioning by maser beams?

One could also test the 'dropping' of ions to larger space-time sheets. If the dropping ions have dissipated their energy this means that system acts like a maser at wavelength defined by the reduction of the zero point kinetic energy liberated in the dropping of the ion. The pumping process would correspond to the leakage of the supra currents to atomic or some other space-time sheet, and induced emission to the dropping induced by the photons already present.

1. The effectiveness of metabolic energy production in which proton drops and absorbs a negative energy photon of energy about .5 eV could be amplified by a beam of coherent IR light "kicking" protons back to the atomic space-time sheets. The irradiation by phase conjugate beam

would "steal" energy from living system by inducing the dropping without locally usable energy. Whether living systems can "steal" energy from other life-forms in this manner could be tested. The "stealing" of the metabolic energy (there is probably a fractal hierarchy of "energy currencies") from cancer cells by phase conjugate laser light might be the first principle explanation for why Priore's machine works.

2. The dropping of ions from say $k = 151$ space-time sheet to larger space-time sheets creates microwaves with frequencies corresponding to zero point kinetic energies about $2^{-15}/A$ eV, A atomic number. For electron the energy is about $1/16$ eV. These processes could define exotic forms of metabolism, perhaps at the level of DNA. This process could be amplified by an external microwave beam or its phase conjugate and phase conjugate beam could induce the correction of genetic errors.
3. The scaling law of homeopathy [I123] states that high and low frequencies accompany each other and are in a constant ratio for which TGD predicts several values determined as ratios of zero point kinetic energies and cyclotron energies at magnetic flux tubes. The scaling law can be understood as follows: dropping of ions to cyclotron states generates with the zero point kinetic energy and cyclotron photons. Low frequency photons can interact resonantly with the system for which the internal excitations have same low frequency. This generates internal excitation with wavelength which is of the order of system size and this excitation couples resonantly to photons with wavelength equal to system size: thus high frequency photons result.

Thus one might achieve the above proposed effects using also low frequency irradiation. For instance, irradiation by kHz waves in order to achieve generation of bio-photons and irradiation by ELF waves in order to achieve generation of microwave photons. In fact, I started to develop the vision about living system as a macroscopic quantum system from the finding of Blackman [J28] and other pioneers of bio-electromagnetism that ELF radiation has delicate effects in the functioning of living matter. It seems that the basic mechanism might be the dropping of ions between space-time sheets or its time reversal. This mechanism could be tested also for remote objects.

5.9.4 How to choose senders and receivers?

An important aspect of testing is optimal choice of targets and the persons acting as sender.

Quite generally, the optimal target system for demonstrating these effects would be a critical system very sensitive to small perturbations. Any critical system would work, and one might even consider that the critical systems used to detect elementary particles might be used. Overcooled vapor or liquid or overheated liquid is one possibility. One could take register what happens in the system using same methods as in particle physics. Organic compounds might be by definition be this kind of systems.

One could also try to identify optimal 'senders'. Persons with strong will power or with firm belief on the effect, or persons with lower level of inhibition (children, actors, artists,...) could be considered as optimal 'senders'. One could find whether some drugs which remove inhibition, could enhance telepathic and psycho-kinetic abilities. The "blessed are the meek since they quantum entangle" prediction could be also tested. Indeed, one of the most dramatic experiments supporting psychokinesis was done using chicken which imprinted to a robot [J83]. The robot, whose behavior was programmed earlier by random number generator, tended to stay near the chicken, as if chicken had induced a quantum jumps changing the geometric past in macro-temporal time scales.

5.9.5 How to test the notion of conscious hologram?

The notion of conscious hologram means that practically any part of body can represent any other part of body or even external world. Concerning the notion of conscious hologram at the length scale of body, Kirlian imaging with simultaneous electrical stimulation of other body parts, in particular ear, is very promising manner to test the hypothesis [I91]. It is also known that ear forms kind of fractal miniature of body with respect to acupuncture points so that stimulation of particular part of ear electrically creates sensation that particular part of body is stimulated [J78].

PLR spectroscopy [I75] provides a precise and accurate manner to prove the viability of the notion of conscious hologram empirically. What is needed is the analysis of the frequency spectrum: does

it really contain the predicted differences of cyclotron harmonics. If this approach and its variants really work it becomes possible to determine experimentally the densities of super-conducting ions and Cooper pairs at parallel space-time sheets.

At the level of remote mental interactions the stimulation of brain electrically could induce in other brain nerve pulse pattern or even experience correlating with the nerve pulse pattern or even experience in the stimulated brain. Even water near criticality could provide this kind of representations. In Imaging laboratory at Hilversum, Holland the following experiment has been performed with success. The experiment involves water droplet near freezing point. A person with abilities of a healer asks for Universe to express something in the structure of the droplet. What results are beautiful fractal patterns representing say plant leaves, even a picture about the laboratory's architecture has been generated in this manner.

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I am grateful for Lian Sidoroff for very inspiring discussions relating to the remote mental interactions, which among other things stimulated several ideas such as the many-sheeted laser, the representation of information at space-time level, the number-theoretic characterization of life, and the representation of prime number factorization at space-time level.

Chapter 6

General Theory of Qualia

6.1 Introduction

Macroscopic quantum phases are an essential element of most quantum theories of consciousness and Topological GeometroDynamics (TGD) is not an exception in this respect. TGD based theory of consciousness relies crucially on the notion of self hierarchy whose geometrical correlate is the hierarchy of space-time sheets realized as a 4-surface in certain 8-dimensional space. The notion of many-sheeted space-time indeed predicts new types of macroscopic quantum phases. This has led to guesses for the quantum correlates of sensory qualia (colors, tastes, odors,..) and conscious thought as various macroscopic quantum phases predicted by TGD but the lack of direct experimental evidence for the macroscopic quantum phases has made more detailed models impossible. The breakthroughs in TGD and TGD inspired theory of consciousness inspired the first trials to construct a general theory qualia. Preliminary and incomplete versions of this theory are published in [L1] and in [L2] . During subsequent years the theory got a rather stable shape.

Dark matter hierarchy with levels labelled by the values of a dynamical quantized Planck constant have been the basic theme of the year 2005. TGD inspired theory of consciousness and TGD based view about quantum biology provide perhaps the most fascinating applications for this concept. It must be however added that condensed matter applications, say the models for the anomalous properties of water and for high T_c superconductivity, are of utmost relevance also for TGD based view about living matter. Dark matter hierarchy allows profound insights about the evolution of consciousness and life as the emergence of new levels of dark matter hierarchy, and deepens the view about the anatomy of quantum jump making it also possible to develop a more detailed view about qualia.

6.1.1 TGD in nutshell

Topological Geometro-Dynamics (TGD) is a unified theory of fundamental interactions. TGD involves a quite far-reaching generalization of the space-time concept and, apart from the notion of quantum jump, reduces quantum theory to infinite-dimensional geometry, which is highly unique from the mere requirement that it exists. Quantum TGD requires the introduction of several new mathematical tools and concepts, in particular p-adic numbers. p-Adic number fields R_p (one number field for each prime $p = 2, 3, 5, \dots$) are analogous to real numbers but differ from them in that p-adic numbers are not well-ordered. p-Adic physics describes the physics of cognitive representations and matter-mind decomposition at space-time level corresponds to the decomposition of space-time surface to real and p-adic regions. The higher the value of p , the better the resolution of cognitive experience is, so that p serves as kind of intelligence quotient. The mappings of the real geometric structures to their p-adic counterparts interpreted as cognitive mappings plays also key role in TGD inspired theory of consciousness.

p-Adic length scale hypothesis states that the p-adic length scales $L_p = l\sqrt{p}$, $l \simeq 10^4$ Planck lengths, $p \simeq 2^k$, k prime or power of prime, are physically preferred. p-Adic length scale hypothesis provides quantitative realization for the hierarchy of space-time sheets and is in key role in TGD inspired theory of consciousness. The seven online books about TGD [K89, K67, K68, K77, K53, K49, K75] and eight online books about TGD inspired theory of consciousness and quantum biology

[K82, K12, K60, K10, K34, K41, K44, K74] are warmly recommended for the reader willing to get overall view about what is involved.

6.1.2 TGD inspired theory of consciousness very briefly

TGD inspired theory of consciousness allows to construct a general model of conscious experiences based on some very general principles.

1. *Quantum jump between quantum histories as moment of consciousness and the notion of self*

The identification of quantum jump between quantum histories as moment of consciousness defines microscopic theory of consciousness whereas the notions of self and self hierarchy allow to understand macroscopic aspects of consciousness absolutely essential for brain consciousness [K45]. Self is identified as a sub-system effectively behaving like its own subuniverse quantum mechanically [K70]. Physically this means that self is a sub-system able to not generate bound state entanglement with environment during subsequent quantum jumps.

Simple assumptions about how the contents of consciousness of self is determined allow to understand the basic structure of conscious experience at general level. One can understand volition as closely related to the classical nondeterminism of the Kähler action; theory leads to a very general model of sensory experience and so called whole-body consciousness explaining basic characteristics of the mystic experiences is basic prediction of the theory [K64].

The localization in configuration space zero modes occurring in each quantum jump implies that the world of conscious experience is classical and standard quantum measurement theory follows as a consequence. Also self measurements are possible and each localization in zero modes is followed by a cascade of self measurements leading to a completely unentangled product state: this is nothing but TGD counterpart of the state preparation process which is also part of quantum measurement theory. Self measurements are governed by Negentropy Maximization Principle [K46]. Self measurements give rise to quantum level self repair mechanism. In p-adic context NMP is the basic variational principle of cognition.

In the absence of macro-temporal quantum coherence de-coherence times for quantum states would be or order 10^4 Planck times. Macro-temporal quantum coherence however effectively binds a sequence of quantum jumps to a single quantum jump, and the quantum jump at a given level of hierarchy corresponds to a sequence of quantum jumps at lower levels, which also contributes to the experience of the higher level self.

1. Macro-temporal quantum coherence is made possible by the quantum spin glass degeneracy due to the fact that canonical transformations of CP_2 act like $U(1)$ gauge transformations but generate physically non-equivalent states having slightly different gravitational energies. Macro-temporal quantum coherence means the formation of bound states. The space-time correlate is the formation of join along boundaries bonds connecting corresponding space-time sheets to single space-time sheet. Bound state formation gives rise to the fusion of selves to a larger self implying what might be called stereo consciousness. During macro-temporal quantum coherence dissipation is absent in bound degrees of freedom so that the resulting mental image stays sharp. Neuronal synchrony is a signature of this phenomenon at brain level.
2. Quantum parallel dissipation is an essential aspect of the new view about quantum jump. Hadron as a quantum coherent system on one hand, and as a soup of quarks and gluons whose distribution functions obey kinetic equations on the other hand, provides a good example about quantum parallel dissipation. Self experiences this dissipation at lower levels of hierarchy as "thermal noise" except during "enlightened" moments of consciousness.
3. The hypothesis that bound state entanglement stable against state function reduction corresponds to algebraic entanglement coefficients gives a more precise quantitative content for what the fusion of quantum jumps could mean. For algebraic entanglement p-adic Shannon entropies obtained by replacing logarithms of probabilities with the logarithms of their p-adic norms are well-defined, and there is a prime p for which Shannon entropy is negative and minimum and identifiable as negentropy.
4. The vision about dark matter hierarchy leads to a more refined view about self hierarchy and hierarchy of moments of consciousness [K25, K26]. The hierarchy of dark matter levels is

labelled by the values of Planck constant having quantized but arbitrarily large values. Mersenne hypothesis states that the basic hierarchy comes as $\hbar = 2^{k_a} \hbar_0$. The larger the value of Planck constant, the longer the subjectively experienced duration and the average geometric duration $T \propto r$ of the quantum jump.

Dark matter hierarchy suggests also a slight modification of the notion of self. Each self involves a hierarchy of dark matter levels, and one is led to ask whether the highest level in this hierarchy corresponds to single quantum jump rather than a sequence of quantum jumps. The averaging of conscious experience over quantum jumps would occur only for sub-selves at lower levels of dark matter hierarchy and these mental images would be ordered, and single moment of consciousness would be experienced as a history of events. One can ask whether even entire life cycle could be regarded as a single quantum jump at the highest level so that consciousness would not be completely lost even during deep sleep. This would allow to understand why we seem to know directly that this biological body of mine existed yesterday.

The fact that we can remember phone numbers with 5 to 9 digits supports the view that self corresponds at the highest dark matter level to single moment of consciousness. Self would experience the average over the sequence of moments of consciousness associated with each sub-self but there would be no averaging over the separate mental images of this kind, be their parallel or serial. These mental images correspond to sub-selves having shorter wake-up periods than self and would be experienced as being time ordered. Hence the digits in the phone number are experienced as separate mental images and ordered with respect to experienced time.

2. *p-Adic physics as physics of cognition and intention*

TGD space-time decomposes into regions obeying real and p-adic topologies labelled by primes $p = 2, 3, 5, \dots$. p-Adic regions obey the same field equations as the real regions but are characterized by p-adic non-determinism since the functions having vanishing p-adic derivative are pseudo constants which are piecewise constant functions. Pseudo constants depend on a finite number of positive binary digits of arguments just like numerical predictions of any theory always involve decimal cutoff. This means that p-adic space-time regions are obtained by gluing together regions for which integration constants are genuine constants. The natural interpretation of the p-adic regions is as cognitive representations of real physics. The freedom of imagination and intention is basically due to the p-adic non-determinism. p-Adic regions perform mimicry and make possible for the Universe to form cognitive representations about itself. In this vision real mind like space-time sheets are interpreted as geometric correlates of experience and corresponding p-adic space-time sheets correspond to imagined experience. The transformation of a p-adic region to a real one in quantum jump corresponds to a transformation of intention to action.

3. *New view about time*

The understanding of the relationship between subjective and geometric time leads to the notion of psychological time involving in an essential manner the new view about space-time, in particular the idea about mind like space-time sheet (defined as space-time sheet having finite time-duration) as a geometric correlate of self [K87, K88]. One can understand psychological time as temporal center of mass coordinate for the cognitive space-time sheet. The arrow of psychological time can be understood as resulting from a drift towards the geometric future. Diffusion in future light-cone alone is probably not enough, also drifting force is needed and special relativity suggests that this force is the fourth component of four-force and could perhaps be identified as proportional to the dissipation rate for energy occurring during the self-organization. This suggests that the average increment of the geometric time per quantum jump is given by $\Delta t = (P/k)\tau$, where P is rate of energy dissipation, k is the coefficient of friction regarded as a Lorentz scalar, and τ some fundamental time scale, most naturally of the order of CP_2 time τ_{CP_2} is CP_2 time about 10^4 Planck times. P/k would determine the fraction of time spent in wake-up state if τ is the average increment of the geometric time in quantum jump.

The notion of psychological time forces to view the entire many-sheeted space-time surface as a living system so that the standard notion of linear time is illusory and reflects the restricted information content of our conscious experience rather than fundamental 4-dimensional reality. The paradigm of 4-dimensional brain provides completely new understanding of the long term memory: no memory storage mechanisms are needed and one avoids the basic difficulties of neural net models. There are

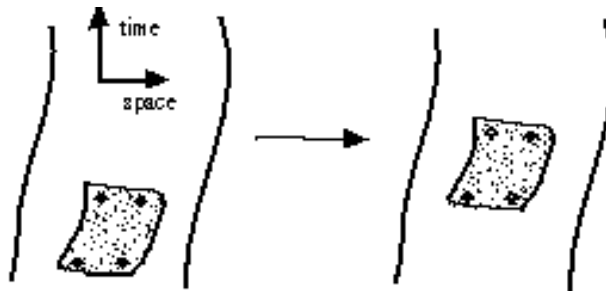


Figure 6.1: The mechanism giving rise to the arrow of psychological time. What happens is that mind like space-time sheet gradually drifts in direction of geometric future. Note that mind like space-time sheet has finite time duration.

two kinds of memories, geometric and subjective, as also two kinds of causalities. Massless extremals, whose light-like boundaries are identified as geometric correlates of selves, realize the paradigm of 4-dimensional brain concretely.

4. Selves self-organize

Subjective time development by quantum jumps implies quantum self-organization which can be regarded as a sequence of quantum jumps between quantum histories [K69]. This evolution corresponds to a sequence of macroscopic space-time surfaces associated with the final state quantum histories. Quantum jumps imply dissipation at fundamental level. Dissipation serves as a Darwinian selector of self-organization patterns, which can represent both genes and memes. In particular, one can understand how habits, skills and behavioral patterns are gradually learned.

5. Self hierarchy

The notion of self hierarchy, starting from elementary particle level and having entire Universe at the top, is a highly nontrivial prediction of TGD inspired theory of consciousness. Self hierarchy is very much analogous to the hierarchy of subprograms of a computer program and defines a hierarchy of increasingly abstract experiences. Self hierarchy allows to understand computational aspects of brain although connectionistic picture realized as quantum association network seems to work at various levels of the hierarchy [K17]. Topological field quanta of em fields are an part of self hierarchy and this force to give up the view that consciousness is brain centered phenomenon (wavelength of 10 Hz EEG photon has size scale of Earth). Self hierarchy is also crucial for the model of sensory qualia.

Dark matter hierarchy [K92, K26] leads to a detailed understanding of the correlates of our consciousness and its relation to lower and higher levels of the self hierarchy. There are good reasons to believe that the levels of the dark matter hierarchy correspond to the evolutionary hierarchy and that great leaps in evolution correspond to the emergence of a new level in the dark matter hierarchy [K43]. The hypothesis leads to precise quantitative predictions. For instance, a hierarchy of EEGs, ZEGs, WEGs, and GEGs (E, Z, E, and G correspond to photon, Z^0 boson, W boson and gluon) is predicted [K26], and the model predicts correctly the band structure and even individual resonances of ordinary EEG.

6.1.3 Biological realization of self hierarchy

Self hierarchy has as a geometric correlate the hierarchy of space-time sheets.

Mersenne hypothesis

The scale of the Josephson frequencies assignable to a given neuron is determined by the value of Planck constant. TGD inspired quantum biology and number theoretical considerations suggest preferred values for $r = \hbar/\hbar_0$. For the most general option the values of \hbar are products and ratios of two integers n_a and n_b . Ruler and compass integers defined by the products of distinct Fermat primes and power

of two are number theoretically favored values for these integers because the phases $\exp(i2\pi/n_i)$, $i \in \{a, b\}$, in this case are number theoretically very simple and should have emerged first in the number theoretical evolution via algebraic extensions of p-adics and of rationals. p-Adic length scale hypothesis favors powers of two as values of r .

One can however ask whether a more precise characterization of preferred Mersennes could exist and whether there could exist a stronger correlation between hierarchies of p-adic length scales and Planck constants. Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1 + i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241, \dots\}$ are expected to be physically highly interesting and up to $k = 127$ indeed correspond to elementary particles. The number theoretical miracle is that all the four p-adic length scales with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μ m). The question has been whether these define scaled up copies of electro-weak and QCD type physics with ordinary value of \hbar . The proposal that this is the case and that these physics are in a well-defined sense induced by the dark scaled up variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$.

This proposal will be referred to as Mersenne hypothesis and it leads to strong predictions about EEG since it predicts a spectrum of preferred Josephson frequencies for a given value of membrane potential and also assigns to given value of \hbar a fixed size scale having interpretations as size scale of body part or magnetic body.

For instance, EEG photons at $k_d = 40$ level of dark matter hierarchy have energy which is above thermal energy at room temperature: this is absolutely essential for understanding the role of EEG photons.

The phase transition increasing k_d by one unit means that the sizes of space-time sheets are scaled up by factor 1. If the density of particles is high enough, the overlap criterion for the formation of a macroscopic quantum phase is satisfied in the resulting dark phase and Bose-Einstein condensates become possible. De-coherence phase transition for dark matter particle means that the size of the space-time sheet is scaled down by $1/r$.

The notion of magnetic body

The notion of magnetic body belongs to the key concepts of TGD inspired theory of consciousness. Magnetic body is the intentional agent, which uses biological body as a sensory receptor and motor instrument. The ideas about dark matter hierarchy lead to a concrete view about what magnetic bodies could look like. The basic observation is that the scaling of the unit \hbar of magnetic flux by r requires the scaling of the area of flux quantum or of field strength by r or a more complex combination of these basic operations. For flux sheets with fixed thickness and fixed field strength the width of the flux quantum must be scaled up by r . Applying this picture in the case of Earth's magnetic field leads to a concrete model for those parts of magnetic bodies which are in a direct contact with the biological body.

Magnetic body utilizes biological body as a sensory receptor most effectively if the flux quanta go through the receptor proteins at cell membranes. Motor instrument function is realized in an optimal manner if magnetic flux quanta connecting magnetic body to biological body are strongly folded thin flux sheets going through the DNA strands of cells which take the role of text lines at the pages of book formed by magnetic flux sheets. Flux quantization implies that sheets must traverse through quite a large number of genomes unless one assumes that the text lines are almost empty. This leads to a generalization of the notion of genome providing a powerful tool in attempts to build a concrete view about the higher levels of self hierarchy.

Super-genome means that sequences of genomes organize like lines of text on pages of a book formed by magnetic flux sheets. Super-genomes are responsible for the organization of cells to organs. Hyper-genome consists of super-genomes of different organisms organized in a similar manner. Mirror neurons could provide an example of this kind of organization at the level of neurons (it is known that autistic children possess much less mirror neurons than healthy ones). Hyper-genome (presumably involving introns and memetic code) is responsible for coding the collective levels of consciousness responsible for culture and social structures.

Massless extremals

The so called massless extremals (MEs) [K55, K62, K65] are excellent candidates for correlates of dark photons at various levels of dark matter hierarchy. There the earlier term "mind like" space-time sheets is justified. MEs are ideal for control and communication purposes since the vacuum current associated with ME has arbitrary time dependence and is ideal for coding both the sensory data and control instructions. The fact that classical space-times are field theoretic counterparts of Bohr orbits, suggests that classical em field decomposes into MEs when classical de-coherence occurs. MEs provide a mechanism of long term memory and the notion of MEs leads to the idea about brain as a sensory and motor organ of higher level selves and to a rather detailed view about the general organization of brain.

By general coordinate invariance the light-like M_{\pm}^4 projections of the light-like boundaries of MEs act as quantum holograms and can be identified as universal (but probably not the only) geometric correlates of selves. The light-like vacuum currents are optimal for coding information and make MEs dynamical holograms in classical sense.

By Uncertainty Principle ELF MEs correspond to topological field quanta with size of Earth. It became clear already before the realization of super-symplectic representations that MEs could be also seen as higher level selves [K35] living in symbiosis with biological life forms and responsible for the cultural aspects of human consciousness. This is in accordance with the idea that the flux tubes of Earth's magnetic fields serve as templates for the formation of bio-structures. Contrary to the Newtonian intuition, the only sensible view seems to be that we ourselves correspond to life forms of electromagnetic size not smaller than Earth size: the illusory identification of 'me' with brain is created by the erratic identification of self with the contents of sensory experience. This view stimulates also rather concrete ideas about biological death and life after biological death.

MEs can carry besides classical em and Z^0 fields also W gluon fields and in general do so. These fields can be assigned to dark matter. The model for nerve pulse [K62] leads to a more detailed view about the division of labor between neutral and charged MEs. Neutral MEs are ideal for communication and coordination purposes. Charged W MEs can induce charge entanglement over macroscopic and even astrophysical length scales. This means a nonlocal mechanism inducing changes of charge equilibria in turn inducing the flow of ordinary em currents.

The model of nerve pulse assumes that magnetic body of neuron induces multiverse states in which no nerve pulse is present at the first branch and nerve pulse is generated at the second branch. In principle this makes possible dissipative quantum computation using nerve pulse patterns (the notion of quantum parallel dissipation justified by dark matter hierarchy is an essential conceptual prerequisite here). Color entanglement can in turn induce local color charging and in the capacitor model of sensory qualia this charging can lead to generation of color discharge giving rise to an experience of visual color.

Hierarchy of magnetic super-conductors

The empirical results [J33] about the effects of oscillating em fields on brain suggest that cyclotron frequencies, and more generally magnetic transition frequencies, of biologically important ions in the magnetic field of Earth correspond to important oscillation frequencies of Josephson currents and MEs. Also the magnetic transition frequencies of electronic Cooper pairs seem to be important.

Second empirical ingredient supporting the view about hierarchy of magnetic super-conductors are the puzzling observations of cell biology (for a summary see the first chapter of [I113]) challenging the association of ionic channels and pumps to cell membrane. The paradoxes disappear if cell and its exterior are assumed to be in a many-sheeted ionic flow equilibrium with ionic currents flowing from super-conducting space-time sheets to atomic space-time sheets and back, so that the densities of ions at atomic space-time sheets are controlled by the very small densities and quantized currents of the ions at super-conducting magnetic flux tube space-time sheets and coding the information about homeostasis of bio-matter [K13, K14, K26] . Also a reason why for liquid crystal and electret properties of bio-matter emerges and one can understand the function of electric circuitry associated with body [J23] .

Dark matter hierarchy leads to a quantitative model for high T_c superconductivity predicting the basic length scales $L(149)$ and $L(151)$ associated with lipid layers of cell membrane and cell membrane itself. Also cell size emerges naturally. At higher levels of dark matter hierarchy scaled up versions

of this basic structure appear. Cyclotron states at magnetic flux tubes are carriers of Bose-Einstein condensates of Cooper pairs and of bosonic ions.

How MEs interact with magnetic super-conductors

One can imagine several mechanism for how MEs interact with magnetic superconductors.

1. Neutral MEs can induce super currents in super-conducting magnetic circuits by magnetic induction mechanism, serve as temporary Josephson junctions between magnetic flux tubes, and induce magnetic quantum phase transitions.
2. Neutral MEs can generate reference waves or their phase conjugates (time reversals) acting on lower level MEs serving as dynamical holograms. The induced coherent light pattern and its phase conjugate could act as a control command and its time reversed version. Conjugate reference waves provide an extremely simple mechanism of healing by time reversal allowing the living matter to fight against second law. MEs can read DNA strand to the light-like vacuum current by moving along it and thus code DNA strand/conjugate strand to a hologram or its phase conjugate in turn acting as a control command or its time reversal. ELF MEs could do the same at the level of axons: instead of DNA sequences nerve pulse patterns would be read now. Thus living matter could be regarded as a symbiosis in which MEs control super-conducting magnetic flux tubes controlling ordinary matter at atomic space-time sheets via many-sheeted ionic flow equilibrium. DNA would represent the ROM of this system.
3. W MEs can induce charge entanglement over macroscopic and even astrophysical distances followed by a quantum jump reducing this entanglement. At the branch of the resulting multiverse for which charge density is affected by the exotic ionization of the cyclotron condensate (say Ca^{++} condensate), ordinary currents are generated in order to restore equilibrium. This mechanism could be behind Ca^{++} waves at various levels of dark matter hierarchy and the generation of nerve pulse would represent only a special instance of this mechanism. Many-sheeted version of the Faraday law is an essential element of this mechanism: it is the change of membrane potential at dark matter space-time sheet induced by the effective ionization which induces the change of potential at the space-time sheet containing ordinary matter or matter at a lower level of dark matter hierarchy. This mechanism means also that dark matter and visible matter can interact via classical fields.

MEs as carriers of super-symplectic and Super Kac-Moody representations

TGD predicts two kinds of super-conformal symmetries [K20, K31] . Super-Kac Moody symmetries assignable to partonic 2-surfaces identifiable as time =constant sections of light-like causal determinants of 4-surfaces correspond to the gauge symmetries of fundamental interactions. Super-symplectic symmetries act at imbedding space level, on $\delta M_{\pm}^4 \times CP_2$, where M_{\pm}^4 is some future/past light-cone of M^4 . The conformal weights of super-symplectic representations are closely related to the complex zeros of Riemann Zeta and the net conformal weight of a physical state is always real: this implies conformal confinement. There is a fractal hierarchy of quantum holograms inside quantum holograms. One can identify the light-like boundaries of MEs as geometric correlates for selves.

Also space-like selves are very probably needed and magnetic flux tube structures could represent them. Indeed, the non-determinism of CP_2 type extremals representing elementary particles (their M_{\pm}^4 projections are random light-like curves) makes it impossible to characterize the quantum state completely by the data on the light-like boundaries of MEs.

Super-symplectic degrees of freedom makes MEs ideal candidates for the correlates of higher level consciousness.

1. The states of super-symplectic representations have gigantic almost-degeneracies broken only by non-commutativity of super-symplectic and Poincare symmetries which means huge information storage capacities. Super-symplectic representations can be realized in real context using Bose Einstein condensates of massless elementary particles on MEs. Super-symplectic representations correspond to genuine quantum gravitational effects since wave functionals in the space of three-surfaces are involved: space-time ceases to be a passive arena of quantum dynamics. In fact,

canonical transformations of CP_2 are approximate symmetries of the theory broken only by classical gravitation. The notion of 'configuration space photon' having nontrivial dependence on configuration space degrees of freedom characterized by Hamiltonian suggests strongly itself and seems to be crucial for understanding of the visual colors.

2. Super-symplectic representations associated with MEs have universal transition frequency spectrum given as multiples of the fundamental frequency determined by the length of ME. If one assumes that MEs have lengths given by p-adic length scale hypothesis, fundamental frequencies turn out to correspond to important resonance frequencies in EEG. For these reasons super-symplectic representations are ideal candidates for an infinite hierarchy of life forms associated with MEs. The great vision is that MEs and magnetic super-conductors associated with the magnetic flux tube structures form a fractal hierarchy interacting with the ordinary bio-matter via the classical gauge fields associated with MEs [K8, K62, K26, K65] .

6.1.4 Qualia and thermodynamics

The connection between thermodynamics and qualia was the real breakthrough in the development of ideas. In some sense this finding is not a news: the close connection between pressure sense and temperature sense and thermodynamics is basic facts of psychophysics. In TGD framework the contents of consciousness is determined as some kind of average over a sequence of very large number of quantum jump. Thus non-geometric qualia should allow a statistical description generalizing ordinary thermodynamical ensemble to the ensemble formed by the prepared states in the sequence of quantum jumps occurred after the last 'wake-up' of self. For instance, this picture allows to see the ageing of self with respect to subjective time as an approach to thermal equilibrium.

1. There are geometric qualia corresponding to zero modes expressing the result of quantum measurement in each quantum jump. All geometric information about space-time surface should reduce to geometric qualia. For instance, geometric data given by visual, auditory, and tactile senses should reduce to conscious information about zero modes or their increments in quantum jumps.
2. The sequence of the prepared states can be modelled as a statistical ensemble of Fock states, which suggests that thermodynamics is basically part of the theory of consciousness. The ensemble of prepared states gives rise to a large number of statistical qualia. The relationship $dE = TdS - PdV + \mu dN + B \cdot dM...$ generalizes to TGD context: note however that in the case of ME selves energy is replaced with the Super Virasoro generator L_0 associated with the light-cone boundary of ME. Each intensive-extensive variable pair in the differential should correspond to a non-geometric quale, which results only when there is gradient (flow) of the extensive variable in the direction of the subjective time. Super-symplectic thermodynamics should obviously map ordinary thermodynamics to the level of conscious experience.
3. Since subjective existence corresponds to quantum jumps, it is natural to assume that only the increments of zero modes and quantum numbers are experienced consciously. Statistical interpretation also suggests that an averaging over the increments occurs. The possibility of sub-selves makes possible to have sequences of sub-selves (mental images) of finite subjective time duration: this makes possible structured subjective memories (for instance, it becomes possible to remember the digits of a phone number). A further working hypothesis analogous to functionalism is universality: the increments of Poincare and color and electro-weak quantum numbers define what might be called universal kinesthetic qualia in the sense that quantum number increment is experienced in the same manner irrespective of context (other quantum number increments).

Spin is perhaps an exception since it does not change in the scaling of \hbar . If magnetic field strength remains invariant and the area of flux quantum scales up as r in the scaling of \hbar , magnetic interaction energy $-\mu \cdot B$ remains invariant whereas cyclotron energy scales up. Hence spin would be thermalized and only cyclotron transitions would contribute to qualia. Spontaneous magnetization and spin flips of spontaneously magnetized regions of spin glass having very large magnetic moment might change the situation. One must also remember that the assignment of

same temperature to all space-time sheets of the dark matter hierarchy is the most pessimistic working hypothesis.

The thermodynamical expression for dE suggests a general classification of qualia consistent with the 'holy trinity' of existences implied by TGD.

Kinesthetic qualia defined by generalized forces

p-V pair corresponds to the geometric existence and is replaced with generalized force-generalized coordinate pairs in quantum fluctuating degrees of freedom. Quite generally, the rates for the increase for a maximum number of mutually commuting Poincare, color and electro-weak quantum numbers define what might be called kinesthetic qualia. Senses of force and torque, hearing, and intensity of color sensation can be regarded as examples of generalized kinesthetic qualia.

Generalized chemical qualia

$\mu - N$ pair corresponds to 'objective existence' defined by quantum histories and N is generalized to a number of particle like excitations in the Fock state resulting in the state preparation. In this case there must be a flow of particle number in the direction of the subjective time, that is Bose-Einstein condensation type process for, say Cooper pairs. Quite generally, super-symplectic and Super Kac-Moody algebras should define these kind of qualia and the number of these qualia is very large. The particle numbers in question can be numbers of ions of Cooper pairs in various magnetic states, numbers of colored configuration space photons in various states of super-symplectic representation, numbers of join along boundaries bonds, etc.. and one can understand chemical qualia, color vision, and sensations of pain and pleasure as generalized chemical qualia.

Boolean qualia

Boolean qualia would be naturally associated with fermion number or fermionic spin degrees of freedom. There are super-symplectic and super-Kac Moody type Boolean qualia. The spin flipping transitions associated with the fermionic generators of super-symplectic algebra might give rise to Boolean consciousness with intrinsic meaning ('This is true') but there are many other possibilities.

A general model for abstraction process based on the Combinatorial Hierarchy [K35] not only explains the basic numbers of the genetic code but also suggests an entire hierarchy of codes in accordance with fractality of TGD Universe.

The next code after genetic code in the hierarchy of codes defined by Combinatorial Hierarchy is very attractive candidate for a 'memetic code'. The hypothesis predicts correctly the .1 second time scale for the duration of 'our' self (immediate short term memory, duration of psychological moment). Code-words correspond to the sequences of 126 bits with a duration of 1/1260 seconds: this is slightly below the time scale of nerve pulse so that membrane oscillations are perhaps a more natural realization for the code. The facts that the time scale of causal diamond CD associated with d quark corresponds to 1280 Hz frequency and the time scale of electron's CD corresponds to 10 Hz frequency suggest that quark pairs allow a realization of the memetic code with single quark sub- CD representing and electron CD the code word.

What kind of qualia could emotions correspond?

The identification of emotions as qualia is far from obvious. What looks clear is that emotions seem to relate closely to information (peptides are information molecules and their distributions also correlates strongly with the emotional state).

1. Do emotional qualia reduce to gradients of entropy or negentropy?

The first brave guess was that emotions reduce to the changes of a negentropy type variable. A more cautious assumption would be that these changes determine only a 2-valued emotional quale having values positive/negative.

1. The first candidate for the entropy type variable is the entropy for the ensemble determined by the quantum jumps of sub-self. More concretely, $T - S$ pair correspond subjective existence

and generalizes to disorder-order type, information theoretic qualia about the state of self: hot-cold and pain-pleasure type sensations and also more abstract experiences associated with various sub-selves of self. These qualia are strongly emotional single-pixel holistic qualia measuring whether some kind of an entropy variable is increasing or decreasing.

The total entropy for the statistical ensemble defined by sub-self determines how sharp the the mental image is. Low entropy content means alertness and attentiveness. High entropy content means fuzzy mental image. Getting tired means inability to keep mental images in low entropy state. Macro-temporal quantum coherence due to quantum spin glass degeneracy and dark matter hierarchy implying a hierarchy of increasing values of Planck constant is absolutely essential in guaranteeing that the mental images stay non-entropic: otherwise 10^4 Planck times would be natural de-coherence time and define the duration of sharp mental images.

The objection is that the entropy of sub-self is expected to increase as sub-self ages so that this kind of emotions would be always negatively colored. The notion of number theoretic negentropy based on p-adic variants of Shannon entropy is however non-negative in general and could increase or decrease as the size of the ensemble determined by quantum jumps increases. It is however not obvious whether it is sensible to assign this kind of entropy to ordinary statistical ensemble.

2. The color of emotion (positive/negative) could correlate with the increase/decrease of the number theoretic entanglement negentropy of the mental image, which characterizes the rational (or even algebraic) entanglement assignable to sub-self as a quantum mechanical bound state. The positive negentropy could be argued to be due to a conscious information due to the possibility to compare different states present in the multiverse state. Certainly the assignment of a non-negative quantum information to algebraically entangled bound state number theoretic entanglement entropy (!) is natural since this entropy does not describe lack of information about classical state. This makes possible the huge information processing capacity of quantum computers. Number theoretic negentropy can also increase in quantum jump and Negentropy Maximization Principle [K46] indeed postulates this increase as the fundamental variational principle of the dynamics of conscious experience.

2. Are emotions and cognition sensory qualia at higher levels of dark matter hierarchy?

Emotions and cognition could be higher level sensory qualia assignable to higher levels of dark matter hierarchy and cyclotron phase transitions at the magnetic bodies induced by EEG and its fractal generalizations would define this kind of qualia. Emotions and cognition represent in this picture two different kinds of communications of information from biological body to the magnetic body. This option is perhaps the most promising one but allows also the identification of the positive/negative attribute of emotion in terms of the sign of the negentropy gradient.

6.1.5 Spectroscopy of consciousness

The quantum correlates of sensory qualia suggest what might be called spectroscopy of consciousness. The original working hypothesis was that EEG frequencies correspond directly to various qualia but it seems that this assumption must be replaced with a less restrictive one.

The idea is that EEG (or ZEG, WEG, or GEG) MEs can be assigned with entanglement of a sub-self of magnetic body with sub-self of biological representing various mental images. That sub-selves can entangle with selves remaining themselves unentangled is one aspect of the generalized notion of sub-system and inspired by the hierarchy of space-time sheets allowing to identify the space-time correlate for this kind of entanglement as join along boundaries bonds connecting space-time sheets representing the sub-systems of disjoint space-time sheets. The entanglement in question could be in cyclotron degrees of freedom, charge entanglement, or color entanglement. An open question is whether this kind of entanglement is possible only for sub-selves characterized by a smaller value of \hbar than self, or always when topologically condensed sub-system is characterized by a smaller value of p-adic prime and separated by a light-like causal horizon from the larger system.

Although EEG and its generalizations seem to serve communication and control purposes rather than representing qualia directly, the notion of spectroscopy of consciousness makes still sense. Furthermore, the identification of the fractal hierarchy of EWEGs and GEGs means a dramatic gener-

alization of this notion making precise quantitative predictions in a huge range of frequency scales resulting by simple scaling from [J17] [K26]. The model allows to assign the frequencies $nf_c \pm f_J$ (f_c is cyclotron frequency and f_J Josephson frequency) with the communications of sensory data to magnetic body and frequencies nf_c with the quantum control performed by the magnetic body. For ordinary EEG the harmonics of cyclotron frequencies of bosonic ions correspond to alpha band and its harmonics assignable to quantum control. Beta and theta bands and their analogs for the harmonics of alpha band correspond to the communication of sensory and cognitive data to the magnetic body. The rough correlations of EEG with the state of consciousness can be understood. The challenge would be to identify detailed EWEG and GEG correlates of sensory experience, emotion, cognition and memory and only the first partially misguided attempts in this direction have been made.

One of the first ideas was a possible connection of the theory of the various magnetic qualia with place and time coding with atomic and nuclear spectroscopy. The correspondence with nuclear spectroscopy is not promising since spin remains invariant in the phase transition to dark matter and if dark matter is at the same temperature as the ordinary matter, spin is thermalized and only cyclotron degrees of freedom are relevant. Spontaneous magnetization could of course change the situation.

Second idea was that the structure of the periodic table could reflect directly itself in the spectroscopy of consciousness. This would mean that various full electronic shells (He, Ne, Ar, Kr, Xe) would correspond to a hierarchy of magnetic qualia relating directly with the band structure of EEG. The periods also seemed to correlate with the five-layered structure of sensory cortex (primary, secondary, etc... areas). The objection against this vision is that biologically important ions must be bosons since only they can form Bose-Einstein condensates. Most of the biologically relevant bosonic ions have cyclotron frequencies in alpha band and this leads to a successful prediction of the band structure and of the narrow resonance bands. The correspondence with the periodic table must be given up unless exotic ions of bosonic atoms (also bosons) are allowed. Exotically ionized bosonic ions (say dark $Ca^{++,\pm}$) are necessary in the model of nerve pulse and result in the charge entanglement by W MEs, which suggests that they are indeed present.

Apart from scaling the spectrum of super-symplectic transition frequencies is constant of Nature if MEs have preferred length scales given by p-adic length scale hypothesis. This leads to powerful predictions and theory is immediately testable. One can indeed identify the basic resonance frequencies associated with EEG as lowest frequencies of this kind. Furthermore, the lower bounds of EEG bands correspond to the fundamental frequencies of super-symplectic transitions assuming p-adic length scale hypothesis. Dark matter hierarchy predicts scaled up variants of these frequencies.

Also now the representations associated with various p-adic length scales seem to correlate with the hierarchy formed by the areas of the sensory cortex.

Without exaggeration, spectroscopy of consciousness could be for brain science what atomic spectroscopy has been for physics and chemistry. It is somewhat astonishing that this possibility has not been noticed before. After all, spectral lines provide extremely effective, reliable and universal manner to code information and brain is the most refined information processing system we know. Ironically, brain modelers busily mimicking EEG numerically know that EEG correlates strongly with mental state but do not still notice the enormous information storage potential of EEG spectrum. This is perhaps the most dramatic example of the power of the scientific prejudices ('there is no evidence for the importance of quantum effects in brain length scale') to hinder seeing the truth staring directly at our face in its full simplicity and beauty. It is also ironic that so many quantum consciousness theorists spend their time by speculating about quantum gravitational Planck length scale basis of consciousness without realizing that spectroscopy is the most important practical outcome of quantum theory and EEG is the most obvious place to search for this kind of spectroscopy.

6.2 General vision about the quantum correlates of qualia

In this section a general theory providing overall view about the identification of the quantum correlates of qualia is developed. Hard trial and error experimentation with concrete models for the identification of qualia has gradually led to a vision about fundamental physics and general principles behind qualia. Several questions remain still unanswered but it seems that following general vision deserves testing and further development.

1. Qualia can be divided into two classes: discrete, non-geometric, quantal qualia on one hand, and 'classical', geometric or what might be called zero mode qualia on the other hand and

measured in the quantum jump. Discrete qualia correspond to quantum jumps defined by the non-diagonal generators of two super algebras. Super Kac-Moody algebra is responsible for the standard elementary particle quantum numbers and the super-symplectic algebra defining the group of isometries for the configuration space of 3-surfaces. Thus quantum measurement theory dealing with the diagonal generators fuses with the theory of non-geometric qualia dealing with the non-diagonal generators.

2. Zero modes can represent various types of geometric information, say position, orientation or more general information about size or shape. Certain subspace of zero modes defines as a coset space a flag-manifold whose points characterize the possible choices of the quantization axes. Flag-manifold coordinates are naturally mapped into magnetic field configurations which in turn determine magnetic transition frequencies. Averages of the increment of the zero modes are experienced but sub-selves make possible to have temporally structured experiences especially important for hearing.
3. Place and time coding is important part of the theory. When EEG frequency (note that there is hierarchy of EEGs and its weak and colored generalizations involved) corresponds to a particular magnetic transition frequency, magnetic transitions in corresponding part of the linear cortical structure occur and induce quantum phase transition waking up mental image giving rise to a sensation that something exist in that particular spatio-temporal position. The sensation about movement of an object of perceptive field and perhaps even the sensation about the rate of time flow result automatically when the mental image moves along the linear spatiotemporal structure.
4. Each quale corresponds to some quantum jump serving as a seed of quantum phase transition for macroscopic quantum phases in quantum critical spin glass state. The assumption that primary sensory organs are the seats of the sensory qualia has turned out to provide the simplest view about sensory experience, imagination, and dreams. Assuming quantum entanglement between sensory organs, brain, and magnetic bodies one can avoid various objections against this scenario. This leaves a lot of room for more detailed identifications. The magnetic transitions for ions in Earth's magnetic fields are good candidates for quantum transitions associated with the sensory qualia. Visual colors could correspond to increments of color quantum numbers.
5. Music metaphor in its recent form states that primary sensory organs contain the music (also neurons are probably sensory experiencers but these experiences would not be ours) and nerve pulse patterns and membrane oscillations are the notes. Thus brain would construct symbolic and cognitive representations rather than direct sensory experiences.

EEG MEs would entangle the mental images at magnetic body and in brain and sensory organs. EEG patterns could be also seen as providing a representations for the notes of the music produced by sensory instrument. The function of nerve pulse patterns is to resonantly excite EEG frequencies entangling brain with the magnetic body and to induce magnetic transitions amplified into quantum phase transitions. The frequencies of many of these transitions can be predicted. Essential prerequisite is quantum criticality of the quantum spin glass phases associated with supra phases.

6. The observation that quantum TGD implies quantum measurement theory meant also a breakthrough in the theory of qualia. The localization in so called zero modes is equivalent with the quantum measurement. The cascade of self measurements whose non-deterministic dynamics is governed by Negentropy Maximization Principle [K46] gives rise to the state preparation process leading to a completely unentangled state serving as the initial state of the next quantum jump. Self defines a statistical ensemble as the set of unentangled prepared states resulting in quantum jumps. The statistical description of this ensemble is assumed to provide the description of qualia. It seems that statistical description applies also to the geometric qualia determined by the increments of zero modes. The quantum correlates of the qualia are assumed to correspond very closely to the primary causes of the qualia (for instance, the sensation of force corresponds to the gradient of momentum of some sub-self with respect to subjective time).

Conscious experience is assumed to depend on the increments of zero modes and quantum numbers are assumed to be experienced consciously but to not contain information about the transition to which

these increments are associated. One could argue that this is too strong an idealization since quantum jump has complex anatomy and there is also an infinite variety of quantum jump anatomies with no change in quantum numbers.

Qualia can be divided into three basic types: the kinesthetic qualia (determined by increments of Poincare, color and other basic quantum numbers) in quantum jumps; the qualia corresponding to the increments of various kinds of particle numbers (say chemical qualia) and topological quantum numbers; and the entropic qualia relating to information flows associated with the sequence of quantum jumps. The connection with the statistical physics suggests that the average over the increments of the quantum numbers for the sequence of quantum jumps defining the self is experienced consciously. Sequences of sub-selves (mental images) however are experienced separately and this makes possible a temporally structured experience, so that the words of a sentence are experienced separately rather than as an average.

6.2.1 What qualia are?

Before going to a detailed model it is useful to pose the question what qualia are. The final answer (as it seems at this moment) to this question provided by the statistical physics analogy has emerged only gradually and in the following this development of ideas is summarized.

Qualia as quantum phase transitions and as discharges of quantum capacitor

In TGD framework the meaning of the primary quale is associated with the mental images created by the self-organization process. If the quale corresponds to an average increment of quantum numbers or zero modes in a long quantum jump sequence, the quantum jump with same increment must occur repeatedly. One can imagine at least two mechanism inducing qualia.

1. *Quantum phase transition produce qualia*

Quantum phase transition in which single particle transition occurs coherently for some macroscopic quantum phase produces qualia defined by the increments of quantum numbers in the transition. Quantum phase transition could be induced by the transition frequency: quantum phase transition leading to the generation of new kind of macroscopic quantum phase is in question. Transition frequencies themselves as such serve as symbols initiating this process, much like sub-program call initiates subprogram. They act like the name of dog: when dog hears its own name, dramatic self-organization process is initiated.

Music metaphor suggests that only the ratios of transition frequency to, say, cyclotron frequency can code for qualia. Only the ratios of Larmor and cyclotron frequencies and Super Virasoro frequencies and the intensities of the Fourier components for various harmonics can affect self-organization process. Furthermore, quale together with its emotional aspects depend on a simultaneous occurrence of several quantum phase transitions induced by the EEG pattern containing several magnetic transition frequencies. For instance, sensation of pain probably involves both the fundamental Super Virasoro transition frequency inducing primary quale and harmonics of this frequency at least partially responsible for the emotional aspects of pain.

2. *Discharge of quantum capacitor produces qualia*

The flow of particles with fixed quantum numbers between "electrodes" of what might be called a quantum capacitor induces qualia defined by the quantum numbers of the particles involved. The "electrodes" carry opposite net quantum numbers. Second electrode corresponds to the sub-self defining the quale mental image. Obviously cell interior and exterior are excellent candidates for the electrodes of the quantum capacitor. Also neuron and postsynaptic neuron. In fact, living matter is full of electrets defining capacitor like structures. The model of sensory receptor as a quantum capacitor will be discussed later. The model applies to various chemical qualia and also to color vision and predicts that also cells should have senses. Ordinary cells would sense only the nearby chemical environment whereas neurons would experience via synapses also representations of external world chemically: at our level of conscious experience these representations could give rise to emotions. The strange behavior of ionic currents leads to the view that even ionic channels and pumps are actually ionic and voltage receptors.

Non-geometric and geometric qualia

Various types of quantum phase transitions are natural candidates for qualia. In accordance with 'Where-What' decomposition of brain information processing, one can decompose qualia into geometric ('Where' and 'When': position, orientation,...) and non-geometric ('What': colors, tastes,..) qualia.

Geometric qualia correspond to the zero modes of configuration space in which a localization takes place in each quantum jump. An objection against the notion of geometric qualia is that the choice of the quantization axes changes in each quantum jump and it is not therefore sensible to speak about the change of quantum numbers. For a given change of quantization axes one can however assign to the final state of the quantum jump unique color and spin quantum numbers so that the increment is also unique although the 'coordinate frame' can change. Perhaps one should interpret the change of the quantization axes as a discrete quantum version of parallel translation. For the asymptotic states of self-organization the values of the zero modes are expected to approach to the values associated with a maximum of Kähler function so that the choice of the quantization axes becomes stationary.

Non-geometric qualia correspond to non-zero modes and hence to quantum jumps between states of super-symplectic and Super Kac-Moody representations. This suggests that non-geometric sensory qualia can be classified at brain level into super-symplectic qualia and Super-Kac Moody qualia.

1. Super-symplectic qualia are higher level qualia in the sense that quantum jump occurs at the level of the entire configuration space rather than at the level of space-time only. The quantum number increments (spin and color quantum numbers) associated with BE-condensing super-symplectic boson characterize the quale. BE-condensation occurs for 'configuration space photons' rather than ordinary photons whose configuration space dependence is characterized by color $SU(3)$ and spin quantum numbers.
2. Magnetic qualia could be much more primitive (perhaps kinesthetic qualia). Endogenous NMR or its generalizations could give rise to entire spectrum of magnetic qualia. Geometric data from external can be coded to zero modes of MEs, in particular the position and other geometric characteristics of sub-self (ME) representing an object of the perceptive field. Most naturally the portion of a magnetic flux tube at which ME is glued to the magnetic flux tube codes the information classically to the properties of ME, especially the light-like vacuum current and classical gauge fields associated with it. Note that this picture leaves open the identification of emotional qualia which seem to something different from sensory qualia.

The entire isometry algebra consists the function algebra of $E^2 \times CP_2$ associated with ME localized with respect to the light-like coordinate of the light-like M_+^4 projection X^3 of the light-like boundary of ME and having well defined conformal weights. This algebra is essentially the function algebra of boundary' $X^3 \times CP_2$. Each element of this algebra defines Hamiltonian depending parametrically on the radial coordinate. This algebra must be extended by the CP_2 -localized radial Virasoro algebra of the light-cone boundary to achieve Lorentz invariance. Hamiltonians have conformal weight which is integer valued. Odd integer valued Hamiltonians correspond to non-zero modes whereas even-integer valued Hamiltonians correspond to zero modes. In particular, the Hamiltonians which do not depend on the radial coordinate of the light-cone boundary and have thus vanishing conformal weight correspond to zero modes [K18].

These canonical transformations specify a very general set of choices of quantization axes.

The most general choices of the quantization axes for the canonical $E^2 \times CP_2$ sub-algebra of zero modes are parameterized by the infinite-dimensional flag-manifold defined as the coset space of the canonical group of zero modes and Cartan group of $O(2) \times SU(3)$. Thus the localization in zero modes means also a choice of the quantization axes. Since zero modes characterize macroscopic geometry of the space-time surface, this localization makes the world of the conscious experience classical.

The monomials in the enveloping algebras of the super-symplectic and Super Kac-Moody algebras defined by the configuration space isometries is the most general candidate for the algebra defining the possible increments of quantum numbers. Primary discrete qualia would correspond to non-diagonal generators of this algebra. Super algebras have decomposition into bosonic and fermionic parts and the first thing coming into mind is that bosonic generators correspond to generalized sensory qualia and fermionic generators to Boolean qualia. This algebra decomposes into zero mode and non-zero mode parts and one should decide which parts give rise to which qualia.

1. The algebra of non-zero modes is obtained by localizing zero mode super-symplectic algebra with respect to the light-like coordinate of the light-like boundary of ME so that the generators are labelled by super-symplectic conformal weight n which does not contribute to mass squared. This supports super-symmetric option: ordinary Lie-algebra generators which act like creation and annihilation operators correspond to complementary pairs of sensory qualia. The pairs of the fermionic generators correspond naturally to Boolean qualia with opposite truth values. The meaning and content of the Boolean statement should be determined by the non-geometric sensory quale associated with the corresponding bosonic generator.
2. Fermionic counterparts of the canonical zero norm generators in zero mode degrees of freedom have zero norm since gamma matrices have vanishing anti-commutators in these degrees of freedom. One might think that also the bosonic generators generate zero norm states. This is however not the case: infinitesimal isometries of the imbedding space do not correspond to pure gauge degrees of freedom. This is in fact the property that distinguishes zero mode symmetries from pure gauge transformations.
3. The interaction of super-symplectic algebra states with the classical gauge fields associated with ME induces quantum jumps. In the lowest order of perturbation theory the interaction must be linear in the generators of SCA. As higher order terms of perturbation theory become significant, also transitions generated by the higher powers of Lie-algebra generators occur with a considerable rate and enhance the experienced intensity of the quale and give rise to transitions not possible in the lowest order.

Comparison with ideas of Noe and Regan

Quite generally, discrete non-geometric sensory qualia (such as colors) must correspond to the changes of the quantum numbers in quantum jumps serving as seeds of quantum phase transitions of the quantum critical macroscopic quantum phases combining to form quantum spin glass phase. This allows to interpret the sequence of quantum jumps giving rise to a quale as a process analogous to what we do when we explore room in total darkness or what physicist does when she studies an unknown system by perturbing it slightly again and again and finding the reaction. The 'world of classical worlds' character of super-symplectic states corresponds to this idea at the level of physical states.

Lie-algebras mathematize the notion of infinitesimal change (small perturbation) induced by symmetry transformation and thus they are expected to characterize fundamental qualia. The reduction of non-geometric qualia to the representations of Super Kac-Moody and super-symplectic algebras ¹, the latter being related to the isometries of the configuration space of 3-surfaces and acting at the light-like boundaries of MEs, seems indeed possible. What is nice that super generators of the algebra could correspond to Boolean 'this is true' qualia in one-one correspondence with sensory qualia.

Poincare algebra is closely related to the Super Kac-Moody algebra. A natural expectation is that the increment of momentum should basically characterize the qualia induced by forces and torques (pressure sense, and sensations caused by ordinary and angular acceleration).

This interpretation is extremely general and implies that quantum TGD and also super Lie-algebra theory at basic level is theory of the fundamental discrete qualia. The unexpected feature is the assignment of qualia to non-diagonal generators rather than diagonal ones as quantum measurement theory would suggest. The notion of quantum jump between quantum histories however provides full support for this interpretation. The realization of the importance of the non-diagonal creation and annihilation operator like generators of Lie-algebra took surprisingly long time although the moment of consciousness is basically nothing but creation of something new and annihilation of something pre-existing. The possibility to understand the special features of color vision, such as the phenomenon of complementary colors and color contrast supports the general idea.

This view is in some aspects consistent with the view represented in the article of Regan and Noe [J79]. The authors do not believe in qualia as properties of the external world and speak about sensory modalities only. To avoid confusions, it is important to make clear that in TGD qualia and sensory modalities are used interchangeably: qualia are not properties of single quantum history but

¹Super-conformal and related super algebras are generalized Lie-algebras introduced in seventies and are encountered in both super string models and TGD.

are identified as mental images generated by self-organization processes involving huge number of quantum jumps between quantum histories.

The approach adopted in [J79] relies on experimental data about vision and states that sensory modalities can be characterized, not as properties of the world, but as modes of exploration of the world that is mediated by knowledge of what the authors call sensorimotor contingencies. More concretely, sensory experience can be identified as exploratory activity, much like feeling by fingers what the object of the tactile field is like. The structure of this exploratory activity determines the quale. What happens is that object of external world, or rather, the system consisting of observer and object of the external world, is perturbed slightly in very manner manners and this gives rise to the sensation about shape of object. The study of the responses generated by small perturbations is very much what physicist does when studying unknown physical system. The fact, that is possible to 'see' external world by signals by hearing or as vibratory stimulation of skin, supports this view.

For tactile senses and for macro-geometric aspects of all modalities this picture seems to make sense. It is however not at all obvious whether one can realize this vision at macroscopic level in the case of, say, color vision. In TGD framework entire physics reduces to configuration space geometry and classically the system representing perceiver and external world corresponds to 3-surface X^3 which can be regarded as a point like object moving in infinite-dimensional configuration space of 3-surfaces. The metaphor for active tactile sensing process could make sense at more abstract level as deduction of the position of system + perceiver 3-surface X^3 in configuration space. This process is deducing the shape of a stone by giving it small kicks. X^3 corresponds in good approximation minimum for the negative of Kähler function and sensory experience is determined by the depth and shape of the bottom of the valley of the spin glass energy landscape. In this self-organization process consisting typically of $N \sim 10^{39}$ kicks per second, the experiences created by kicks would be summed up to average experience giving a conscious view what the surroundings of object look like. This metaphor applies to the sensing of the internal state of observer itself and could involve active perturbation of parts of CNS and receiving of the response.

It is interesting to see how this picture relates to the capacitor model of sensory receptor and to the model of nerve pulse [K62] .

1. The capacitor model for sensory receptor assumes that a generalized discharge results as the charge of the other "capacitor plate" changes and crosses the threshold for the occurrence of discharge.
2. In the case of cell membrane a reduction of the magnitude of membrane voltage below criticality would be in question. W ME induces charge entanglement between magnetic body and neuron interior (second plate of the capacitor) and a quantum superposition of states "no nerve pulses" and "nerve pulse".
3. Magnetic body shares the mental images created in brain via entanglement of subselves. From the point of view of magnetic bod the sub-self represented by the entangled state experience is superposition of "no nerve pulses" and "nerve pulses" states so that conscious experience could in principle involve also the comparison aspect. This comparison aspect could explain why rational entanglement can carry positive information (recall that the p-adic variants of Shannon entropy can be negative). It must be emphasized that the comparison aspect would be due to the sharing of mental images.
4. Multiverse state would be the quantum counterpart of the small perturbation created by the magnetic body curious to get information about the state of biological body by perturbing and comparing. The remote modification of the charge density inside neuron at the "nerve pulse" branch of multiverse could be seen as a (remote) motor action in an abstract sense. Whether qualia quite generally involve generalized motor action creating multiverse making possible comparison remains an open question.

What about emotions?

What seems essential is that qualia involve meaning. In some cases this meaning is emotionally stronger (pain, pleasure), in some cases it is emotionally weaker (colors): in fact, it would seem that one could permute colors without changing much of the overall emotional meaning (actually colors can be distinguished by the behavior they induce [J81]). It seems that emotions give this meaning.

The previous ideas do not however give a slightest hint about how emotional content of the quale emerges. As a matter of fact, the first guess was that emotions are generalized sensory qualia about the state of body and averaging over sub-selves of sub-selves could explain their single pixel nature and low information content but not the emotional quale itself. This might be part of the story since the neuronal sensory experiences created by nerve pulses at synapses at level of neuronal bodies could determine the emotions. Also cellular qualia about nearby chemical environment could contribute to emotions. The realization of the connection with statistical physics led to more concrete ideas about how emotional content of conscious experience might emerge.

Second guess is that emotions and also cognitions correspond to sensory qualia of magnetic body and perhaps correspond to higher level of dark matter hierarchy than ordinary sensory qualia. This leads to a rather concrete view about emotions and cognitions as patterns of cyclotron phase transitions induced at the magnetic body by EEG radiation consisting of dark photons. Entire fractal hierarchy of EEGs, ZEGs, WEGs, and GEGs corresponding to photons, Z^0 bosons, W bosons, and gluons and labelled by p-adic length scales and values of the Planck constant is predicted. Charged bosons could correspond in this framework to sensory qualia in the standard sense of the word whereas neutral bosons could correspond to cognitive and emotional qualia.

General classification of qualia inspired by the connection with quantum measurement theory and statistical physics

The connection between qualia and quantum measurement theory and statistical physics was the real breakthrough in the development of ideas. In some sense this finding is not a news: the close connection between pressure sense and temperature sense and thermodynamics is basic facts of psychophysics and quantum measurement theory involves in essential manner consciousness. First of all, millenium had to change before I realized that quantum TGD predicts standard quantum measurement theory. Each quantum jump can be regarded as an ordinary quantum measurement involving a localization in zero modes representing geometric information following by a state preparation procedure realized as a sequence of self measurements whose dynamics is dictated by Negentropy Maximization Principle (NMP). This suggests strongly the division of qualia to geometric qualia associated with quantum measurement part of quantum jump and non-geometric qualia associated with the state preparation stage.

In TGD framework the contents of consciousness is determined as some kind of average over the sequence of a very large number of quantum jumps defining self. This suggests that qualia allow a statistical description generalizing ordinary thermodynamical ensemble to the ensemble formed by the prepared states in the sequence of quantum jumps after the last 'wake-up' of self. This ensemble is dynamical since each quantum jump generates a new member in the ensemble. In standard statistical physics the notion of ensemble is only a fictive concept but in the ensemble defined by self would be the fundamental statistical ensemble realized at the level of subjective existence. Therefore consciousness theory would provide foundations of both quantum measurement theory and of statistical physics. Before continuing, notice that this picture allows to see the ageing of self with respect to subjective time as a universal phenomenon resulting from an approach to thermal equilibrium. Getting tired would be only one aspect of the same phenomenon. Also mental images should age and this would correspond to gradual loss of the sharpness of the mental image.

Quite generally, one can divide qualia to the geometric qualia characterized by the increments of the zero modes, to the generalized kinesthetic qualia characterized by the increments of Poincare, color and electro-weak quantum numbers, to the generalized chemical qualia labelled by the increments of various particle numbers, such as the numbers of ions or Cooper pairs in various magnetic states and the topological quantum numbers characterizing the topology of the many-sheeted space-time surface, and to the information theoretic qualia characterized by entropy gradients. Besides the gradients of the state variables with respect to subjective time for the statistical ensemble determined by the quantum jumps, also the values of the state variables themselves contribute to the contents of conscious experience. It would thus seem that the theory of qualia reduces to statistical physics and one can expect rather concrete correspondences between sensory inputs and their quantum correlates. In particular various physical metaphors for conscious experience might find a justification in this approach.

6.2.2 Classification of qualia in thermodynamical framework

Consider now the general classification of qualia in this conceptual framework.

Do qualia depend on the averages of quantum number increments only?

Functionalism, which has been one of the dominating views in neuroscience, states roughly that the contents of consciousness of system is determined solely by its functional structure. The analog of this hypothesis in TGD framework states that the contents of consciousness are determined completely by the increments of zero modes, quantum numbers and particle numbers in various quantum jumps in context independent manner. This hypothesis has very strong implications and internal consistency requirements make possible to test it. For instance, kinesthetic qualia characterized by the increments of Poincare, color and electro-weak quantum numbers would be universal and would not depend on the system to which they are associated.

1. All quantum phase transitions involve frequency increments. Therefore, if hearing is frequency quale and if energy and frequency increments are equivalent, some kind of auditory sensation should be involved with all sensory experiences. The fact that EEG frequencies cover only a small part of the range of audible frequencies, the weakness for the intensity of this sensation could explain why visual and other experiences do not involve sensation of hearing something. One could also argue that the background noise always present in auditory experience actually corresponds to the contribution from other senses.

Also deaf persons should experience some kind of auditory sensation, kind of background noise, if this view is correct. Interesting question is whether this sensation is present if person is made cortically deaf in an artificial manner. One must of course be very cautious here: it might be that this sensation relates only to the dynamical nature of hearing: several qualia, such as pain, have similar time-like nature.

2. The increments of various quantum numbers in magnetic quantum phase transitions would yield similar sensory experiences, generally kinesthetic experiences.

The connection of the theory of qualia with the statistical physics suggests that self experiences some kind of average over the experiences associated with the quantum jumps of subself but self itself at highest dark matter level corresponds to single moment of consciousness. Thus averages of the increments of zero modes and various quantum numbers would dictate the contents of mental images. This would in general mean that the approach to a thermal equilibrium would make conscious experience increasingly diffuse when sub-self (mental image) ages unless sub-self is able to fight against second law. Macro-temporal quantum coherence allows to circumvent the pessimistic conclusion that every mental images in the human time scale of order .1 second consists of about 10^{38} quantum jumps and should be completely fuzzy as a statistical average. Note also that dark matter hierarchy implies hierarchy of average geometric durations of moments of consciousness.

If averages over the increments of zero modes are experienced this implies that kind of a zigzag curve defined by the averages of the increments of the zero modes formed by sub-selves is experienced consciously but not the initial point of this curve. Kind of a principle of relativity at the level of conscious experience would be in question. In fact, it is very difficult to imagine, how zero modes as such could be experienced. For instance, the huge symmetries involved would make it impossible to experience differently symmetry related points. Note that also in physics one can measure only changes of the observables, rather than observables themselves. The fact that conscious observation of visual textures (say lines) is not possible without saccadic motion is consistent with the assumption that only the increments of the zero modes are experienced consciously. The assumption that intersections of the line sight with lines of figure are time coded is consistent with the assumption that short time averages of zero mode increments are coded to sub-selves.

The fact that position and momentum are quantum incompatible qualia seems to be incompatible with the belief that we experience these geometric qualia simultaneously. One could think that it could be possible to circumvent Uncertainty Principle at the level of conscious experience by using the fact that the velocities that we observe are not velocities with respect to geometric time but with respect to subjective time. This is not the case if we experience only the increments of the zero modes which are analogous to momentum variables. The presence of sub-selves each representing

some average value of a zero mode increment make it possible to have an idea about continuous path in zero modes which, in accordance with Uncertainty Principle, is however determined apart from a shift in the space of zero modes.

Various types of non-geometric qualia

As found, one can classify qualia into geometric and non-geometric qualia. Geometric qualia correspond to the increments of zero modes expressing the result of quantum measurement in each quantum jump. All geometric information about space-time surface should reduce to geometric qualia. For instance, geometric data given by visual, auditory, and tactile senses should reduce to conscious information increments of zero modes in the quantum jump. Non-geometric qualia correspond to the preparation of state stage of the quantum jump during which zero modes remain constant.

The sequence of the prepared states can be modelled as a statistical ensemble of Fock states, which suggests that thermodynamics, which like quantum measurement theory is a black sheet of fundamental physics, forms basically a part of the theory of consciousness. The ensemble of prepared states gives rise to a large number of statistical qualia. The relationship $dE = TdS - PdV + \mu dN + B \cdot dM \dots$ generalizes to TGD context: note however that in the case of ME selves energy is replaced with the Super Virasoro generator L_0 associated with the light-cone boundary of ME, which for super-symplectic representations need not annihilate the physical states. Each intensive-extensive variable pair in the differential should correspond to a non-geometric quale, which results only when there is gradient (flow) of the extensive variable in the direction of the subjective time. Super-symplectic thermodynamics should obviously map ordinary thermodynamics to the level of conscious experience.

The thermodynamical expression for dE suggests a general classification of qualia consistent with the 'holy trinity' of existences implied by TGD.

1. Emotions as order-disorder qualia

$T - S$ pair correspond subjective existence and generalizes to disorder-order type, information theoretic qualia about the state of self: hot-cold and pain-pleasure type sensations and also more abstract experiences associated with various sub-selves of self. These qualia are strongly emotional single-pixel holistic qualia measuring whether some kind of an entropy variable is increasing or decreasing. Also zero modes define a statistical ensemble and these geometric emotional qualia might be about external world: perhaps aesthetic experiences and other 'non-self-centered' emotions could be in question. The total entropy for the statistical ensemble defined by self determines how sharp the mental image is. Low entropy content means alertness and attentiveness. High entropy content means fuzzy mental image. Getting tired means inability to keep mental images in low entropy state. Fighting against the second law is an essential part in the martial art of having sharp conscious experiences.

2. Kinesthetic qualia defined by generalized forces

$p-V$ pair corresponds to the geometric existence and is replaced with generalized force-generalized coordinate pairs in quantum fluctuating degrees of freedom. The increments of maximum number of mutually commuting Poincare, color and electro-weak quantum numbers define this kind of qualia. The increments of four-momentum code for the sensation of force whereas the increments of orbital angular momentum code for the sensation of torque.

Tactile senses such as pressure sense and their generalizations involve kinesthetic qualia. The increment of energy or equivalently, increment of frequency, can be identified as a correlate for hearing in generalized sense responsible for the essentially dynamical nature of the auditory experience (hearing is time-like version of force sense). Whether spin flip codes something different from torque, and what this something different might be, is not obvious. I

The rate for the increase of the two diagonal color quantum numbers should code intensity type variables associated with color sensation. At least the intensity of color is this kind of variable. The rate for the increase of electric charge of sub-self should code for electric sense possessed by, say, fishes. Also $B - M$, $\phi\rho$ and $E - P$ pairs correspond to generalized forces since electromagnetic fields are reduced to space-time geometry in TGD framework.

3. Generalized chemical qualia

$\mu - N$ pair corresponds to 'objective existence' defined by quantum histories with N being gen-

eralized to a number of particle like excitations in the Fock state resulting in the state preparation. In this case there must be a flow of particle number in the direction of the subjective time, that is Bose-Einstein condensation type process for, say Cooper pairs. That is the particle number of sub-self increases or decreases. Quite generally, super-symplectic and Super Kac-Moody algebras should define these qualia and the number of these qualia is very large.

1. One can assign particle numbers to super-conducting phases with various magnetic quantum numbers and these could define generalized chemical qualia. They could perhaps be regarded as qualia and subqualia of chemical qualia defined by a particular ion and chemical qualia could actually reduce to magnetic qualia. Since the changes of the magnetic field induce these quantum phase transition, it would seem that magnetic quantum phase transitions at super-conducting magnetic flux tubes could induce this kind of qualia besides kinesthetic qualia. In principle, endogenous NMR and its generalizations induced by the interaction of magnetic fields of MEs with magnetic magnetic flux tube structures are possible.

Our chemical qualia could correspond to the Bose-Einstein condensation of ions to the super-conducting magnetic flux tubes. The paradigm of four-dimensional brain allows even the possibility that these ions are ions of the tastant or odorant. Also secondary representations at the level of cortex in terms of super-conducting light ions are possible and would give rise to a classification of primary tastes and odors. Magnetic qualia are characterized by definite transition frequencies and this makes possible place (time) coding by magnetic transition frequencies if magnetic field varies along magnetic flux tube (is a function of time). The activation of a point of the living sensory map would generate some quale at that point.

2. For super-symplectic qualia the number of Bose-Einstein condensed possibly colored 'configuration space photons' having nontrivial dependence on configuration space degrees of freedom replaces number of molecules. The condensation rates for the numbers of the configuration space photons with non-vanishing color quantum numbers could be interpreted as correlates of color qualia, whereas the condensation rates for color singlet configuration space photons could relate to the intensity of color sensation. If the rates for the transfer of color quantum numbers define intensity type variables associated with the color sensation, then BE condensation to color singlet states does not give rise to experienced quale so that only non-diagonal color generators correspond to visual colors. Also the BE condensation of the ordinary coherent light should give rise to some kind of quale: perhaps vibratory sense which can be developed to effective vision, could correspond to non-colored vision. Configuration space Hamiltonians are also labelled by 2-dimensional orbital spin quantum number and longitudinal momentum. Polarization sense and sensation about motion of the object of visual field would naturally relate to spin and longitudinal momentum.
3. Tactile senses involve topological phase transitions involving the creation of join along boundaries contacts between object and skin whose number would thus be the relevant variable. The purely sensory aspect of physical pain could correspond to a topological phase transition involving the splitting of join-along boundaries bonds between space-time sheets (MEs could even define these bonds) so that N would be now the number of join along boundaries bonds. The simplest picture requires that the MEs associated with sensory organs are connected to the MEs responsible for our experience. Of course, splitting and generation of join along boundaries contacts could occur also at the level of sensory representations.

4. Boolean qualia

Boolean qualia would be naturally associated with fermion number or fermionic spin degrees of freedom. There are super-symplectic and super-Kac Moody type Boolean qualia. The spin flipping transitions associated with the fermionic generators of super-symplectic algebra might give rise to Boolean consciousness with intrinsic meaning ('This is true/false').

Fermion number $1/0$ can also represent truth value when wormhole contacts with fermion and antifermion at causal horizons of the wormhole contact (having interpretation as partons) are used. The assumption that only fermions/antifermions are associated with the "upper" space-time sheet would select automatically a maximal set of independent statements. Boolean statements could be

seen as particle-antiparticle pairs living simultaneously at two space-time sheets and one might speak about 'Boolean matter'.

In zero energy ontology quantum states are pairs of positive and negative energy states with opposite net quantum numbers. Therefore it is possible to represent Boolean statements in such a manner that fermion number represents bit. This also gives rise to a representation of Boolean rule $A \rightarrow B$ as quantum superposition of pairs of Fock states of fermions with individual instances of A and B represented by the states in the Fock basis for fermions. The basic "laws" for this system of rules would be consistent with the conservation laws.

One can argue that the experience of true/false involves always comparison. As proposed, during sharing of mental images the entanglement of two states could also involve comparison which would explain the positive information content of the rational (algebraic) entanglement in p-adic sense. If indeed so, one might think that the conscious experience that statement is true involves a comparison of the statement with a collection of the true reference statements, one half of all possible statements for a given Boolean algebra constructed from N elementary statements and having 2^{N-1} mutually consistent true statements. If true statements are represented as their negation in comparison process based on entanglement, 'false' would mean that for one comparison the statement and reference statement area identical and entanglement is not possible and no shared mental image is formed. For 'true' the entanglement is possible for all comparisons.

A general model for abstraction process not only explains the basic numbers of the genetic code but also suggests an entire hierarchy of codes [K35] in accordance with fractality of TGD Universe. The next code in the hierarchy is very attractive candidate for 'memetic code'. The hypothesis predicts correctly the .1 second time scale for the duration of 'our' self (immediate short term memory, duration of psychological moment). Codewords corresponds to sequences of 126 bits with duration of one millisecond: this is indeed the time scale of nerve pulse. The most plausible realization of the codon of the memetic code is in terms of electron's CD of duration .1 s containing d quark sub- CD s of duration $1/1.28$ ms representing the bits. The frequency of about 10 Hz is in EEG frequency range and also corresponds to ELF topological field quanta with size of Earth representing our cognitive sub-self. Dark matter hierarchy represents a hierarchy of durations of memetic codon coming as $T = rT_0$, $T_0 = .1$ seconds and r is integer valued.

About quantum correlates of alertness and attention

It is a matter of definition whether one can regard alertness, attention, the level of arousal, and other similar attributes of conscious experience as qualia. What is clear that they are not geometric, sensory or emotional qualia. A possible identification for the quantum correlates of this kind of aspects of conscious experience might be based on the entropy type variables associated with the statistical ensemble defined by self. Thus also entropy rather than only its gradient with subjective time would characterize the conscious experience. Very high/low entropy would obviously mean correlate with diffuse/sharp conscious experience. Obviously macro-temporal quantum coherence would be absolutely essential for having sharp mental images. In this picture alertness would correspond to low entropy state, possibly very few mental images which would have very low entropy. Directing attention to some object of perceptive field could also be regarded as purposeful reduction of the entropy of the sub-self representing the attended mental image. For instance, the diffuse background of my computer screen would correspond to high entropy sub-self and the icon to which I am concentrating my attention corresponds to the low entropy sub-self.

Directing attention to an object of the perceptive field involves amplification type phenomenon and is seen directly as neural activity. This activity would make possible to fight successfully against second law so that the entropy of the attended sub-self would be reduced rather than increase. 7 ± 2 rule might be interpreted as stating that 7 ± 2 is the maximum number of mental images (sub-selves) which can be kept in a low-entropy state simultaneously. Meditative practices often involve concentration of the attention to some object of perceptive field: the number of mental images would be thus minimized to achieve low entropy state of pure alertness. It is interesting to compare the notions of attention and arousal. Arousal wakes-up several mental images. Highly alert state can be even empty of mental images (sub-selves). High level of arousal necessarily involves entropy growth of the mental images by 7 ± 2 rule. One form of attention deficit disorder would involve generation of too many mental images so that mental images necessary become entropic.

Getting tired and fatigue would mean the inability to keep mental images in a low entropy state.

The connection with the level of metabolism is thus obvious. One function of sleep might be to 'kill' mental images with long wake-up period so that they can reincarnate in a low entropy state. Without this these mental images would become more and more entropic. Sleep would be a fractal phenomenon having counterpart at all time scales: for instance, the wake-up time for sensory mental images would be of order .1 seconds.

6.2.3 Critical questions and open problems

The identification of qualia involves several open questions and the best manner to proceed is to make the unclear aspects of the model as explicit as possible.

Does the brain construct meta-stable sensory maps?

Several highly interesting questions relate to sensory maps. For instance, does brain construct quasi-static sensory maps for the visual world updated continually? The view represented in [J79] is that this need not be the case, and is motivated by several empirical facts, in particular by the observations that there seems to be no visual memory besides the memory of duration of order .1 seconds. It is further argued in [J79] that external world provides the fundamental representation.

Also TGD framework suggests the possibility that the MEs connecting retinas to the object of the perceptive field might be essential for our ability to experience the object of perceptive field as a part of external world. TGD predicts that objects of perceptive field are represented as mind like space-time sheets. Where these mental images are located is a difficult question to answer but the most elegant option is that they reside at the level of sensory organs [K40]. Sensory organs have also magnetic bodies, which can serve as seats for the fundamental sensory representations. Brain would in turn construct symbolic and cognitive representations entangled with these fundamental sensory representations. These representations would entangle with mental images at magnetic bodies associated with various parts of brain so that the resulting structure would have astrophysical size.

If this is the case then the experienced position of the object of perceptive field corresponds to the position of this mind like sheet at the sensory magnetic canvas associated with eyes. Brain would somehow deduce the distances and sizes of the objective of the perceptive field and by back-projection mechanism construct the sensory representation at the level of sensory organs. Remote tactile sensing and the ability to 'see' external world by vibratory sense [J79] support the view that it is orientation-position quale which determines whether an object of perceptive field is experienced as belonging to external world or to body. Also the illusions associated with tactile senses, such as the experienced location of sensation to even dead material object of perceptive field, suggest the same. Perhaps one must make here a careful distinction between sensations about external world on one hand, and about body and body-external world boundary on the other hand.

In TGD view our eyes can be visualized as tubes connecting brain to external world and changing their orientation all the time. Through these tubes light enters to a screen representing visual cortex in a room representing head. Also head is moving and changing its orientation with respect to the external world all the time. The mind like space-time sheets representing objects of perceptive field are certainly present, but they are not static but short-lived objects, having lifetimes not longer than .1 seconds and are recreated all the time and in general in new position of the visual cortex. There is no homunculus inside this room; the experience is not computed nor do 40 Hz EEG waves in some mysterious manner give rise to experience. It is self-organization processes generated by nerve pulse patterns coming from sensory organs and generated by brain itself which give rise to qualia and magnetic transition frequencies serve as names for these processes.

Are super-symplectic qualia associated with vision only?

Super-symplectic qualia are labelled by the increments of color and 2-dimensional spin quantum numbers which for 8-dimensional basic representation correspond naturally to 3+3 basic colors and to polarization sense.

The idea that qualia should correspond very closely to the physical phenomena what qualia suggests that super-symplectic qualia are associated with vision. Light-like 3-surfaces associated with MEs provide indeed classical model for a light front and MEs themselves model geometrical optics in a well-defined sense. MEs inside MEs represent naturally light rays. Also the two-dimensionality of

light-like coordinate constant section of the light-like boundary conforms with the two-dimensional nature of the visual experience. In the case of other qualia (except perhaps tactile senses) the two-dimensionality of the objects of the perceptive field is not obvious.

One cannot exclude the possibility that color Lie-algebra, as opposed to higher representations of color group, could correspond to colors, tastes and basic tactile qualia (warm, cold, pain,...). In the case of odors, and perhaps also in the case of tactile qualia, CP_2 Hamiltonians in higher-dimensional representations of the color group would be needed to account for the large number of these qualia. One could even ask whether some emotional qualia could involve super-symplectic BE condensation type phase transitions or possible phase transition changing the direction of spin polarization of the BE condensate of configuration space photons. Although the connection with thermodynamics excludes this possibility, pros and cons of this kind of identification are still worth of a detailed consideration.

1. MEs seem to correspond to the most abstract level in the control hierarchy formed by MEs, superconducting magnetic flux tubes and ordinary matter. More precisely, super-symplectic states are state functionals in the space of three-surfaces, 'world of classical worlds' and thus correspond to a higher level of abstraction. This would suggest that our qualia should correspond to what happens on the light-like boundaries of MEs. One could however identify super-symplectic-magnetic dichotomy with spirit-flesh dichotomy so that visual experience would represent higher level sense in comparison to other senses.
2. Colors, tastes, odors and tactile qualia like cold, warm and pain allow dichotomic pairs supports the identification as discrete qualia. These good-bad dichotomies are analogous to color-complementary, which supports the view that they could correspond super-symplectic qualia. On the other hand, all sensory qualia can be accompanied by strong entropy gradients explaining positive/negative emotional aspects for qualia such as odors. For reasons of survival organism might even amplify these entropic gradients.
3. One could argue that also emotions could regarded as generalized sensory qualia and the interpretation of pure emotions coming as dichotomic pairs of complementary emotional colors does not exclude the identification in terms of SCA. Emotions involve however often also comparison aspect and this could be reduced to the geometric aspect of the generalized sensory experience represented as a flag-manifold quale representing information about the space-time surface describing the state of body and CNS geometrically. Therefore, if emotions are accompanied by super-symplectic qualia, they represent pure emotion without any comparison aspect. Does it make sense to speak about, say, pure rage, is difficult philosophical problem.
4. Zero modes involve infinite hierarchy of CP_2 Hamiltonians grouped into representations of color group and odors should correspond to Lie-algebra generators belonging to higher representations of color group instead of octet representation. The simplest vision is that the only difference between colors and, say, odors and tastes is that the Hamiltonians belong to different representations of the color group. The prediction would be that the phenomenon of color contrast and perhaps even color constancy should have counterparts at the level of other qualia. One can argue that this kind of close structural relationship should have been observed if it is really there and tables organizing various sensory qualia neatly to the representations of color group could be found in the text books of neuroscience.
5. One can also wonder why higher representations of color algebra should be experienced so differently from the 8-dimensional representations assumed to be responsible for visual colors. This picture also requires that configuration space photons belonging to only single color representation are produced in sensory pathway. It is difficult to imagine a mechanism producing configuration space photons belonging to only single color representation unless it is octet representation. One could also argue that only configuration space photons in octet representation are produced abundantly and that this is due to the classical color gauge fields accompanying classical electromagnetic fields: if so then higher colors would be rarely realized as conscious qualia.

The assumption that only color octets qualia are possible, allows in principle the identification of colors, tastes and tactile qualia as generalized colors cannot be excluded. Thus a more detailed analysis of this option is motivated.

1. The simplest hypothesis is that 6 basic colors, tastes and basic tactile qualia could all correspond to color flips. This hypothesis is very strong since it suggests that the basic phenomena of color perception such as complementary colors, color contrast, color constancy and possibly even color summation (this phenomenon involves also neural circuitry in essential manner) could have tactile and gustatory counterparts.
2. In the case of tactile senses the very fact that cool resp. warm serves as metaphor for black, blue and green resp. white, yellow and red, encourages the view that tactile qualia correspond to color algebra. In this spirit one could identify the dichotomic pairs cold-warm, pain-pleasant touch and touch-sensation of numbness as counterparts of 3 pairs of color generators of with opposite quantum numbers. Numbness is indeed quale in itself and analogous to sensation of black since it is experienced in absence of sensory input from skin. Proprioception could perhaps be understood as a mixture of sensations of touch and pain-pleasure sensation with geometric qualia. If this view is correct, then superficial touch and pressure sensation are analogous to sensation of color white at different values of brightness.
3. Model predicts six basic tastes. There is evidence for five basic tastes [J44] but situation has not been resolved. Dichotomies suggest that the triplet of bitter, sour and salty corresponds to the triplet of cool colors whereas the sweet, the fifth taste and some sixth taste. One possibility is that different variants of sweet are in question: for instance, sugar and salt and sweet-sour could correspond to different variants of sweet. The sixth taste complementary to bitter could be analogous to color black or sensation of numbness. Very strongly flavored food or bitter food could perhaps induce experience of sixth taste in the same manner as very bright light dazzles.

The basic objection against this kind of assignments is that the tactile and gustatory counterparts of color complementarity and color contrast need not make sense: to my best unprofessional knowledge these phenomena are not observed. One must be however very cautious: these phenomena might be masked by the emotional reactions accompanying these sensations, by the complexity of the phenomena involved and by the non-topographical character of odor and taste perception. For instance, color contrast phenomenon requires precise object-background separation not possible in the case of odors and tastes. Summation of colors red and green to yellow involves also neural circuitry and does not generalized to the case of tactile senses, tastes and odors.

How qualia are compared?

An interesting question is how geometric qualia are compared consciously. Velocities might be regarded as basic types of qualia for which this kind of comparison occurs. It however seems that velocity type qualia reduce to experience of self about genuine motion of sub-selves inside it if geometric coordinates are mapped to spatial arrays of neurons such that given neuron (or large structure) is sensitive to particular EEG frequency and represents point of map which becomes 'alive' when it is activated. Self could also automatically compare the sub-selves representing qualia of same type so that not specific mechanism would be needed. Concerning the comparison of qualia, an interesting idea is that the simultaneous experience of these slightly different qualia gives rise to the simultaneous wake-up of nearby points of the sensory map. This mechanism might be the same as involved with the binaural beat [J63]. This beat mechanism makes it possible, not only to discriminate between slightly different frequencies but also to 'hear' very low frequencies not otherwise audible to us. For instance, when one feeds slightly different audible frequencies to ears, difference frequency is heard consciously. Of course, one can argue that this anomalous hearing has nothing to do with comparison in the fundamental sense.

Association problem

How different type qualia are associated with each other? Is spatial and temporal association in the geometric sense always necessary or could it be enough to associate the qualia in subjective time so that they would be associated with same quantum jump and same sub-self always? It would seem that geometric association with same sub-self is the most natural option. Topographical association by the topology of neural circuits is the simplest manner to achieve this and should be involved with vision. The coding of qualia by EEG frequencies is second option. In the case of magnetic transition

frequencies continuous spectrum of positions can be coded. Of p-adic lengths define preferred lengths for MEs then the frequency spectrum would be discrete given by integer multiples of basic length: discretization of positional qualia would result if the fundamental frequencies of MEs code for position.

6.3 About the identification of the non-geometric qualia

Non-geometric qualia by definition correspond to the quale associated with the state preparation part of quantum jump whereas geometric qualia are understood as characterized by the increments of the zero modes fixed in quantum measurement part of quantum jump. This terminology is somewhat clumsy since one could argue that qualia like pressure and force sense are in a very general sense geometrical.

6.3.1 Color vision and super-symplectic algebra

Super-symplectic algebra contains infinite number of Hamiltonians in representations of color group and possessing definite two-dimensional spin. For color octet representations, which is the lowest one, there are 3+3 non-diagonal oscillator operator like color generators with opposite quantum numbers. Perhaps the discoverers of color symmetry had some precognition about the possible role of this symmetry when they jokingly choose to call it color symmetry. The 3+3 color generators carrying opposite quantum numbers indeed can be related to the six primary colors forming complementary pairs (with black and white included). This identification, originally stimulated by the observations of mathematician Barbara Shipman [A13] about the dance of honeybee, makes sense.

TGD predicts that classical em field are accompanied by classical long range color fields and super-symplectic representation can give rise to colored states. Of course, quantum jumps of any color system could give rise to color qualia and one cannot even exclude copies of QCD in the length scales of living matter in TGD framework: if this is the case then even the generation of color charged gluons quantum coherently could give rise to color quale. A very strong support for the correctness of the prediction is that it nicely explains the basic characteristics of color vision (color contrast, color opponency, color constancy) besides reducing the existence of six primary colors to the symmetries of the 8-dimensional imbedding space (the structure of which can thus be deduced from the basic properties of color vision!). Perhaps the most realistic interpretation of the higher color representations is as higher level colors. One cannot however exclude the possibility that these representations could act as correlates for other qualia, such as odors and tastes.

Basic facts about color vision

Color space provides a multidimensional representation for different color experiences and satisfying the requirement that colors producing nearly same experience are represented by nearby points of color space. Color circle devised by Newton is the simplest example of color space and provides very economical manner to represent huge amount of information about experience of color (say the fact that blue is more similar to purple than it is to yellow). One can classify colors into spectral colors present in rainbow and non-spectral colors, including many reds, all magentas and most purples and also brown. The famous 'inverted spectrum argument' of Locke states that other people might have the same overall set of color experiences as you but differently connected to objects in the external world. For instance, you might experience the colors of rainbow as inverted: your 'red' might be my 'blue'. This is clearly about possible symmetries of the color space and the very emergence of symmetries is consistent with the idea that qualia correspond at the fundamental level to Lie-algebra generators.

Colors can be represented as composites of primary colors defined as colors which have no other 'colorishness' in them: for instance, orange has some yellowishness and redness in it. Red, green, blue and yellow are the primary colors and correspond to diametrically opposite points along the two orthogonal axes of color plane. Complete model of color experience must explain the existence of the primary colors and why some colors are experienced as composite of them. It is clear that the existence of fundamental colors breaks complete color symmetry and leaves only discrete set of symmetries consisting of rotations by multiples of $\pi/2$ and reflections with respect to two color axes and two axes forming angle $\pi/4$ with respect to them. Also these symmetries are broken as detailed study of behavior correlates of color experience has demonstrated [J81]. Color circle is not a complete

model of color experience since it leaves out the vast majority of color experiences, including white and black, all their mixtures with each other (grays) and their mixtures with chromatic colors.

One can however generalize color circle to 3-dimensional color space by introducing white-black axis orthogonal to green-red and yellow-blue axis. The three cylindrical coordinates of color space are called hue, saturation and lightness (or brightness). Hue is the azimuthal angle along color circle and corresponds to the basic 'color' of surface. Saturation represents the vividness of color experience and corresponds to the perpendicular distance from the central axis for the position of the color experience in color space. For instance, the vivid colors of rainbow lie along the outside edge. All the grays lie along the central axis because they have zero saturation. The 'muted', 'muddy' and 'pastel' in between have intermediate levels of saturation. The third dimension of surface color is lightness and refers to the height of color's position. The color circle corresponds to the perimeter of an oblique section through this color solid. This section is oblique because the most saturated yellows are quite light and therefore higher in color spaces whereas the most saturated blues and purples are quite dark and therefore lower in color space.

The phenomena of color constancy, color summation and color contrast are further phenomena related to color vision. Color constancy means that completely homogenous lighting of the visual field by monochromatic light gives rise to no color experiences. This is as it should be since in natural conditions the lighting conditions change all the time. Color summation says that basic colors red, green and blue in suitable proportions sum up to white color. Color contrast means that the region around objects having primary color inherit slight complementary colorishness. For instance, grey object in a red background looks somewhat greenish. The phenomena of color constancy, color contrast and color summation can be satisfactorily understood in terms of experimentally established neural mechanisms [J44] . This does not of course eliminate the need for deeper explanation: the neural mechanisms involved might only reflect the more fundamental facts about color vision.

Can one understand colors Lie-algebraically?

Could one understand these basic facts about color vision in terms of color Lie-algebra? The first question is whether to assign to visual colors the color quantum numbers of states or the color numbers characterizing the changes of states. One could indeed consider the association of three primary chromatic colors and their complementary colors with quark triplet and antiquark triplet, with antitriplet perhaps resulting in tensor product of operation for two triplets. The however implies that color rotation changing the quantization axes should change also the color experience and replace primary colors with new ones: it is however an experimental fact that primary colors are something unique. If they correspond to changes of color quantum numbers induced by specific Lie-algebra generators this is true independently of the particular quantization axes used.

Taking seriously the idea that color Lie-algebra might represent basic facts about color experience, the next question concerns the detailed identification of colors with Lie-algebra generators of color algebra.

1. What seems obvious is that complementary colors must correspond to Lie-algebra generators with opposite sign of quantum numbers. With this assumption 3-dimensional color space could be understood as a space spanned by three diagonal color generators for which there are no linear dependences between color quantum numbers.
2. Primary colors correspond to the six non-diagonal Lie-algebra generators consisting of 3 creation operator like and 3 annihilation operator like generators. There are six primary colors red-green, yellow-blue and white-black.

This leaves only one possibility: the six non-diagonal generators of color algebra correspond to all the primary colors with white and black included. This conclusion came as a little surprise since the identification of white-black pair as associated with spin flips was competing hypothesis.

3. All color pairs are dichotomic pairs providing metaphorical representation for cool-warm dichotomy such that red, yellow and white correspond to warm colors and green, blue and black correspond to cool colors. What could distinguish between white-black pair and non-chromatic colors is color hypercharge: white and black would have vanishing hyper charge. Thus the following identification of quantum number increments (hypercharge and isospin represented as column vector) associated with various colors suggests itself:

$$\begin{aligned}
\begin{pmatrix} 0 \\ 1 \end{pmatrix} &\leftrightarrow \textit{white} & \begin{pmatrix} 0 \\ -1 \end{pmatrix} &\leftrightarrow \textit{black} \\
\begin{pmatrix} 1 \\ 1/2 \end{pmatrix} &\leftrightarrow \textit{red} & \begin{pmatrix} -1 \\ -1/2 \end{pmatrix} &\leftrightarrow \textit{green} \\
\begin{pmatrix} 1 \\ -1/2 \end{pmatrix} &\leftrightarrow \textit{blue} & \begin{pmatrix} -1 \\ +1/2 \end{pmatrix} &\leftrightarrow \textit{yellow}
\end{aligned} \tag{6.3.1}$$

It seems that one can indeed reduce color opponency, color contrast and color constancy to deeper level in this framework.

1. Opponent process theory of Ewald Hering [J44] explains basic facts about color summation (for example, summation of red and green to yellow which cannot be understood as summation of color quantum numbers). Color opponent processing means that the members of each pair of complementary colors (red, green), (blue, yellow) and (white, black) tend to compete in the sense that receptors give excitatory response for color and inhibitory response for complementary color, or vice versa.

Therefore no sensory experience results for suitably balanced intensities of light for complementary colors. For instance, in the case of red and green the sensation of yellow which represents a wavelength between these two remains as a result of this competition. Color opponency can be understood as reflecting the competition between quantum jump and its reversal induced by two Lie-algebra generators acting like creation and annihilation operators with same color quantum numbers. Note that the sensation of darkness after closing eyes could correlate with quantum jumps in which the ions or Cooper pairs of macroscopic quantum phase generated by quantum jumps 'white' gradually decays back to ground state by quantum jumps 'black'. This suggest that same phenomenon should be associated also with other colors. This would mean that immediate after images should tend to have complementary color. Dazzling phenomenon could result from the depletion of the macroscopic quantum phase from which quantum jumps 'white' occur.

2. Color contrast is apparently just the opposite of color opponency: region of given color creates the illusion that background has tinge of complementary color. Thus the complementary colors seem to facilitate each other across boundaries whereas inside the boundaries they tend to cancel each. The called double-opponent cells located in the visual cortex can explain at least partially color contrast phenomenon [J44].

A more fundamental explanation is based on the properties of color-charged macroscopic quantum phase and on the properties of the classical color field accompanying ELF em field associated with EEG and inducing the color quantum jumps. Color confinement requires that color charge density of the macroscopic quantum phase formed by exotic super-symplectic representations is such that net color vanishes. Thus a region containing exotic particles with given color quantum numbers would be surrounded by a region of opposite color quantum numbers. Only the second sign for the increment of color quantum numbers is possible for a given colored state of lowest-dimensional representations of color group as one finds easily by studying color triplet and octet representations. Color contrast would thus result from the fact that classical color gauge field does not approach zero sufficiently fast at the boundary of colored region and as a real field necessarily contains with the same intensity the Lie-algebra components stimulating color and its complementary color.

3. Color constancy can be reduced to the phenomenon of color contrast. If the net color charge of a color charged Super Virasoro quantum phase vanishes, there must be also a region of complementary color charge. Since this is not possible for a constant illumination by monochromatic light, no sensory experience results. Color constancy is not absolute law: the exceptional cases could correspond to situations in which the entire perceptive field is not actually perceived and

this effectively leads to the situation in which constant illumination covers only part of the visual field. In this case complementary colors should be seen on the boundaries.

The neurology-inspired manner to understand color constancy is that color vision involves comparison in an essential manner. One might say that conscious experience is generated as an integral of the derivative of the intensity of the sensory input such that the initial values at the boundaries of the perceptive field vanishes (this corresponds to the vanishing of the net color charge). If entire perceptive field is illuminated by monochromatic light of constant intensity, there is no sensory experience. A concrete realization of this would be in terms of a saccadic motion. Saccadic motion would translate spatial gradients of the illumination with a given wavelength to increments of color quantum numbers in quantum jump.

6.3.2 Chemical qualia

Chemical qualia (tastes and odors) are in a well defined sense more primitive than visual qualia. Unless one takes statistical physics connection as an axiom, there are several options concerning the identification of the quantum correlates of chemical qualia.

1. Thermodynamical analogy suggests that basic chemical qualia can be assigned with the Bose-Einstein condensation of super-conducting ions (possibly tastant or odorant), or, less plausibly, to various magnetic transitions of super-conducting ions amplified to macroscopic quantum phase transitions.
2. An alternative identification is in terms of super-symplectic qualia labelled by color and spin quantum numbers. The general objections against assigning other than visual colors and polarization sense to super-symplectic representations have been already discussed.
3. The third option is motivated by the observation that entire hierarchy of experiencers is involved. Thus chemical stimuli, such as odors, could be literally seen at some levels of the self hierarchy. There is indeed empirical evidence for infrared vision based on odor molecules which is however not conscious-to-us.

Quantum correlates of 'our' chemical qualia

The naivest identification of chemical qualia is as correlates of BE condensation of tastants and odorants to the super-conducting space-time magnetic flux tubes. This would predict that the primary chemical sensory experience occurs at the level of sensory organ. The paradigm of four-dimensional brain allows to explain also chemical sensory hallucinations as olfactory memories. The fact that olfactory organs can be regarded as part of brain also supports the view that our primary odor sensation can be localized to primary sensory organ. Quite generally, if super-conducting magnetic flux tube circuits run along sensory pathways to cortex, the events at the level of primary sensory organ can correspond to 'our' qualia. This is however not the only option as the following considerations demonstrate.

The energy involved with the BE condensation of single molecule should be extremely small if EEG frequencies are assumed to be able to induce or amplify this process, of order $E \sim 14$ eV for 10 Hz frequency. If BE condensation occurs by the transfer along join along boundaries bonds carrying electric field, this is indeed the case since the BE-condensation energy of BE condensation per molecule is just the change of potential energy when molecule traverses through the join along boundaries bond. It must be emphasized that this kind of mechanism allows also the generation of the BE condensate of ions giving rise to emotion at cortical level. In this case the BE condensation by this mechanism would occur for ions representing large classes of odorants and it would make sense to speak about finite number of chemical qualia. It would not be too surprising if cortex would have developed this kind of classification chemical senses.

Some facts about odors

There are hundreds of receptors for different odorants and this forces to question the idea about primitivity of olfaction. Olfaction is often regarded as the most primitive modality being the only sense involving projections from sensory organs to paleobrain: all other sensory organs project directly

via thalamus to cortex. There are two olfactory pathways. The first leads directly to amygdala whereas second leads via the thalamus to cortex as also other sensory pathways. Also entorhinal cortex receives direct projections from olfactory bulb.

Olfactory memories are most emotional and most stable, which is perhaps related with the fact that amygdala which is often regarded as emotional brain, receives direct projections from olfactory bulb but not from other primary sensory organs. The fact that strong odorants are bio-chemically active and induce strong entropy gradients would explain why odors are so emotional. Evolution might have even developed mechanisms amplifying the entropic gradients and thus also emotional responses to odors. The large number of odors is consistent with the idea that each molecule generates its own odor quale in BE condensation on super-conducting magnetic flux tubes. The finite number of odor receptors would not imply that the number of basic odors is finite, but only that there is classification of odors at the cognitive level determining the accuracy of the odor discrimination.

Evidence for infrared vision based on odor molecules?

Callahan has studied the sense of smell of insects [I58] . Many insects, such as moths and ants, are known to be attracted by light, say candles and electric lamps and Callahan took as his challenge to understand what is involved. Callahan discovered that insect's olfaction is not based on chemistry but to a maser like emission of infrared light generated by various molecules such as pheromones, scent molecules and many other bio-molecules. Insects would see rather than sense chemically the sources of the infrared light. The sensillae of the insects serve as receiving antennas and amplify the incoming maser like infrared emissions. Callahan also observed that the oscillation of insect antennae induce maser like emission from scent/etc. molecules by creating an oscillating emf. Thus sensory experiencing seems to involve active participation from the part of insect. The work of Callahan demonstrates that ELF modulation of IR light is an essential element of the perception mechanism [I58] .

In the case of insects infrared light emissions from pheromones mediate sexual messages. Pheromones are known to mediate sexual and social signals also in the case of many mammals. For instance, certain chemical messages from female mouse can make male mouse to mate immediately while certain chemical messages from other males make him aggressive. Many mammals, for instance rodents, are known to possess vomeronasal organs, small cigar like sacks containing neurons and having length of order few millimeters [J3] , giving rise to an accessory olfactory system, which is known to have much more primitive structure and to work in different way than the ordinary olfactory system. It is also known that this systems bypasses cerebral cortex in rodents. There is evidence that even humans have the ability to sniff certain chemicals mediating social and sexual signals without being aware of it and there is already now flourishing perfume industry based on this evidence. The chemicals responsible for sexual attraction are probably pheromones. The fact that pheromones mediate sexual signals in the case of both insects and mammals, is hardly an accident and suggests that the sensory mechanism must be the same and be based on the infrared emissions by pheromones. If the response is at neuronal level and if the cortex is not involved, one could understand why these messages are not experienced consciously. One could test this hypothesis by finding whether coherent infrared radiation at frequencies emitted by pheromones can affect the behavior of higher mammals including humans.

There is a further peculiar co-incidence: the cascade of the transduction events occurring in the absorption of photon in retina is repeated in a remarkably similar way in olfactory receptor cells, which respond to odors whereas the receptor cells that respond to sound use a very different system [J3] .

Odor perception as IR vision at the level of odor receptors?

The facts described above suggest that also in the case of mammals the experience of odor involves the, possibly un-conscious, detection of infrared light so that humans would not basically differ from insects and that olfactory system has evolved from the receptor neurons sensing infrared light. The proposed identification means that IR odors are like colors and large number of odors means high acuity with respect to the IR wavelength: this is natural if large number of odorants must be distinguished from each other. Furthermore, odor perception at the level of primary sensory organs could involve exotic super-symplectic representations associated p-adic length scales $L(173) = .02$ mm, $L_3(59) = .08$ mm, $L_2(89) = .11$ mm, $L(179) = .16$ mm, $L(181) = .32$ mm and perhaps even shorter length scales corresponding to $k = 167$ and 169 .

If incoming IR photons indeed induce super-symplectic transitions, integer multiples of the fundamental frequency generate maximum response. Good sensory acuity requires that fundamental frequency of the super-symplectic representation is small enough and that the resonant frequencies coded to our conscious experience correspond to relatively high multiples of the fundamental frequency (this conclusion depends crucially on assumption that super-symplectic transition frequencies are multiples of the fundamental frequency). This would suggest that olfactory receptors can perceive consciously very low IR frequencies not conscious-to-us. Similar argument in the case of color vision would suggest that photoreceptors perceive consciously IR frequencies not conscious-to-us. The structures responsible for primary color vision could be cilia containing micro-tubuli with length distribution covering besides visible wavelengths also UV and IR wavelengths. Also in the case of odor perception micro-tubuli are good candidate for the primary detectors of odors: the longest axonal micro-tubuli have length of order .1 mm.

Frequency coding of odors

It is known that odor discrimination relies on spatiotemporal patterns of nerve pulse patterns [J76]. This spike pattern could be however interpreted as coding information about EEG and/or ZEG frequencies which must be excited in order to generate quantum phase transitions generating the sensation of a particular odor which in general involves several primary components. Also geometric information about, say, the direction of source of odor must be coded into magnetic transition frequencies. A good metaphor is provided by color vision but with much larger number of basic colors and therefore counterparts of cones. The higher harmonics of the transition frequencies might also code emotional reaction to odor discrimination. The importance of ELF modulation in the case of odor perception of insects [I58] suggests that this modulation basically codes for the odor experienced by the insect and is thus in the same role as EEG rhythm coding for odor in human brain. The testing of whether infrared light can affect the behavior of mammals would be also a test of TGD based theory of consciousness.

6.3.3 Magnetic qualia as generalized chemical qualia

Magnetic quantum phase transitions are characterized not only by the increments of the Poincare quantum numbers perhaps giving rise to kinesthetic qualia but also by increments of the particle numbers in various macroscopic quantum phase labelled by magnetic quantum numbers. This would suggest the interpretation as generalized chemical qualia. The BE condensation of particle numbers to given magnetic phase could give rise to a sub-quala of a chemical quale.

The model for the interaction between sensory organ and its magnetic body [K65] leads to the conclusion that the spatio-temporal patterns of cyclotron phase transitions at the magnetic bodies must be fundamental from the point of view of our consciousness. Varying cyclotron frequencies are ideal for the coding of various perceived geometric variables like frequencies and distances as positions at the magnetic body, and cyclotron frequency patterns generated by biological body would define kind of somatosensory sensations at the level of magnetic body. The representations of the sensory input constructed as temporal sequences of phoneme and note type basic units modulating cyclotron frequencies could be interpreted as cognitive and emotional representations (left brain talks, right brain sings). The chemical qualia of the magnetic body would be cognitive and emotional qualia of ours and correspond to higher level of dark matter hierarchy than our sensory qualia.

Spin flips are problematic since spin does not change in the scaling of \hbar . If magnetic field strength remains invariant and the area of flux quantum scales up as r in the scaling of \hbar , magnetic interaction energy $-\mu \cdot B$ remains invariant whereas cyclotron energy scales up. If dark space-time sheets are at same temperature as ordinary ones, spin would be thermalized and only cyclotron transitions would contribute to qualia. Spontaneous magnetization and spin flips of spontaneously magnetized regions of spin glass having very large magnetic moment might change the situation. One must also remember that the assignment of same temperature to all space-time sheets of the dark matter hierarchy is the most pessimistic working hypothesis.

For instance, magnetic spin flip phase transitions changing the direction of spontaneous magnetization inside figure could induce conscious figure-background splitting. The repeated occurrence of this phase transition and its reversal induced by an oscillating ELF em field would make figure analogous to a twinkling star. This is like superposing to a harmonic background a tone shifted by constant

amount so that dissonance distinguishes the superposed tone from background. The Fourier dual of this representation is by phase shift and there is evidence that hippocampal neurons of rat apply this method to represent the position of rat with respect to surroundings as a temporal phase shift of spike patterns with respect to EEG rhythm with hippocampal theta frequency [J104]. Figure-background separation involves decomposition of the perceptive field to objects which means that higher level representation is indeed in question.

Endogenous NMR spectroscopy?

MEs could induce the rotating part of the magnetic field associated with flux tube inducing magnetic transitions. This could make possible an endogenous NMR spectroscopy in which purely magnetic qualia besides force and torque accompanying magnetic transitions would code the points of a living chemical map. Conscious NMR spectroscopy need not however correspond to *our* experiences directly. Rather, it could contribute to proprioception after several averageings implied by the lower position of the cell-sized selves in the self hierarchy. Note however that the BE condensation of coherent photons generated in the magnetic phase transitions on MEs could induce experiences of force and torque at super-symplectic level.

If p-adic length scales define preferred lengths for MEs, then there is a difference between magnetic and super-symplectic transitions. The tunability of the magnetic transition frequencies makes possible the mapping of the geometric information to flag-manifold coordinates mapped to the magnetic transition frequencies mapped to an excitation of certain neuron or neuron group of 4-dimensional brain and thus waking-up the point of cognitive map of the external world or of body.

6.3.4 Kinesthetic qualia

The connection with statistical physics allows very nice understanding of kinesthetic qualia and tight connections with basic physics.

Are kinesthetic qualia universal?

TGD version of functionalism would state that kinesthetic qualia are completely universal in the sense that the quale is determined completely by the increments of the Poincare, color, and electro-weak quantum numbers in the quantum jumps. Thus both magnetic quantum phase transitions as well as super-symplectic transitions could give rise to similar kinesthetic qualia. Since super-symplectic qualia seem to correspond to higher level qualia in a well-defined sense, there are good motivations to consider the possibility that our kinesthetic qualia correspond to magnetic quantum phase transitions.

The quantum numbers which change in the magnetic quantum phase transitions are spin, orbital angular momentum, momentum in the direction of the magnetic flux tube, and the energy of the single particle state. The kinesthetic qualia associated with the magnetic quantum phase transitions could basically correspond to the experiences of torque in the case of angular momentum increment and force in the case of increment of longitudinal momentum. Also the increment of the integer n characterizing the radial dependence of the harmonic oscillator wave function could give rise to some kind of quale. Kinesthetic interpretation would encourage to assign a sensation of radial force to this kind of transition. Since the eigenvalues of the harmonic oscillator Hamiltonian are integers, one could consider also the possibility that elementary arithmetic quale could be in question. Generalized hearing as time-like force sense seems however to provide the most convincing identification.

Momenta correspond to spatial translations whereas energy corresponds to time translations and in spirit of special relativity one expects that sensation of energy flow is the counterpart of sensation of force. Sense of force involves always some spatial direction and sense of torque direction of rotation besides the intensity of the force or torque. Auditory experience involves duration and direction of time in an essential manner and the increment of energy, or equivalently of frequency, relates closely with hearing which is basically frequency sense. Thus the unification of hearing and force senses to generalized four-force sense suggests itself.

An objection against this identification is that energy increments are involved with all quantum transitions so that also vision would involve some kind of auditory aspect. Most audible frequencies are however above EEG range makes hearing especially makes possible to store a lot of information to auditory sensation whereas for other senses the content of dynamical information is so small that

the auditory information of these senses remains un-noticed. Alternatively, the net energy flow in the direction of subjective time in turn could correspond to the intensity of the quale for all qualia. This would be in nice accordance with the universality of the kinesthetic qualia. The intensity of quale could however have other identifications: for instance, very entropic mental images should give rise to dim qualia.

One can wonder what the interpretation of Lorentz boosts, do they correspond to independent qualia or not? Very probably not: what is needed to characterize the basic qualia is quantum number increments for a maximum number of mutually commuting observables. Boosts induce increments of four-momentum and thus force and energy qualia.

Linear and angular acceleration

Magnetic states have well defined momentum and angular momentum component in the direction of the magnetic field and the sensation of acceleration or force in the direction of the magnetic field and angular acceleration around this direction naturally correspond to a quantum phase transition changing the momentum and angular momentum of charged particles of the macroscopic quantum phase. For instance, sensations of falling in gravitational field and sensation of dizziness when the world rotates around could be related correspond to primitive angular acceleration quale.

Note that it is also possible to have state basis for which two momentum components are well defined quantum numbers with suitable choice of gauge. In TGD framework the choice of gauge is not however completely free since classical fields are induced from CP_2 spinor connection. For instance, canonical transformations of CP_2 acting formally as $U(1)$ gauge symmetries of the Kähler potential do not act as ordinary gauge symmetries but isometries of the configuration space and deform space-time surface and affect classical gravitational fields.

Identification as linear and angular acceleration probably makes sense when the experience is about body. If spin flip and increment of momentum are associated with an object of perceptive field they might give rise to figure-background separation in magnetic case. Object of perceptive field effectively 'pops up' from the background or makes small twists with respect to the background. In this case the net changes of these quantum numbers vanish in the long run and kind of 'twinkling' results. A classical example about the the flipping of the figure-background identification between two alternatives is the figure in which Freud's head and naked woman is seen alternately but never simultaneously.

Increment of orbital angular momentum and color flip are in general associated with the same Hamiltonian which can be chosen to be a product of functions in E^2 resp. CP_2 . Hamiltonians associated with E^2 can be chosen to be eigen states of the angular momentum in the direction determined by the point of flag-manifold. Functions are most naturally localized around point of E^2 and thus only angular momentum component J_z is good quantum number. The transitions are thus characterized by the increment $\Delta M = J_z$ of angular momentum and by the increments of color quantum numbers and for given color representation D infinite series of qualia or variants of same quale labelled by ΔM are possible. The identification of spin increment as related to polarization sense is very natural if color corresponds to the visual color. Polarization would be experienced as some kind of a torque of universality holds true.

Hearing as time-like counterpart of force sense?

As already found, a natural identification for the energy increment is as being related to hearing which would be thus time component of sense of four-force. This identification is elegant but perhaps formal and one must compare it with alternative possibilities.

The quantum model of hearing [K61] has evolved through painful steps. At this moment it however seems that basic auditory quale could correspond to an increment of electroweak spin at the level of cell membrane (see the discussion towards the end of the chapter). The increment of electroweak spin can be assigned to either quark pair assignable to a lipid of receptor membrane or a pair of quark pairs assignable to separate receptor membranes and joined by flux tube during sensory reception. The experienced pitch in turn seems to correspond to a quale of magnetic body and correspond to a frequency modulation of Josephson frequency by the frequency of the sound [K26].

The modulation of Josephson frequencies would provide a completely general representation of sensory and other information at the magnetic body. Music metaphor allows to see this representation

as analogous to that produced by a choir of whales. Both neurons and astrocytes are expected to sing and the value of Planck constant for a given neuron or astrocyte characterizes the octave associated with this particular singer. Speech and song would be direct motor expressions of this representation. Also ordinary speech involves frequency modulation as becomes clear by playing a recorded speech with abnormally slow rate.

Increments of spin and momentum and figure-background separation

In M_+^4 degrees of freedom there are two quantum numbers corresponding to the $SO(2) \times R$ Cartan algebra of $SO(3, 1)$. These quantum numbers can be chosen to be spin and momentum in direction of the quantization axis. It is probably of significance that just these quantum numbers are also associated with the magnetic states besides magnetic quantum number which is analogous to the conformal weight in the case of Virasoro algebra. This suggests that discrete magnetic qualia and Super Virasoro qualia in Lorentz degrees of freedom might have a close relationship. Universality of the kinesthetic qualia indeed implies this kind of a relationship.

There is no change in orbital degrees of freedom involved with spin flip, which suggests that sensation of torque is not involved. A possible identification is in terms of figure background separation. In the case of magnetic qualia spin flips associated with the representations of objects of the external world could correspond to figure-background separation since transition frequencies for spin flip transitions are shifted with respect to the frequencies of transitions without spin flip. Indeed, by music metaphor the addition of the spin-flip frequency to the cyclotron frequency implies that figure is separated from background like dissonance from harmony.

There is also a second metaphor for what figure-background separation means. In order to separate figure from background one can to give it a small push upwards or perform a tiny twist for the figure with respect to background. This is what increments of spin and momentum in the direction of quantization axes could represent. This kind of tiny pushes and rotations would give vanishing net effect in the sequence of quantum jumps but take care that the object of the perceptive field gains attention. Perhaps this has something to do with the fact that primitive organisms like insects are unable to see objects which are not moving with respect to the surrounding world. Saccadic motion might be essential in generating artificially the motions separating figure from background: if saccadic motion is made impossible, visual field gradually falls in total darkness [J79] .

'Push-or-twist' metaphor would allow to assign figure-background separation also to super-symplectic spin flips. For super-symplectic algebra transition frequencies of the transitions induced by classical gauge fields associated with MEs are however harmonics of the fundamental frequency and the generation of figure-background separation by the shift of the EEG frequency is not possible. This implies that there is infinite number of qualia or variants of the same quale associated with given increments of color quantum numbers.

6.3.5 Tactile qualia

Concerning the identification of the tactile qualia (sense of touch, pressure sense, temperature sense, physical pain and pleasure), the first hint comes from the observation that a topological phase transition involving the formation of join along boundaries contacts with the object is involved. Thus the number of the join along boundaries contacts could play the number of particles in this case.

In the case of purely physical pain/pleasure (different from the emotional aspect of pain and pleasure) the splitting/formation of the join along boundaries contacts associated with the tissue occurs and the number of these contacts could define the relevant particle number. The purely emotional aspect of pain and pleasure in turn would correspond to the presence of entropy gradient with respect to the subjective time implied by this process. The most naive interpretation is that primary sensory experience is located with skin since the replication of this kind of activity at brain level would seem somewhat artificial.

Join along boundaries bonds are natural space-time correlates for quantum entanglement and their splitting means a loss of entanglement. Rational (algebraic) entanglement corresponds to positive information and also information is lost in the splitting process. At higher levels of dark matter hierarchy physical pain is replaced with more abstract psychic pain but the space-time correlate for it would remain same.

This is however not the only possible option. Also tactile qualia could be induced by EEG frequencies as our qualia at the level of cortex. This would mean a rather concrete representation of the topological aspects of tactile qualia. The fact that various objects of perceptive field are represented as recognizable patterns of neural activity supports the view that also tactile experiences are regenerated at the level of the virtual world of cortex. EEG waves should induce the generation and splitting of internal and internal-external join along boundaries bonds inside cortex and this requires that the energy for the generation of join along boundaries bond is extremely small, of order of 10^{-14} eV for 10 Hz frequency for ordinary value of \hbar : for $k_d = 40$ level of dark matter hierarchy energy is above thermal threshold.

The join along boundaries bonds in question must be electric (magnetic flux conservation does not allow splitting of the bond). By assuming that the electric flux through the bond is given by elementary charge, one obtains that the electric energy associated with the bond is given by the potential energy difference over the bond for electron. Josephson junctions with potential differences of this order of magnitude should be indeed present in bio-matter and the number of the Josephson junctions would become the basic variable. The Josephson junctions acting as join along boundaries could be also MEs, which indeed can have very small thickness and can carry also constant component of electric and magnetic fields in the case that they appear as pairs (the throats of wormhole contacts connecting the members of ME pair would serve as sources of these fields).

The purely physical aspect of the temperature sense (as opposed to the emotional aspect) most naturally corresponds to energy flow in the direction of subjective time. Temperature sense would be energy sense basically. Sensors for cold and hot would detect consciously the flow of energy from body/into body and code this into increment of energy for magnetic or super-symplectic states. The average increment of transition frequency using p-adic frequency scale as unit would measure the intensity of sensation.

6.3.6 Emotions

The thermodynamical approach suggests that emotions correspond to the gradients with respect to subjective time for various entropy like variables associated with sub-systems of self. Thus positive/negative emotions should reflect the increase/decrease of order. This identification is supported by the general characteristics of emotions.

Emotions contain only few bits of information but this information is very important for survival. Emotions are holistic, 'single-pixel' qualia and about the state of the entire body or relatively large part of body. Emotions are very much like conscious representations for time rates for the deviations from homeostasis realized as many-sheeted ionic flow equilibrium and tend to appear in complementary pairs. Emotions correlate very strongly with the chemical state of the body. In particular, peptides are often regarded as both the molecules of emotion as well as of information. Since peptides perform bio-control as information molecules they must induce especially intense entropy gradients with respect to subjective time and thus strong emotions if TGD view is correct.

In the sequel TGD view about emotions are compared with the ideas of Damasio described in his book [J38]. To avoid confusions it is good to emphasize that in TGD approach emotions are defined as sensations rather than as motor responses to sensory input about state of body as Damasio defines them [J38]. In the following various classifications of emotions and various aspects of the concept of emotion are discussed. After that the general identification of emotions as generalized sensory qualia about state of body and CNS containing both geometric and non-geometric component is described.

About classification of emotions

In order to even try to say something sensible about the identification of correlates of emotions, one must try first to try to develop general view about different kinds of emotions.

1. One classification of emotions [J87] is based on the notions of cognitive world model and goal structure. The simplest emotion is excitement which does not involve any recognizable goal or cognitive model. Surprise and relief involve conflict or resolved conflict between prediction of model world and real world experience. 'Amygdalar emotions' fear, anger, craving, protection and disgust are directed and involve goals and external threats to goals. Also cortico-striatal emotions like sadness, hate, embarrassment, contentment and joy involve goal structures and

failure or success to achieve the goal in essential manner. A general representation for goal should be in terms of generalized geometric qualia representing the desired state of body or some other system and represented as mind like space-time sheets.

2. Damasio classifies emotions to six universal 'big' emotions: happiness, sadness, fear, anger, surprise and disgust; to background emotions or moods (feeling good/bad, tired, excited, depressed, strong,..) and to social emotions (feeling embarrassed, ashamed, guilty,..). One can also classify emotions to bipolar pairs (fear/anger, craving/disgust, pain/pleasure,...) according to whether they involve approach or withdrawal from some situation (fight or flight) or ambivalent rest and digest emotions (surprise, excitement) or emotions related to seeking of pleasure. Drives induce emotions like hunger or thirst and satiation follows the achievement of the related goal. The dichotomic nature of these emotions conforms nicely with the fact that Super algebra generators appear as complementary pairs.
3. If simple emotions are just generalized sensory qualia, it is natural to interpret emotional expression as a generalized motor action so that motor action, imagination and emotional expression would be very much analogous to each other. It is known that the expression of emotions is indeed very brain area specific and hence very much analogous to motor expression [J38]. The ideas about e-motor expression and emotional imagination sounds perhaps strange since emotions are often regarded as something which just come from heaven and do not involve volition. This is not the case always: for instance, actors have specialized in practicing e-motor activities. Damasio tells in his book about pianist who told about emotional currents going through her body and about her ability to control them at her will: it turned out that this ability had direct neurophysiological signatures. One can also distinguish between active and passive emotions. For instance, pleasure and craving, anger and hate, and fear and anxiety (not a direct reaction) differ in that they are passive/active emotions.
4. Some metaphorical representations of emotions as qualia like tastes and basic tactile senses [(warm,cold,pain) at least] appear very naturally. This could be understood if also emotions are accompanied by super-symplectic qualia. As already found, there are however strong objections against this identification.
5. The fact that emotions are holistic 'single-pixel' experiences suggests that emotions represent experiences about average state of body or body part. This averaging is natural if emotions correspond to $k = 67_3, 101_2$ and/or $k = 103_2$ level sensory qualia at length scales 32, 45 and 180 cm and are determined as reactions to what happens in shorter length scales. Of course, also shorter length scales $L(k)$, $k = 191, 193, 97_2, 197, 199$ could be involved.
6. There are also very refined emotions like those accompanying music experience. It is not at all clear whether these emotions can be regarded as representing 'average pixels' of lower level sensory experience about body and might be primary emotions experience directly and correlating with the patterns of ELF em waves. One can indeed assign to the Fourier decomposition of EEG wave entropy in terms of the probabilities defined by the Fourier coefficients of EEG wave and the gradient of this kind of entropy with respect to subjective could correlate with the emotional aspects of music. White noise and monochromatic sound (and more generally EEG wave) would represent the two extremes. Interestingly, $1/f$ noise for the distribution of frequencies and durations of notes is a characteristic of musical sounds. The assignment of entropy gradients with respect to subjective time (this is important!) as correlates of aesthetic experiences is indeed natural.
7. There are also emotions which indeed seem to 'come from heaven'. It is difficult to believe that religious and spiritual experiences could be mere representations of the state of body and CNS. More feasible assumption is that these emotions are communications from the higher levels of self hierarchy to our level. Communication mechanism would be semitrance mechanism transforming the communications to emotions and e-motor actions. Probably a loop in which selves below us in self hierarchy are affected and yield e-motor expression which is perceived by us and in turn stimulates emotion at our level.

How emotions differ from ordinary sensory experiences?

Emotions differ from ordinary senses in that they seem to be relatively simple in some respects. Instead of providing a detailed picture with each pixel having several possible colors they seem to provide a single big pixel. Thus a plausible view about emotions is as 'single pixel qualia' associated with the levels $k = 67_3, 101_2$ and $k = 103_2$ levels of the self hierarchy (at least). There are also alternative explanations for the diffuse character of emotions. These explanations are however consistent with this first principle explanation.

1. The sensory information about internal milieu is about pH, ionic concentrations, hormone levels,.. and thus not topographical bit map type information. If this information dominates emotional input, it is easy to understand why emotions tend to have single pixel character: the color of the pixel simply varies very slowly. Also the control of moods by mono-aminergic and catecholaminergic and other neuromodulator systems is based on diffuse projections. On the other hand, the somatosensory information from muscles (in insular cortex and some regions of parietal lobe), known to be important for emotions, has bitmap character. One could also see the correlation of emotions with peptides and other important bio-molecules whose presence induces large entropy gradients as a direct support for the view that emotions are associated with entropy gradients.
2. Our emotions are determined to a high degree by experiences which are averages....over averages over all sub-selves of the lower level self. These averages replace a picture containing very many colored pixels with single pixel picture having the average color. The generalized sensory experiences of the lower level selves are in turn determined by the input from muscles, smooth muscles and inner environment and by hormonal communications.
3. It could be also that at least some emotions (for instance, those involving comparison of what happened with long term goals) are communicated to us from the higher levels of self hierarchy. The primary communication could be to some lower level self and we would experience these emotions both as averaged experiences and by reading our body language (also the body language spoken by the inner organs) language. Unconscious-to-us sensory qualia also induce e-motor reactions realized as bodily expression of emotion. We perceive this bodily expression and it affects strongly our emotional state. Thus there is close relationship between pure emotional coloring and the generalized geometric qualia inducing it. This option is consistent with the ideas of Damasio about self hierarchy [J38] .

According to Damasio [J38] , the ability to experience and express mood like emotions is preserved even when neocortex suffers lesions destroying practically all cognitive abilities and the ability to process sensory information and respond to it. On basis of this fact Damasio suggests that mood like emotions are associated with 'pre-self'. Pre-self is prerequisite of nuclear consciousness and extended consciousness involving cognition and long term goals [J38] . The regions assigned by Damasio to 'pre-self' correspond to the nuclei of brainstem, hypothalamus, basal forebrain, insular cortex and somatosensory regions (S1 and S2) in the medial parietal cortex. Perhaps these regions represent sub-selves which receive the sensory input determining our emotions. The hypothesis that primary and secondary regions of the cortex correspond to the first and second period of the periodic table and do not correspond to sensory input directly conscious-to-us is consistent with this picture.

Can one identify emotion with its expression?

There are empirical data supporting Damasio's view that our emotions can be identified with their expressions. For instance, if the motor pathways in the reticular formation are destroyed, person is unable to perform volitional movement and the bodily expression of emotions becomes impossible. Contrary to what one might expect, the patients are calm and peaceful although they can feel frustration and sorrow at intellectual level. Damasio interprets this as support for the correctness of the identification of emotions with their bodily expressions.

The sharp distinction between emotional and purely sensory aspects of pain can be understood if emotions accompany generalized sensory experiences. The purely sensory aspect of pain would correspond to non-geometric and geometric qualia giving information about the state of body and CNS whereas emotional coloring would be due to the entropic gradients necessarily involved with the

sequence of the quantum jumps. The reason why sensory input from our body induces much stronger entropic gradients than that from the everyday external world would be dictated by the relatively higher importance of this input and positive feedback loops exaggerating the entropic gradients from body might quite well be involved. That also the sensory input from external world can induce emotional reactions is in accordance with this view.

A more detailed TGD based model of emotions consistent with the observations of Damasio is following. Emotions are based on sensory perceptions about the state of body directly by some lower level self, perhaps the 'pre-self' of Damasio. We experience these qualia as averaged qualia which is much like objective sensory perception: emotions provide summaries rather than bitmaps. The more levels there are between the primary experiencer the slower is the dynamics of emotions and moods correspond therefore to the lowest level self, perhaps the level of 'pre-self' of Damasio. The lower level self reacts to its emotional percepts by e-motor activity generating emotional expression affecting the state of body and of internal organs, which higher level selves in hierarchy and also we in turn perceive. The entropic gradients characterizing this perception determined the emotion and in turn the reaction and it is easy to imagine a positive feedback generating a response which contains increasingly stronger entropic gradients. It seems to be the perception of the e-motor responses of pre-self to which cause mostly the suffering at our level.

If lower level self of the patient is not able to react e-motorially to its emotional percepts, the patient do not get in a state of horror. Of course, an open question is what 'pre-self' experiences, when it cannot express its experiences: not necessarily anything dramatic and not necessarily anything emotional. It might be that the holistic nature of emotional content is essentially due to single pixel character of emotional experience. Note that this feedback loop resembles the loop created by typing text or talking loudly one's own thoughts. Lower level self communicates directly to us via our body using body language and via lower level selves below us via nervous system. This model explains also why many bodily expressions of emotions occur before we become conscious about them.

Peptides as molecules of emotion and information molecules

It is known that peptides correlate strongly with emotions and moods [J85] and they are even called molecules of emotions. Peptides are also regarded as information molecules. This connection between information and emotions fits nicely with the fact that peptides and other important bio-molecules certainly induce strong entropy gradients with respect to subjective time. We do not taste or smell the presence of peptides or other information molecules in our body. A possible explanation is that Bose-Einstein condensation of peptides on super-conducting space-time sheets does not occur. This could quite well be the case for the simple reason that peptides are macromolecules. Of course, one could also argue that the color of emotion is nothing but a generalized taste or odor.

Although it looks more plausible that peptides are only one step in a control sequence leading to quantum phase transition giving rise to quale, one cannot rule out the possibility is that also magnetic transition frequencies of peptides (short proteins acting as hormones) correspond to geometric aspects of emotional qualia. The cyclotron frequencies of singly charged aminoacids are in the range of 1 – 4 Hz and it is known that proteins carry constant charge density per unit length. If this density is same as for DNA, the charge per protein would be about 6 elementary charges. For unit charge per single protein $n = 1$ cyclotron transition is in delta band whereas for 6 elementary charge per unit $n = 1$ cyclotron transition frequency is in alpha band and would be conscious-to-us.

Since proteins and DNA are spin glass type system allowing huge number of ground states and angular momenta, explosion in complexity is expected to occur and make possible extremely rich spectrum of geometric aspects of emotions.

What emotions could be in TGD framework?

TGD suggests several visions about emotions and it is not yet completely clear whether these views are really mutually consistent.

1. The statistical physics approach to qualia leads to the hypothesis that emotions correspond to rates for the generation of various type of entropies for sub-systems of self. The sign of rate tells whether emotion is positive or negative and thus negative emotions would thus be conscious control variables warning self when some sub-system is generating entropy. The holistic nature of emotions can be understood easily in this picture and also the fact that they are not directly

related to sensory input. One could perhaps also understand higher level emotions like sorrow as reflecting the growing disorder of the virtual world of brain resulting from the primary cause of sorrow. The connection of peptides and other information molecules with emotions provides a strong support for this view.

2. Many emotions are comparison type emotions. These emotions tend to be negative (say envy).
 - i) At fundamental level one could perhaps regard comparison type emotions as resulting from the comparison of geometric and subjective memories occurring automatically in any quantum jump and thus to some degree with any quale. Unfortunately, it is very difficult to imagine how to concretely test this kind of hypothesis and it is also difficult to see how the connection with entropy gradient could emerge.
 - ii) One must also seriously consider the possibility that emotions result from the comparison of remembered/anticipated quale and real quale rather than the fundamental comparison involved with anticipation and memory: kind of quasi-computerized version of geometric memory would be in question. The result of comparison would be coded to the sign of the growth rate of some entropy variable. The comparison could perhaps be realized in such a manner that subsequent quantum jumps for comparing sub-system could represent either the anticipated or real quale. If this were the case, the difference between anticipated and real would automatically induce growth of entropy and negative emotion would result. This would be the basic mechanism of disappointment.
3. One could also regard emotion as or induced by generalized sensory qualia giving information about CNS itself rather than external world or the boundary between external world and body. Regulation involved with the homeostasis involves comparison in an essential manner so that one could perhaps regard emotions as analogous to control variables representing consciously the result of comparison of expected and desired forcing the organism to behave in a manner to reduce this difference and end up to a rest and digest state. This aspect is consistent with the statistical interpretation since the entropy gradients associated with the organism are stronger than those associated with surrounding world. Also amplification mechanisms exaggerating the entropy gradients might have developed. For instance, our reactions to some odors or tastes could involve this kind of amplification.
4. A hypothesis consistent with these views is that emotional component is involved with all sensory experiences and that we are used to call generalized sensory experiences emotions when they are about body. The emotionality of qualia indeed increases in the sequence of perceptive fields external world – CNS-world boundary – body. The degree of emotionality of experience should be characterized by the deviation of real from expected or desired and this suggests that the emotional component is much stronger for sensory experiences about CNS itself, since the system in question is much less predictable than the external world consisting of dead objects. Interpretation of emotion as measure for entropy gradient explains also this hierarchy.
5. A further point of view is provided by music metaphor. Music is language of emotions which suggests that emotions are at least partially coded into the EEG pattern. Perhaps pure emotions which seem to involve no obvious comparison (love, joy, excitement,..). At least the emotions produced by music might represent this kind of emotions. The view about emotions as entropy gradients allows to understand also emotions of this kind. In state of deep love, self enters into very low-entropy state and mental images (not necessarily even present in 'enlightened states') become very pure. Comparison type emotions could be seen as a system of rewards and punishments used to control the self (the controller could be higher level self (conscience) or higher levels selves which also want to survive (the emotions generated by hunger, first, and physical pain).
6. Sensory qualia can be divided to geometric and non-geometric ones. One can classify also emotions in this manner. Emotions corresponding to the localization in zero modes would perhaps correspond to 'higher level emotions' about external world (say, aesthetic qualia) whereas the non-geometric emotions associated with the state preparation would correspond to 'self-centered' emotions about the state of body (pain, physical pleasure,...).

Some examples of concrete identification of emotions

In the following some examples about the identification of emotions are discussed to see what problems are encountered in attempts to concretize the general theory.

1. *Simple emotions*

Pleasure and pain are the most important emotions (pain as emotion must be distinguished from physiological pain which is ordinary sensory experience). The identification as conscious entropy type variables works very nicely in this case. Relief and disappointment are examples of simple emotions induced by some unexpected event and involving comparison and goal structures. Emotions as entropy gradients vision allows to understand these emotions along the lines already described. Surprise is an ambivalent emotion which is associated with the deviation between expected and real. The lack of comparison aspect could be understood if surprise involves a generation of totally new mental image. Getting bored is more or less a complementary emotion to surprise. It probably involves the growth of the entropy content of the mental images. There are six basic emotions involving goal structures arrangeable into two triplets (happiness, sadness, craving) and (fear, hatred, disgust) or three doublets (happiness, sadness), (fear, rage), (craving, disgust). These emotions are comparison type emotions allowing description in terms of entropy gradients.

2. *About geometric aspect of emotions*

Simplest comparison type emotions involve comparison of the model of reality with reality. More complicated emotions involve goals and their comparison with what was achieved. This suggests that world model and abstract goals can be mapped to the generalized geometric qualia. The metaphorical correspondence of emotions and motions suggests that flag-manifold qualia indeed could represent abstract goals and cognitive structures. The infinite-dimensional flag-manifold associated with the group of zero mode canonical symmetries of configuration space must describe the geometric aspect of emotional experience. This gives huge flexibility and good hopes of coding various goals to the geometry of the space-time sheet (and thus also to cyclotron frequency) by applying appropriate canonical transformation to it.

The most concrete goals are expressible as desired position and posture of body. Consciousness builds geometric metaphors for abstract concepts and goals and metaphorizes also abstract evolution in terms of simple dynamical concept. For instance, goals are often metaphorized using expressions like achieving certain position in society. This suggests that various metaphorization might have developed from these concrete 'geometrodynamical' goals. Therefore one must take seriously the possibility that flag-manifold qualia associated with Lorentz and color group can code also geometric aspects of emotional experience. This reduction could be also due to the fact that flag-manifold coordinates must be eventually mapped to concrete standard configurations of the magnetic flux tubes characterized by position, orientation and internal states achieved by applying Lorentz boosts in the longitudinal direction of tube.

3. *Higher level emotions*

TGD suggests that higher level emotions are communicated to us by higher level selves by semitrance mechanism in which some part of brain, presumably belonging to right temporal lobe and including hippocampus and amygdala, entangles with higher level self and serve as a medium allowing higher level self to communicate its message as emotions, sensory 'hallucinations' or internal speech as nerve pulse patterns to the audience consisting of those parts of brain which are in wake-up state. The physical correlate for this process would be standing EEG waves which in turn correspond to spatially constant 'space-like' soliton sequences associated with the region of brain serving as medium whereas propagating EEG waves are associated with soliton sequences propagating in linear circuits of brain. The standing wave part of EEG would clearly correspond to 'free part' of EEG wave not induced by sensory experience alone and identifiable as active aspect of collective consciousness represented by ELF MEs.

The assumption of Damasio that emotion accompanies a generalized sensory experience about the state of body seems to be in conflict with the idea that higher level emotions are communicated to us by higher level selves. Entropic interpretation of emotions does not require that emotions are always about state of body. On the one hand, body could serve as an instrument making possible to represent higher level emotions. Higher level self could use semitrance mechanism to induce nerve pulse patterns

giving rise to characteristic temporal patterns of EEG in turn giving rise to communicated emotions. Higher level selves could also induce neural activity at some lower level of self hierarchy which would in turn be experienced by us as average emotions like moods.

For instance, higher level selves above us could be responsible for the higher level social emotions like shame and experience of having done something wrong. The experiences of higher level self could be communicated to us, or rather to our lower level sub-selves, as kind of artificially generated virtual world emotions which correspond to EEG frequencies which are higher octaves of the magnetic transition frequencies associated with the fundamental experience. p-Adic length scale hypothesis implies that this communication optimal. The spectrum of super-symplectic frequency scales indeed comes as powers of 2 for primary p-adic length scales: if secondary and higher p-adic length scales are included, frequency scales come as powers of $\sqrt{2}$.

6.3.7 Dark matter hierarchy and emotions

The ideas related to dark matter hierarchy led to a progress in the attempts to understand what emotions and cognition might correspond physically. The new views discussed in more detail in [K65] challenge the assumption that emotions reduce to negentropy gradients and suggest that the sensory qualia of the magnetic body assignable to cyclotron phase transitions correspond to emotions and cognitions. Only the negative-positive coloring of emotions would reduce to the sign of the negentropy gradient in this framework. In the following earlier view and the dark matter inspired vision about emotions are confronted.

Emotions as higher level qualia?

Emotions have metaphorical resemblance to qualia (white/black, cold-warm,...) but intuitively correspond somehow to a higher level than sensory qualia. For instance, insects presumably possess sensory qualia but do not look emotional. Pain-pleasure dichotomy is especially interesting since physical pain can be regarded as a sensory quale and psychological pain as an emotion. This suggests that emotions might be qualia of some kind, perhaps sensory qualia of the magnetic bodies at higher levels of the dark matter hierarchy. This correspondence might however be illusory: the association of certain kind of emotions with certain kind of qualia could explain these metaphors.

It is not at all clear whether this identification is consistent with the assignment of emotions to the negentropy change. One can of course ask whether the "sign" of the emotion as a higher level sensory quale is determined by the sign of the negentropy change. One could also argue that the sign of the negentropy change for sub-self defines one particular higher level sensory quale.

Emotions are whole body feelings

Emotions are holistic and not localizable in any part of the biological body. The time scale for the change of emotions is long as compared to that for the sensory qualia. Emotions possess time scale hierarchy and vary from temporary irritation as you find that you email box is full of junk mail to moods and emotional states like love and hatred lasting for decades. To love some-one for decades one must be able to remember this person. If one assumes that the time scale associated with the level of dark matter hierarchy fixes the geometric duration of the moment of conscious and the characteristic time span of long term memories at that particular level of hierarchy, the conclusion would be that emotions are associated with the higher levels of dark matter hierarchy and are indeed assignable to the magnetic bodies.

Could Josephson radiation to the magnetic body generate emotions?

The simplest hypothesis is that magnetic bodies share the sensory mental images localizable at the sensory organs. The same would hold true for the mental images generated by brain as symbolic representations of the sensory input. The sharing of mental images would correspond to quantum entanglement between sub-selves of the magnetic body and biological body. Charge entanglement induced by W MEs is a good candidate in this respect and would be also in a key role in the motor control. The selection involved in the state function reduction process would correspond to a selection of percepts known to occur (binocular rivalry provides a standard example).

This leaves open the interpretation of the communications to the magnetic body based on Josephson radiation at frequencies $nf_c \pm f_J$, where f_c is ionic cyclotron frequency and f_J Josephson frequency determined by membrane resting voltage. Also more general frequencies are possible. In particular, communications based on slow (in cyclotron time scale) modulations of Josephson frequency induced by modulation of membrane voltage are of special interest.

The Josephson radiation consisting of dark photons induces cyclotron transitions at the magnetic body and in the absence of any other identification, the natural interpretation would be that these transitions define emotions as somatosensory experiences of the magnetic body. The intentionally generated generalized motor actions involving charge entanglement by W MEs would induce the emotional expression just like other motor interactions.

If magnetic body experiences emotions as somatosensory input, it is difficult to avoid the question whether magnetic body is also able to move and change its shape. The model for various kind of OBE experiences [K81] indeed relies on the assumption motor control is induced by motor actions deforming the magnetic body: biological body would be like a puppet hanging from strings.

There is quite recent finding that the sensation of movement is generated by the intention to move rather than by the real motion of body part itself [J7]. The explanation would be that the sensation of movement is a somatosensory of magnetic body about its own motion (the interference patterns for Josephson radiation from the body are changed and therefore also cyclotron transition patterns). The communication-control loop between magnetic body and biological body would guarantee that the two movements correspond to each other. This interpretation would provide also a new view about dreams and hallucinations.

6.3.8 Dark matter hierarchy, hierarchical structure of nervous system, and hierarchy of emotions

One can ask how the structural and functional hierarchy of CNS and the hierarchy of emotions relates to the dark matter hierarchy. The basic picture wherefrom one can start is following.

1. The emergence of nervous system corresponds to the emergence of $k_{eff} < 205$ levels of dark matter hierarchy above $k_{eff} < 167$. For instance, worms and insects would correspond to this level.
2. Vertebrates have EEG and thus the most primitive vertebrates (reptiles) should correspond to $k_{eff} \geq 205$.
3. The emergence of new structures need not mean the emergence of new levels of dark matter hierarchy. Rather, the most reasonable criterion for the presence of these levels is the emergence of behaviors involving long term goals and the magnetic bodies of the parts of brain assignable to the control of this kind of behaviors would correspond to higher values of k_{eff} . Also the maximum span of memories at given level should be characterized by the value of k_{eff} associated with the brain structures involved (hippocampus, mammillary bodies). This picture conforms with the fact that already insects possess neurons, ganglia, and head containing the predecessor of cerebrum but correspond to $k_{eff} \leq 205$ most naturally.

For goal related emotions the maximal time scale assignable to the achievement of the goal might allow to identify the time scale characterizing corresponding level of dark matter hierarchy. The lowest level emotions would be "primitive" emotions not related to any goal and one can ask whether they could be assigned to organs consisting of ordinary cells and correspond to $k_{eff} \leq 205$.

1. The time scale of planned behavior and of long term memories makes possible to estimate upper bounds for the values of k_{eff} assuming Josephson frequency hypothesis. $k_{eff} \leq 205$ would give the upper bound of 6 ms which corresponds to cerebellar resonance frequency 160 Hz. This time scale looks too short even for the simplest vertebrates and one must be very cautious here.
2. An alternative interpretation is as the shortest possible span for short term memory whose time scale is known to vary.
3. Cerebellar rhythm could be analogous to hippocampal theta rhythm and involved with the cerebellar memory storage and therefore would not tell anything about the span of the memory but

would characterize the time resolution of memories and planned actions. The role of cerebellum in the fine coordination of motor actions indeed requires high time resolution.

Brain has anatomic division into midbrain, hindbrain, and forebrain [J90]. Midbrain and hindbrain (sometimes both are included in brain stem) is possessed by even the most primitive vertebrates and its emergence could therefore correspond to the emergence of $k_{eff} \geq 205$ levels and EEG. The emergence of these levels relates naturally to the emergence of long term planning of motor actions in motor areas. The emergence of limbic brain, which defines the most primitive forebrain, could mean the emergence of the Gaussian Mersenne defined by $k_{eff} = 239$ containing dark electron condensates level and goal related emotions. This conforms with the fact that for mammals forebrain and cerebral hemispheres dominate whereas for other vertebrates hindbrain and cerebellum are in the dominant role.

Reptilian brain as $k_{eff} \leq 205$ system?

Reptilian brain contains only the structures corresponding to brain stem (midbrain and hind brain, in particular cerebellum) and as far structures are considered would correspond to $k_{eff} \leq 205$ levels of the hierarchy. Cerebellum is not believed to contribute directly to our consciousness. The absence of higher looks however an unrealistic assumption since reptiles certainly have long term memories.

Simplest emotions correspond to emotions involving no goal. Moods like excitement, feeling good/bad/tired/strong, etc.. could represent examples of such emotions and could be experienced already by reptilians. Of course, the scaled up variants of these emotions could appear at higher levels of hierarchy and would relate to the states of magnetic bodies (degree of the quantum coherence of Bose-Einstein condensates!).

Limbic system

Limbic system is not possessed by reptiles [J9]. It is responsible for emotions, control of emotions, and also emotional intelligence. Limbic system corresponds to the brain of the most mammals. The limbic brain includes the amygdala, anterior thalamic nucleus, cingulate gyrus, fornix, hippocampus, hypothalamus, mammillary bodies, medial forebrain bundle, prefrontal lobes, septal nuclei, and other areas and pathways of the brain.

1. The sub-cortical part of the limbic system involves amygdalar and septal divisions. According to [J9] amygdalar division promotes feeding, food-search, angry, and defensive behaviors related to obtaining food. Septal division promotes sexual pleasure, genital swelling, grooming, courtship, and maternal behavior. These divisions are emotional mirror images of each other hand could correspond to $205 < k_{eff} < 239$.
2. The cortical part of the limbic system contains cingulate gyrus which is the newest part of the limbic system and belongs to thalamo-cingulate division which promotes play, vocalization (e.g., the separation cry), and maternal behavior. The time scale of memories would be shorter than 3.4 at this level.
3. Frontal lobes [J6] are often regarded as the organ of volition. The frontal lobes are involved in motor function, problem solving, spontaneity, memory, language, initiation, judgement, impulse control, and social and sexual behavior. Prefrontal lobes representing the extreme front part of frontal lobes belong also to the limbic system and are responsible for motivation and ability to pose long term goals. This ability distinguishes humans from other primates. For these reasons frontal lobes, in particular prefrontal lobes, could involve the highest levels of dark matter hierarchy in the case of humans. The Gaussian Mersenne levels $k_{eff} = (239, 241)$ could be assigned as lowest level in this hierarchy. The time scale of long term memories would be longer than 3.4 years at these levels.

Cortico-striatal emotions like sadness, hate, fear anger, surprise, embarrassment, happiness, contentment, and joy involve goal structures and failure or success to achieve the goal in essential manner and would involve prefrontal lobes.

These levels would naturally relate to collective levels of consciousness coded by hyper genes. Hence these emotions could also relate to goals not directly related to the fate of biological body.

Mirror neurons are a crucial prerequisite of a social behavior (autistic children seem to lack them), which suggests that hyper genes are involved at least with them.

Social emotions (feeling embarrassed, ashamed, guilty, loved, accepted, ...) could be induced by the collective levels of dark matter hierarchy as punishments or rewards for social behavior very much like neurotransmitters are believed to provide rewards and punishments at neuronal level.

Neocortex and two kinds of intelligences

Neocortex is often assumed to be superior ("neomammalian") part of the brain and makes the majority of brain hemispheres. The species which are considered to be highly intelligent, such as humans and dolphins, tend to have large amounts of neocortex. The amount of neocortex is roughly proportional to the brain size for primates.

Neocortex cannot correspond to $k_{eff} \geq 239$ (defining Gaussian Mersenne) as a whole. The decomposition of sensory areas to layers is consistent with the presence of lower levels since it is time resolution which matters in the case of sensory representations. Same conclusion applies to sensory association areas. The fine tuning of the motor control performed by cerebellum is consistent with $k_{eff} \leq 205$. Intelligence understood in the conventional sense of the word is accurate, works fast, and is computer like. The part of neocortex responsible for ordinary intelligence would be a rapid and accurate processor of sensory and cognitive representations. Hence $k_{eff} < 239$ would naturally characterize sensory areas, secondary and primary motor areas, to hippocampal representation of declarative memories, and all association areas except dorsolateral prefrontal sensory-motor association cortex where short term memories are represented.

Emotional intelligence works slowly and is responsible for visions and holistic views and would thus correspond to higher levels of dark matter hierarchy. Limbic system is involved with emotions, motivation and long term planning and would thus be responsible for emotional intelligence. Indeed, the damage to frontal lobes [J6] need not affect ordinary intelligence but affects emotional intelligence.

The levels of dark matter hierarchy associated with short and long term memory

The first thing to ask is of course whether the notions of short and long term memory make sense in TGD framework. Indeed, it would seem that it is more natural to speak about hierarchy of memories with characteristic time scales coming as selected powers of two.

1. According to [J13], the span of other than visual short term memories is 30-45 seconds. This requires $k_{eff} \in \{217, 218\}$.
2. Visual short term memories [J2] representing selected features of visual field are reported to have time span of few seconds. This suggests $k_{eff} \in \{213, 214, 215\}$.
3. Iconic visual memories representing entire visual field have much shorter time span of order 1 s: $k_{eff} \in \{211, 212\}$ would be appropriate for them,
4. Long term memories would correspond to $k_{eff} > 218$.

Hippocampus and mammillary bodies involved with long term memory recall are part of the limbic system. The hippocampal theta rhythm 4-12 Hz, which could correspond roughly to $k_{eff} \in \{163, 162, 161\}$ has nothing to do with the span of long term memories but would define the time resolution of the memories: the moment of sensory experience indeed corresponds to 10 Hz frequency. The frequencies responsible for memory storage need not have anything to do with the ultralow frequencies characterizing the temporal distance of the past event associated with the memory recall and hippocampus could just build a kind of bit sequence which during memory recall is communicated from the geometric past to some part of the future brain or magnetic body.

Anterograde amnesia means an inability to restore long term memories. The damage of hippocampus or of mammillary bodies can induce anterograde amnesia. In the usual conceptual framework the explanation would be the inability to store new long memories. In TGD framework this would be inability to construct those cognitive representations which are communicated to the geometric future in long term memory recall. Retrograde amnesia seems to involve almost always anterograde amnesia and means loss of memories for some time span before the injury. A possible explanation is that injury can propagate also to the geometric past of the brain quantum jump by quantum jump.

During ageing memories tend to be lost but the memories of childhood are the most stable ones. A possible interpretation is that faster rhythms of the generalized EEG tend to disappear: kind of scaled up variant for the process of falling into sleep accompanied by silencing of higher EEG bands could be in question.

What about transpersonal levels of consciousness?

$k_{eff} > 245$ levels of dark matter hierarchy correspond to time span longer than 109 years and cannot relate to the biological body alone. They could relate to higher collective levels of the dark matter hierarchy and evolution of social structures. The memories extending over personal life span claimed by meditators could have interpretation in terms of $k_{eff} > 245$ transpersonal levels of consciousness. Also the "god module" located to temporal lobes could correspond to this kind of levels of dark matter hierarchy. If it corresponds to Gaussian Mersenne with $k_{eff} = 283$ the time scale of memories becomes huge: about 10^{14} years so that the notion of "god module" is indeed appropriate.

Boolean qualia, fermions, and memetic code

The original proposal for the realization of Boolean mind was in terms of sequences cognitive neutrino pairs. These can be interpreted as wormhole contacts carrying neutrino and antineutrino at the light-like wormhole throats and would thus represent boson like entities. In the framework of the standard model the proposal looks of course completely non-sensical. TGD however predicts the existence of long range classical electro-weak fields, and one might imagine that inside neutrino- whose Compton length corresponds to length scale of cell- intermediate gauge bosons behave like massless fields. Although neutrinos could be important, the time scale of corresponding CD - about 10^4 years - suggests that cognitive neutrinos might be important in much longer time scale than the .1 second time scale assignable to the memetic code.

The recent view about TGD allows a much more general view. Zero energy ontology allows to interpret the fermionic parts of zero energy states as quantum superpositions of Boolean statements of form $a \rightarrow b$ with a and b represented in terms of positive and negative energy parts of the zero energy state. If one has negentropic entanglement this kind of state has interpretation as an abstraction - a "law of physics"- representing as a quantum superposition various instances of a more general law.

The simplest situation corresponds to a CD having only single positive energy fermion and negative energy fermion at its light-like boundaries. The fermion number or spin or isospin of the fermion could represent qubit. The hypothesis that memetic code corresponds to the next level of Combinatorial Hierarchy, when combined with p-adic length scale hypothesis, led to a prediction of order .1 seconds for the duration of the 'wake-up' period of subself corresponding to the codeword of the memetic code. Since the CD assignable to electron has time scale .1 seconds and the CD assignable to u and d quarks has time scale 1/1.28 milliseconds there is a temptation to proposed that the quark-like sub- CD s of electronic CD give to a realization of memetic code word as a sequence of 126 quark like sub- CD s. u and d quarks would be assigned to the magnetic flux tubes connecting DNA and the lipids of the cell membrane in the model of DNA as topological quantum computer. Clearly, beautiful connection between new elementary particle physics, genetic code, nerve pulse activity, DNA as topological quantum computer, logical thought, and the basic time scales of speech are suggestive.

This codeword consists of 126 bits represented by quarks such that the two possible magnetization directions correspond to the two values of Boolean statement. This implies that the duration of single bit should 1/1260 seconds. The duration of the nerve pulse is slightly longer than this which might mean that the full memetic code is realized as membrane oscillations rather than nerve pulse patterns. Both hearing and vision have .1 second time scale as a fundamental time scale and sounds are indeed coded to membrane oscillations in ear.

One can consider also the realization of genetic code with six bits of the codon represented by various scaled up versions of quark CD coming as size powers of 2. In this case the ordering of the bits would come from the size of sub- CD whereas in previous example temporal ordering would define the ordering. It is not however clear whether the powers of two can be realized physically.

One can understand the number 126 as related to the total number of separately experienced frequencies in the interval 20 – 20.000 Hz spanning 10 octaves. $10 \times 12 = 120$ is not far from 126: here 12 corresponds to 12 tones of basic music scale. Also speech has 10 Hz frequency as fundamental frequency. In visual primary cortex replicating triplets, 4-,5- and 6-plets of spikes with highly regular

intervals between spikes have been detected. The triplets are accompanied by ghost doublets. This would suggest a coding of some features of visual experience to reverberating mental images. The time scale for various patterns is .1 seconds. This could be seen as a support for the realization of some degenerate version of the memetic code as nerve pulse patterns.

The model for the memetic code encourages the following conclusions.

1. Membrane oscillation/nerve pulse patterns correspond to temporal sequences of magnetization directions for quarks representing yes/no Boolean statements.
2. The spin polarization of quarks is changed from the standard direction fixed by the spontaneous magnetization in the direction of axon by a ME moving parallel to axon, and inducing membrane oscillation or even a nerve pulse. Nerve pulses could correspond to a degenerate memetic code resulting by frequency coding for which the number of distinguishable code words is 64, and would thus naturally correspond to the reduction of the memetic code to the genetic code.

A very precise correspondence with the basic structures of the genetic code results. mRNA \rightarrow protein translation corresponds to the translation of temporal sequences of magnetization directions to conscious cognitive experiences. Under very natural constraints the mapping to cognitive experiences is not one-to-one and the predicted degeneracy (2^{126} sequences correspond to $(2^{126} - 1)/63$ cognitive experiences) can be understood.

One might think that the full memetic code is an evolutionary newcomer and involved only with the logical thought: this would explain the completely exceptional characteristics of human brain. The full memetic code could be realized for certain regions of brain only. These regions certainly include auditory pathways responsible for the comprehension of speech

6.4 A general model for sensory receptor

Various sensory qualia correspond to the average increments of quantum numbers for a quite long sequence of quantum jumps. Quantum numbers could be spin, momentum, energy, electromagnetic charge, color quantum numbers (isospin and hypercharge in a constant proportion), various particle numbers, etc... What happens in the sensory receptors is that the gradient of some physical quantity is transformed to average increments of appropriate quantum numbers responsible for the quale representing the gradient of the physical quantity. Spatial gradients are transformed first to temporal gradients by a process, which is essentially scanning (say saccadic motion). Temporal gradients are then transformed to non-vanishing average increments of appropriate charges per quantum jump in a long sequence of quantum jumps. The problem is to understand how this process is realized at the level of sensory receptors.

6.4.1 Capacitor model for sensory receptor

The assumption that sensory qualia are realized at the level of sensory receptors, when combined with the requirement that the average increments are non-vanishing, and perhaps even same from quantum jump to quantum jump, poses strong constraints on the model of the sensory receptor.

These constraints suggest what might be called the capacitor model of the sensory receptor.

1. There are two reservoirs of quantum charges having total charges of equal magnitude but of opposite sign. The charges are macroscopic in order to guarantee robustness. These reservoirs are analogous to capacitor plates, and only the second one corresponds to the sensory experienced quale unless both the quale and its conjugate are experienced simultaneously. Capacitor plates can carry several charges.
2. When the sensory quale is generated, there is a flow of charge quanta between the quantum capacitor plates. The charge quanta are more or less constant. This requirement could be relaxed to the condition that only the average increment is constant.

Cell membrane, or rather the pair formed by cell interior and exterior, and synaptic junction are excellent candidates for quantum capacitors.

1. During nerve pulse various ions flow between cell interior and exterior, which suggests that sub-neuronal sensory qualia are generated in a time scale of a millisecond. Also membrane oscillations might give rise to some kind of sensory qualia. In particular, super-conducting Cooper pairs and bosonic ions enter or leave the Bose-Einstein condensates at the magnetic flux tubes and this should give rise to a chemical experience defined by the quantum numbers of the carrier particle. Not only the increment of electric charge but increments of magnetic quantum numbers characterize the qualia in question. Various information molecules transferred through the cell membrane could also give rise to sensory qualia.
2. In the synaptic contact the vesicles containing neurotransmitter are transmitted, and the net quantum numbers for the vesicles should determine the neuronal chemical qualia associated with the process.

This model does not apply to all qualia. Qualia can be also associated with the quantum phase transitions at magnetic flux quanta. A typical example is a coherently occurring cyclotron transition for a macroscopic phase of Cooper pairs. It would seem that quantum phase transitions at the magnetic flux quanta and particle flows between the quantum electrodes associated with electret type structures could define two basic types of qualia. Note that electret structures are dual to magnetic flux quanta as solutions of field equations. Vision and hearing would be basic examples of these two types of qualia.

6.4.2 Capacitor model for color vision

Capacitor model allows to attack the problem of how color qualia are generated physically.

1. Color sensation results from a spatial gradient of illumination at a given wavelength transformed first to a temporal gradient: presumably by a saccadic motion. This explains color constancy naturally. The temporal gradient of illumination in turn induces a quantum jump sequence for which average increments of color isospin and hypercharge per quantum jump are non-vanishing and characterizes the color in question.
2. What is needed are two color capacitor plates with opposite color charges. Since color confinement implies the vanishing total color charges below certain length scale, the notion of color capacitor is very natural. The fact that a region of a given visual color has at its boundaries a narrow stripe with the complementary color could relate closely to color confinement. Also the after images with varying colors could relate to the back-flow of the color charges establishing the equilibrium situation between the plates of color capacitor. The color black experienced when eyes are closed could be interpreted as being due to a background flow occurring even in the absence of the visual stimulus (this sensation disappears and visual consciousness is lost if saccadic motions is not allowed to occur).
3. The temporal gradient of illumination induces a flow of color charges between the plates of the color capacitor. The coding of photon frequencies to colors results if the quanta transferred between the plates are colored particles with an isospin-hypercharge ratio characterizing the visual receptor in question. The simplest possibility is that color octet particles are in question so that three primary colors and their conjugates define the basic colors. A Bose-Einstein condensate of colored bosons is the most elegant manner to realize the capacitor. This mechanism requires only that the receptor is frequency sensitive, and that the quantum numbers of the colored particles associated with the capacitor plates depend on the receptor. Depending on the direction of the color charge flow a given receptor contributes color or its conjugate color to the experience, which is average over some set of receptors and thus a mixed color.
4. 3+3 primary colors (black and white are counted as conjugate colors) correspond naturally to the charged "gluons" in the octet representation. For higher color representations a more refined color palette results. For white-black vision the increment of the color hypercharge would be vanishing on the average. It could be also vanishing for the quanta involved (charged "gluons" belonging to $SU(2)$ triplet of gluons). If the classical color gauge field associated with the plates of the color capacitor reduces to $SU(2)$ one could indeed expect that black-white vision results.

The role of classical color gauge fields

The classical color gauge fields associated with the receptor plates could favor BE condensate with particular color quantum numbers. Classical color gauge fields in general give rise to vacuum color currents, and these could generate coherent states of some gluon like particles giving in turn rise to BE condensates. Since classical color fields are proportional to the induced Kähler field, one expects that strong color gauge fields are associated to solutions which are far from vacuum extremals. Other sensory receptors might differ from visual receptors in that they correspond to almost vacuum space-time sheets with very weak classical color gauge fields. A weaker condition is that the classical color gauge fields are so random that only weak coherent state and BE condensate results. MEs are excellent candidates for the carriers of colored BE condensates since their CP_2 projections are 2-dimensional and the classical color gauge field is Abelian and thus corresponds to a fixed $U(1)$ sub-group.

The model leaves a lot of room for the identification of the colored particles. The color could be in color rotational degrees of freedom of the space-time sheets, it could be gluonic color for a QCD realized in cellular length scale, or super-conformal color associated with what might be called configuration space photons.

Rigid body color?

The identification of the color as a degree of freedom analogous to rigid body rotational degrees of freedom is rather attractive because of its simplicity.

1. Every space-time sheet has color-rotational rigid body degrees of freedom. Since the space-time sheet is topologically condensed at a larger space-time sheet and connected by join along boundaries bonds to other space-time sheets, these degrees of freedom are partially frozen. This means breaking of color symmetry to a subgroup of color group. $U(2)$, $U(1) \times U(1)$, and $U(1)$ are the options besides complete breaking of color symmetry. This could explain why color capacitor mechanism is not involved with all cell membranes but requires special receptors.
2. The gluing operation for two space-time sheets occurs along 3-dimensional surface for both wormhole contacts and join along boundaries bonds. The requirement that gluing is possible implies that this portion of surface is a fixed point with respect to the subgroup of color group, which remains unbroken. If the region in question corresponds to a single point of CP_2 , the isotropy group is maximal and equal to $U(2)$. This means that quantum states correspond to a rigid body motion in $U(2)$. For $U(1) \times U(1)$ the states are also characterized by isospin and hypercharge. For $U(1)$ only isospin labels the states and this would correspond to black-white vision.
3. The simplest states correspond to the restriction of color representations in $SU(3)$ realized as matrix elements of color representations to $U(2)$. The restriction means that certain states drop off. To get some grasp on the situation, consider a simple example first. In the case of $SO(3)$ CP_2 is replaced by the sphere S^2 and the restriction to the group $U(1)$ drops away all matrix elements which vanish at the equator. For $J = 1$ triplet only the states having spin $J_z = \pm 1$ remain. Probably also in the case of $SU(3)$ only charged gluons survive in the octet representation restricted to $U(2)$. Since also color neutral states must be possible, the restrictions of higher representations must contain also color neutral states.
4. The freezing of color degrees of freedom means that the remaining degrees of freedom for the space-time sheet are zero mode like degrees of freedom. These degrees of freedom define what is known as a flag manifold. For $U(2)$ these degrees of freedom correspond to $CP_2 = SU(3)/U(2)$, for $U(1) \times U(1)$ the flag manifold is six-dimensional $SU(3)/U(1) \times U(1)$. Flag manifold qualia would correspond to sequences of constant changes for flag manifold coordinates. In the simplest case, sequences of steps along one parameter subgroup of $SU(3)$. The connection between the dance of the honeybee and color group made by Barbara Shipman supports the view that flag manifold coordinates define fundamental geometric qualia and are responsible, not only for the geometric aspects of vision, but of also other sensory modalities.

Gluons of scaled down versions of QCD and dark matter hierarchy

It became years ago clear that TGD allows a hierarchy of QCDs. The assumption that these QCDs are not asymptotically free allowed to circumvent the experimental bounds on the number of elementary particles. Given QCD would exist only in a certain range of p-adic length scales and thus in a certain range of energy and momentum transfers.

After the discovery of dark matter hierarchy with levels labelled by the values of Planck constant [K25, K26] it became clear that TGD not only allows but predicts hierarchies of electro-weak and color physics. Particles of different physics do not have direct interactions and bosons at a higher level of dark matter transform to bosons of a lower level by de-coherence phase transitions. In particular, ordinary intermediate gauge bosons do not decay to the particles of the predicted exotic color and electro-weak physics, and asymptotic freedom can be assumed for all these QCDs.

This forces to consider the possibility that QCDs could exist even in cellular length scales, and that Bose-Einstein condensates of gluons give rise to the opposite color charges of color capacitors. The topological condensation of gluons forces the breaking of the color symmetry for all colored particles, even gluons.

Configuration space photons?

TGD predicts also configuration space color degrees of freedom. What is remarkable is that these states do not carry any energy and momentum. Actually infinite-dimensional super-symplectic representations decomposing into representations of color group are in question. Rigid body color would represent the lowest states of these representations. MEs are especially good candidates for carrying this kind of color. If MEs with sizes below cell membrane thickness are involved with the transfer of color between the color capacitor plates, the energies of the particles involved must be in ultraviolet range by Uncertainty Principle. If the transfer occurs between cells, the length scale could be of order micrometer and thus visible wavelengths would be in question as is indeed natural. Perhaps the structures formed by cell layers are involved with our color qualia.

6.4.3 The structure of the retina and sensory organs as sites of sensory qualia

The assumption that sensory organs are carriers of the sensory representations entangling with symbolic representations realized at the level of cortex does not mean any revolution of neuroscience, just adding something what is perhaps lacking. Neuronal/symbolic level would do its best to symbolically represent what occurs naturally at the level of qualia. Color constancy could be understood as a basic characteristic of color qualia re-realized at the neuronal level.

Center-surround opponency for the conjugate colors is the neural counterpart for the contrast phenomenon in which the boundary for a region of the perceptive field with a given color carries the conjugate color (black-white opponency associated with the luminance is only a special case of this). The contrast phenomenon at the level of visual qualia could derive from the vanishing of the net color quantum numbers for the electrodes of the retinal color capacitors.

The basic prediction is the presence of the back projection at least in the sensory modalities in which hallucinations are possible. MEs with MEs mechanism is the most natural candidate for realizing the back projection, negative/positive energy MEs would realize the back projection based on quantum/classical communications, and the capacitor model of the sensory receptor can be applied to model photoreceptors and retina. This picture integrates nicely with the various speculations about the role of the ciliary micro-tubules in vision. The obvious question is how the presence and character of the back projection reflects itself in the structure of the sensory pathways and sensory organs. Basic facts about how gastrulation and neurulation proceed during the development of the embryo, lead to testable predictions about the character of the back projection for various sensory modalities, and one can speak about "brain senses" and "skin senses" according to whether the back projection is based on quantum or classical communications.

Various micro-tubular structures as photoreceptors/transducers

There is a definite evidence supporting the idea that micro-tubuli might be involved with a primitive vision. The information below is from the lecture "Quantum Vitalism" of Stuart Hameroff during an

online course about quantum consciousness held in Arizona University 1999.

Albrecht-Buehler [I47] has shown that single fibroblast cells move toward red/infra-red light by utilizing their micro-tubule-based centrioles for directional detection and guidance; he also points out that centrioles are ideally designed photodetectors. Photoreception/phototransduction mechanisms at all stages of evolution involve the nine micro-tubule doublet or triplet structures found in centrioles, cilia, flagella and axonemes. The centriole is a pair of micro-tubule-based mega-cylinders arrayed in T shape [I99]. Albrecht-Buehler has identified centrioles as the photoreceptor/phototransducer in photosensitive eukaryotic cells.

Flagellar axonemes are the photosensitive structures in protozoa such as *Euglena gracilis*. Cilia in rod and cone retinal cells in vertebrate eyes (including humans) bridge two parts of the cells and have length distribution covering visible wavelengths. Photosensitive pigments (rhodopsin) is contained in the outer segment while cell nucleus, mitochondria and synaptic connection are contained in the cell body. Light enters the eye and traverses the cell body and cilium to reach the rhodopsin-containing outer segment.

Mari Jibu, Kunio Yasue and colleagues [J68] have proposed that super-radiance in a micro-tubule could be involved with the photo-reception.

1. The energy gain due to the thermal fluctuations of tubulins is assumed to increase the number of water molecules in the first excited rotational energy state.
2. A collective mode of the system of water molecules in rotationally excited states is generated. A long-range coherence is achieved inside a micro-tubule by means of spontaneous symmetry breaking. The collective mode of the system of water molecules in rotationally excited states loses its energy collectively, and creates coherent photons in the quantized electromagnetic field inside a micro-tubule.
3. Water molecules, having lost their first excited rotational energies by super-radiance, start again to gain energy from the thermal fluctuation of tubulins, and the system of water molecules ends up to the initial state. Jibu and collaborators have predicted that cellular vision depends on a quantum state of ordered water in micro-tubular inner cores. The authors postulate a nonlinear quantum optical effect termed "super-radiance" conveying evanescent photons by a process of "self-induced transparency" (the optical analogue of super-conductivity) involving formation of BE condensate of photons.

Interestingly, the energy scale of the rotational excitations of water is that of microwave photons, and microwave MEs play a key role in bio-control in the TGD based model of living matter. Perhaps the mechanism proposed by Jibu and collaborators could have a variant realized in terms of TGD based physics and involving microwave-, visible-, and very low frequency MEs. In particular, the collective excitation of the water inside micro-tubule could be generated by coherent radiation of microwave photons accompanying microwave MEs rather than thermally. On basis of the second law one could indeed argue that thermal excitations cannot lead to the generation of macroscopic quantum coherent states.

In simple multicellular organisms, eyes and visual systems began with groups of differentiated light-sensitive ciliated cells which formed primitive "eye cups" (up to 100 photoreceptor cells) in many phyla including flatworms, annelid worms, molluscs, crustacea, echinoderms and chordates (our original evolutionary branch). The retinas in human eyes include over 4×10^8 rod and cone photoreceptors each comprised of an inner and outer segment connected by a ciliated stalk. Since each cilium is comprised of about 3×10^5 tubulins, our retinas contain about 3×10^{13} tubulins per eye. Retinal rods, cones and glia are interconnected by gap junctions [J71] and this could be crucial for the generation of the macro-temporal quantum coherence, which quite generally relies on the generation of join along boundaries bonds connecting the boundaries of the space-time sheets forming the bound state in question.

It is usually assumed that the cilium is a purely structural element, but the centriole/cilium/flagella micro-tubular structure, which Albrecht-Buehler has analyzed as an ideal directional photoreceptor, may detect or guide photons in eye spots of single cells, primitive eye cups in early multicellular organisms, and rods and cones in our retinas. The proposal that retinal macro-temporal quantum coherence leading to a new qualitative level of consciousness with much longer de-coherence time could have emerged in sheets of gap junction-connected ciliated cells in eye cups of early Cambrian worms, generalizes the vision of Hameroff and Penrose to TGD context.

The identification of the color capacitor structure

The first segment of the photoreceptor consists of the cell soma and a part containing mitochondria. This segment is connected by ciliated stalk to a layered structure containing the photosensitive pigments. The length distribution of the ciliary micro-tubuli covers visible wavelengths.

The closing of eyes generates so called dark current [J47] flowing along the receptor and inducing the hyper-polarization of the receptor membrane. Since visual consciousness is not lost, the natural TGD inspired conclusion is that dark current is the neural correlate for the quale black as a background color quale which in turn results by the color capacitor mechanism.

The fact that vertebrate retina differs by inversion from the retina of invertebrates [I61] inspires the question whether the micro-tubular vision of invertebrates about external world might have been inverted to produce "inner vision" providing back projection in the case of the vertebrates. If so vertebrate cilia would receive the "inner light" or generate it itself with brain remotely controlling the process. Mitochondria in turn could provide the needed metabolic energy but could also act as amplifiers of the incoming light.

The photosensitive layers consist of endoplasmic membranes so that the realization of the capacitor mechanism would be the same as for the ordinary axonal membrane (nerve pulse inducing flows of ions giving rise to the neuronal chemical qualia). The membrane would be at criticality as regards to the occurrence of the spontaneous color discharge and incoming photon would cause the breakdown. Since the color discharge can be assumed to flow from the side determined by the direction of the membrane electric field, each layer generates same visual qualia although the direction of the color discharge varies. Layered structure would increase the sensitivity of the retina and facilitate the recharging of the capacitors since discharge would make intermediate regions charged and thus unstable.

It would not be surprising if also the endoplasmic membranes filling the cell interior might serve the purpose of acting as quantum capacitors providing neuron with sensory receptors of various kinds. Also neuronal vision is quite possible: the difference from our vision would be that our vision involves integration of a very large number of neuronal experiences (more than .1 billion receptors) by quantum entanglement to form our vision. The gap junctions between visual receptors would make possible macro-temporal quantum coherence and the fusion of receptor level visual mental images to our visual mental images.

Back projection mechanism

The basic mechanism responsible for the back projection would involve curved low frequency MEs. Low frequency MEs could be regarded as topological light rays inside effective wave cavities defined by the magnetic flux tubes parallel to the axons, and leading from the cortex to lateral geniculate nucleus to ganglions to the retina. These magnetic flux tubes would form a part of the magnetic body associated with the retina and have quite large a size. Inside low frequency MEs high frequency MEs would propagate as effectively massless particles. In the case of vision high frequency MEs would have lengths in the wavelength range covering that of the visible light.

1. *The inverted structure of retina and back projection hypothesis*

Photo receptors consist of rods and cones. Only rods are active at low luminance level (black-white vision). Cones are active at high luminance levels and sensitive to the wavelength of the light. Receptor cells are coupled via bipolar cells to ganglions which in turn feed the sensory input along the inner surface of the retina to the blind spot, and from the blind spot to the lateral geniculate nucleus (LGN) of the thalamus. Below (above) bipolar cells are horizontal (amacrine) cells responsible for the lateral couplings between receptor bipolar synapses.

Back projection hypothesis could allow to understand why the incoming light meets first ganglions and wanders through amacrine, bipolar, and horizontal cells to receptors. The inverted structure is indeed required by the back projection: the inner light (coming along, say curved MEs parallel to magnetic flux tubes parallel to micro-tubuli to ganglions or even remotely generated in the ciliated stalk), must superpose with the incoming light. If the structure would be what a naive engineering argument would suggest, the inner light should meet the receptors from an opposite side than the light from the external world, and thus from a wrong side.

2. *Back projection and retinal magnetic body*

It is interesting to relate back projection to the retinal magnetic body. The following two arguments lead to the same estimate for the size of the retinal magnetic body.

1. The value of the ratio f_h/f_l of high and low frequencies appearing in the scaling law of [I20] [K36] determines f_l . For the value $f_h/f_l \simeq 2 \times 10^{11}$ identifiable as the ratio of the ionic zero point kinetic energy at atomic space-time sheets and ionic cyclotron energy E_c in the Earth's magnetic field, this would predict that f_l is about $f_l \sim 3$ kHz so that retinal magnetic body would have size of order 100 km.
2. The scaling law relating the sizes L_{CNS} of brain structures to the sizes L_{magn} of the corresponding magnetic bodies would give in the case of eye $L_{magn} = (c/v)L_{CNS}$, where v is the conduction velocity of nerve pulses or some other relevant velocity parameter. For $v = 10$ m/s and the size of retina about $L_{CNS} \sim 1/3$ cm, this would give $L_{magn} \sim 300$ kilometers so that the estimates are of same order of magnitude.

The ratio c/v could be interpreted as the ratio of the ionic zero point kinetic energy at the cell membrane space-time sheet and of the ionic cyclotron energy E_c . The thickness of the ionospheric cavity is approximately $d = 100$ km. Could this mean that the size of the retinal magnetic body is determined by the thickness of this cavity believed to also give rise to Schumann resonances? If so, then low frequency retinal MEs could be seen as correlates for a radiation moving between the Earth's surface and ionospheric lower boundary forth and back, somewhat like between two mirrors. For $d = 100$ km the period for a single forth-back reflection would be $\tau = .67$ ms, which is near to the duration .78 ms for a single bit of the memetic codon. For $d = 118$ km the duration of the memetic bit would result. Of course, retinal magnetic flux tubes could also be loops returning from the surface of the ionosphere which would make τ longer. If this identification is correct, the temporal variations of various perceptive time scales, say the time resolution of visual perception, determined by the duration of memetic bit, could correlate directly with those of d . In particular, during night time, when ionosphere tends to fall to lower heights, the time scales would become shorter making reaction times shorter.

3. Negative or positive energy MEs or both?

There are reasons to believe that negative energy MEs act as quantum entanglers whereas positive energy MEs are dissipative structures in the sense that the effective phase velocity of the classical fields associated with them is much slower than light velocity. The quantum mechanism leading to the lowering of the effective phase velocity would be basically the sticking of the ME along its boundaries to say cell membrane space-time sheet and to the magnetic flux tube of the Earth's magnetic field.

According to the general model of the motor action as a geometric time reversal of the sensory perception, motor action involves always the generation of low frequency negative energy MEs. Their presence explains the findings of Libet related to the active aspects of consciousness and implies that motor action involves precognitive aspect. The interpretation would be that some higher level structure of CNS or even magnetic body draws negative energy from the motor organs with the mediation of the negative energy MEs. In the case of sensory perception low frequency negative energy MEs would act as bridges allowing the sharing of the mental images between brain and sensory organ.

To sum up, one has two basic options: classical and quantum:

1. Positive energy MEs are involved with the back projection. In this case back-projection would be based on classical communications.
2. Negative energy MEs are responsible for the back projection which might be regarded as a generalized motor action. The phase conjugate of the laser wave would be the standard physics analog. If so then buy now-let other pay mechanism making possible remote metabolism could be involved with the back-projection. This mechanism is the basic mechanism of the metabolism in TGD framework [K38] and implies extreme flexibility.

There are reasons to believe that both options are realized, and one can classify sensory modalities according to whether the back projection is realized by classical or quantum communications. One can also relate these two options to what happens to the embryo during the gastrulation and neurulation.

4. Where the control of back projection mechanism is?

One should also understand where the MEs at visible frequencies are generated.

1. Fractality suggests that the back projections are generated at several levels: ganglions, LGN and various sensory areas. For option 2) the generation of the inner light could mean generation of the quantum entangling negative energy low frequency ME carrying inside it negative energy visible frequency MEs to the appropriate part of the brain. The process could be interpreted as sucking of negative energy from retina.
2. Back projection could be partially responsible for the appearance of the conjugate color at the boundary of a region of given color to improve contrast. Neuronal level would mimic this qualia level phenomenon at levels of the hierarchy. Whether back-projection from ganglia could relate the on-off structure of the receptive fields even at ganglion level, is an open question. The appearance of the conjugate color at the boundaries of a region of the visual field of a given color could relate to the vanishing of the net color charge for the "positive" electrodes of the system of parallel color capacitors formed by the photoreceptors coupled by gap junctions to form single macroscopic color neutral system.
3. The chromo-oxidase (CO) blobs associated with the visual areas V1 and V2 [J65] are a signature of high metabolic activity. For option 2) this would mean that the mitochondria in the neurons of CO blobs suck negative energy photons from some part of the retina, perhaps from the micro-tubuli in the ciliated stalk. The interpretation would be that retina shares the mental image representing the desire of some higher level structure to modify the sensory image and acts accordingly. For option 1) CO blobs would generate positive energy visual MEs propagating to the retina along low frequency MEs: this communication would be classical and limited by the effective phase velocity of the positive energy MEs, presumably of order 10 m/s.

5. *Which cellular structures are involved with the generation of the inner light?*

The basic question is which cellular structures are involved with the, possibly non-local, generation of the inner light and which are the mechanisms involved. One can imagine several options. Option 1) is most plausible in the case of vision and olfaction whereas option 2) might be realized when the back projection occurs via classical communications.

1. Mitochondria could act as suckers of the negative energy from the retina. Cytochrome oxidase (CO) [J65] is involved with the liberation of the metabolic energy and is associated with mitochondria which are everywhere. The large amount of CO in CO blobs suggest that they are metabolically very active. This could be due to the sucking of negative energy photons responsible for the remote metabolism at retina. Note that this mechanism would be essentially lossless and could be said to involve a temporal change of the arrow of the geometric time at the level of MEs. In fact, it is known that metabolism is almost lossless.
2. Mitochondrial autofluorescence could generate the inner light actively [I48] rather than as a mere by-product of metabolism: in this case however positive energy photons would be generated at CO blobs. The study of fluorescent life forms, say fireflies and life forms able to change their skin color might provide understanding about the feasibility of back projection using this mechanism (applying for option 1)).
3. Also cell nucleus must be considered as a candidate for the source of the inner light. Cell nucleus is believed to produce bio-photons and they cover just the right frequency range. The TGD based model for bio-photons leads to the conclusion that pairs of positive and negative energy MEs are involved with the standard mechanism of the bio-photon emission. Nucleus could participate in the processing of the neuronal sensory input actively if the intronic portion of the genome expresses itself using MEs obeying swift dynamics. In the case of positive energy MEs communications would be classical and memetic code could be involved. The nuclear inner light is naturally involved with the communications between cell nucleus and membrane and cellular vision. If the cell nucleus is the brain of the cell, one must keep mind open for the possibility that cell nuclei inside CO blobs control the generation of inner light by drawing negative energy photons from receptors. The absorption of compensating positive energy photons from the mitochondria would be however necessary and make the mechanism too complicated. A somewhat more natural mechanism would be based on sending of negative energy bio-photons to mitochondria and positive energy bio-photons to the retinal receptors along low frequency

MEs. Certainly the simplest option is that mitochondria control back-projection by sucking negative energy from retina.

6. *Do the cilia/mitochondria in photoreceptors serve as pre-amplifiers?*

Cilia might act as pre-amplifiers for the light coming the external world, at least in the case that the illumination is very weak. If the inner light comes from brain as positive energy photons (option 1)), it is expected to have extremely weak intensity and pre-amplification mechanism could be at work also now. For option 2) the pre-amplification mechanism would be replaced by the sharing of the mental image representing the desired modification of the visual mental image and realized by buy now-pay later mechanism.

One can consider at least two different options for the pre-amplification mechanism.

1. Cilia act as pre-amplifiers and the process is triggered by the incoming inner light by a stimulated emission mechanism for which the rate for the generation of photons is proportional to N^2 , N the number of photons already existing in the system. For option 1) this mechanism would be at work also for the inner light.
2. The article about reversible excited light induced enhanced fluorescence (briefly RELIEF [I48]) supports the view that mitochondria need not only produce fluorescence as a passive by-product of energy yield but could act as amplifiers of the incoming light [I48]. Also now buy now-pay later mechanism could be involved. RELIEF phenomenon allows to consider the possibility that the large number of mitochondria preceding cilia in the visual receptors could serve as a pre-amplifier for the incoming inner light. The precise information about the mechanism of autofluorescence in the case of fireflies and life forms able to change their skin color might provide strong constraints on the model.

Does the back projection emerge in the transition from invertebrates to vertebrates?

Three inversions characterize the transition from invertebrates to vertebrates.

1. The inversion of the retina occurs [I61] .
2. In vertebrates *resp.* invertebrates incoming color generates hyperpolarization *resp.* polarization of the receptor membrane [I61] . Thus it would seem that the roles of white and black are changed in the vision of invertebrates: invertebrates detect the lack of light.
3. During morphogenesis the generation of neural tube giving rise to spinal cord, motor nerve, eyes and other sensory organs in head occurs [A20] , [I53] . Neural tube is formed through a folding process implying that neural tube results essentially from an inside-outside inversion of the outer epithelial sheet of the skin.

The finding that neural tube and skin are related by inversion inspires the following questions.

1. Could one relate the first two inversions to the the third one? The following arguments summarizing the basic facts about gastrulation and neurulation support this guess.
2. What implications the inversion could have for consciousness? Did it change the character of some sensory modalities in a decisive manner so that one see "skin senses" and "brain senses" as inversions of each other in some sense. Could it be that the "skin senses" do not involve the telepathic back projection and that the possible back projection is based on classical communications in this case? Could one understand the emergence of the vertebrates as a step in which the telepathic back projection emerged in vision and perhaps also in some other sensory modalities like olfaction, and made vertebrates dreamers and artists building visual representations as caricatures? Could it be that under appropriate circumstances tactile senses could provide telepathic information from the external world making possible a telepathic remote sensing which in general need however not provide information directly conscious-to-us?

1. Gastrulation and the differences between vertebrates and invertebrates

Gastrulation [A20] , [I53] during which the growing embryo gets gut, is said to be the most important and vulnerable period in the life cycle of a multi-cellular organism. During this period the embryo begins to express its own genome (mother's genome has taken care of development hitherto). The details of this process differ for invertebrates (sea urchin is standard example), amphibians (say frog), and higher vertebrates (birds, reptiles, mammals). In the case of vertebrates the process leads to the generation of essentially three kinds of cell populations. Endoderm develops to inner organs like stomach, intestine and lungs. Mesoderm consists of cells originally contained by the surface of the blastula and differentiates to muscles and inner organs like heart. Ectoderm is the outermost cell layer of the embryo consisting two parts which differentiate later to the nervous system and skin.

For invertebrates gastrulation occurs through a process known as invagination, which is essentially the inpocketing of the epithelial sheet. The pocket like structure elongates to gut tube like structure consisting mainly of endoderm. The nervous system develops from the mesoderm.

Gastrulation occurs differently for amphibians and higher vertebrates. In the case of amphibians gastrulation involves so called involution which means that the mesoderm part of the epithelial sheet rolls below the epiderm to form a double-layered structure (the folding of a rug gives idea of what happens). This process occurs for both halves of the embryo and give. In the case of birds, reptiles, and mammals the gastrulation starts from a situation to which gastrulation leads in the case of amphibians. This in the sense that the outer surface of the blastula is a double layered structure consisting of epiblast and hypoblast below it already in the beginning of the gastrulation. The ingression (detachment) of the cells from the the epiblast *resp.* hypoblast sheet to the interior of the blastula gives rise to mesoderm (muscles, heart,...) *resp.* endoderm (stomach, intestine, lungs,...). The remaining epiblast will later transform to skin and nervous system.

2. Neurulation and the difference between "skin senses" and "brain senses"

Before neurulation the outer surface of the vertebrate embryo consists of two parts: the future skin and neural plate forming the future nervous system [A20] , [I53] . During neurulation the ectoderm in neural plate invaginates to form neural tube and neural crest between the neural tube and the ectoderm surface forming the future skin. Neural crest is formed by the ingression of cells from the skin and gives rise to sensory and autonomic nerves, Schwann cells, pigment cells, ... Neural tube in turn gives rise to brain, spinal cord, motor nerves, eyes,...

The surface of the neural tube is essentially the outer layer of the skin, which has suffered inside-outside inversion. The inversion might mean that the external world is replaced effectively by internal world as far as possible sensory experiencing relying on micro-tubule based sensory organs is considered. This suggests that all "brain" senses such as vision and olfaction involve a telepathy based back projection (sharing of mental images) in an essential manner. "Skin senses", in particular hearing, would in turn involve non-telepathic back projection based on classical communications. Invertebrate eye is formed from the surface cell layer which has not suffered inversion: this could explain why vertebrate and invertebrate eyes differ by inversion. Invertebrates are "almost-predicted" to have back projection based on the classical signalling, in particular in the case of vision: this prediction is testable.

If hearing is "skin sense", as suggested by the fact that we "hear" low frequencies by skin (besides my fragmentary information on the development of the embryo), one must conclude that the back projection to ears must be classical. This conforms with the fact that geometro-temporal patterns of sound waves are the key element of audition. Oto-acoustic sounds audible even by outsiders are indeed a well-known phenomenon and also tinnitus should be caused by back projection involving classical signalling, perhaps by MEs inducing oscillations of nuclei and thus sounds in the inner ear. The hallucinations in "skin senses" and "brain senses" should have a different character. This might explain why dreams are usually either visual or based on internal speech whereas the dreams accompanied by auditory hallucinations are rare and those involving tactile sensations even rarer.

Telepathic "skin senses" (with hearing included) are predicted to be possible and should involve a sharing of remote mental images. The shared mental image need not be directly conscious-to-us. Interestingly, galvanic skin response is a well-known physiological correlate of parapsychological effects and skin seems to play an important role quite generally (e.g. healing by touch and the time varying magnetic fields emitted by the hands of some persons with psychokinetic abilities). Blind people can develop tactile vision and also tactile hearing is possible: an interesting question is whether these

senses involve quantum entanglement with the object of the perceptive field. The "sense of presence" might also be seen as a remote "skin sense". That car driver experiences the road through the heels of the moving car as if the vehicle were a part of his body, might be understood in terms of the entanglement associated with touch. Furthermore, it is far from trivial how we know that the sounds from the external world really enter from the external world: perhaps quantum entanglement with the sources of the sound waves is part of the explanation.

The notion of bicamerality introduced by Jaynes [J67] inspires the hypothesis that bicamerals and also schizophrenics can receive conscious information from collective levels of consciousness as auditory and visual hallucinations (see the last part of the book). The direct sharing of sensory mental images or of symbolic mental images back projected to sensory mental images would be in question. In the case of auditory hallucinations this process should involve classical back projection unless a genuine telepathy is in question. This prediction could be perhaps tested by studying the physiological correlates of hallucinogen induced experiences.

3. Back projection hypothesis and olfaction

Back projection hypothesis could allow to understand also some strange findings about insect olfaction.

1. As Callahan has demonstrated, insects experience odorant molecules through the infrared light that they generate, rather than chemically [I58] .
2. Olfactory and visual receptors resemble strongly each other. The fact that olfactory bulb can be seen as part of brain, suggests that the inversion of the receptors occurred also for infrared sensitive micro-tubular receptors, that the back projection is "telepathic" also in the case of the odor perception, and that for "brain senses" the sensory input is always transformed to photons at some wavelength range before it enters to the quantum capacitor and is transformed to qualia.

The infrared light responsible for the "inner odors" could be generated by the same mechanism as the "inner light" the case of vision and would probably involve micro-tubular structures. The micro-tubuli involved with odor receptors should have lengths in the range 5-100 micrometers. Albrecht-Buehler, who has done a lot of experimental work in cellular infrared vision, has demonstrated that infrared signals affect the behavior of cells and that the infrared detector is in the centrosome [I46] .

How to test the general model?

The basic assumption of the model are following.

1. Sensory organs are the seats of the sensory qualia and basic sensory representations are realized at the magnetic bodies associated with the sensory organs.
2. Back projection is based on quantum *resp.* classical communications for "brain senses" *resp.* "skin senses".

There are huge quantities of information about sensory perception so that one can invent tests for these assumptions by just going to Mednet and by loading abstracts.

1. Phantom sensations, back projection, and the notion of magnetic body

Tactile hallucinations provide interesting tests and challenges for the notion of magnetic body and for the assumption about sensory organs as seats of sensory qualia.

1. It is known that a tactile stimulation of the existing leg can evoke a dual phantom sensation in a symmetric position, that visual input affects the spontaneous but not the evoked phantom sensation, and that sensory-motor input affects the spontaneous phantom leg sensation [J52] . The role of the visual input suggests that the evoked phantom leg sensation involves an erratic localization of the tactile sensation at the level of the sensory map of the geometric now and thus involves cortical information processing. The loss of the leg need not lead to the loss of the magnetic body associated with the leg. The tactile back projection could generate tactile mental image in the stump of the leg, which would be entangled with a point of the magnetic body of the amputated leg at the same position as as the tactile mental image associated with the existing leg.

2. The sharing of mental images in principle makes possible to have sensory experiences without sensory input to cortex, a genuine quantum telepathy in the scale of the human body. Anton's syndrome could be seen as an example of this. Also various bodily sensations experienced when the afferents to the brain are anesthetized could be seen as sensory telepathy. Typically sensations of swelling, elongation, and shortening as well as of cold, warm, and prickling are involved ("numbness" of hand is familiar to anyone) [J56]. The latter sensations could be interpreted as an evidence for the sharing of sensory mental images. The experiences about swelling, elongation and shortening would result from the erratic estimation of the geometric parameters of the body part in the absence of the sensory input to the cortex implying in turn the distortion of the image of the body part at the magnetic body.

2. Basic tests for back projection mechanism

Dreams and hallucinations should not involve "skin senses" except in the case that classical back projection is activated. Auditory/tactile hallucinations should involve classical communications from brain to ears/skin unless geometric memories or remote sharing of mental images are involved. Hypnotically induced hallucinations combined with the physiological monitoring of primary sensory organs and sensory pathways allow to test whether the predicted differences between skin and brain senses are indeed there.

The presence of the back projection could be tested by using hypnotic suggestion to experience particular qualia. One can test whether it is possible at all experience hypnotically induced tactile qualia and does this experience involve classical signalling from brain. One could test whether something occur in color receptors of a person with closed eyes or in a dark room under hypnotic suggestion. One could investigate whether the activity of CO blobs or say P cells in LGN correlates directly with the activity at the retinal level during hallucinations. One could check whether the back projection for invertebrates involves always classical signalling.

3. Hypnosis and back projection

The findings about hypnosis and color vision [J54] suggest more detailed tests for the back projection hypothesis.

1. The study in question was designed to determine whether hypnosis can modulate color perception. Such evidence would provide insight into the nature of hypnosis and its underlying mechanisms.
2. Eight highly hypnotizable subjects were asked to see a color pattern in color, a similar gray-scale pattern in color, the color pattern as gray scale, and the gray-scale pattern as gray scale during positron emission tomography scanning by means of CO_2 . The classic color area in the fusiform or lingual region of the brain was first identified by analyzing the results when subjects were asked to perceive color as color versus when they were asked to perceive gray scale as gray scale.
3. When subjects were hypnotized, color areas of the left and right hemispheres were activated when they were asked to perceive color, whether they were actually shown the color or the gray-scale stimulus. These brain regions had decreased activation when subjects were told to see gray scale, whether they were actually shown the color or gray-scale stimuli. These results were obtained only during hypnosis in the left hemisphere, whereas blood flow changes reflected instructions to perceive color versus gray scale in the right hemisphere, whether or not subjects had been hypnotized.
4. The conclusions were that among highly hypnotizable subjects the observed changes in subjective experience achieved during hypnosis were reflected by changes in brain function similar to those that occur in visual perception. These findings support the claim that hypnosis is a psychological state with distinct neural correlates and is not just the result of adopting a role.

The findings of [J54] inspire following comments.

1. The occurrence of hypnotically induced changes in brain function similar to those occurring in visual perception supports the view that sensory organs are the seats of the primary sensory experience. If eyes are the seats of color qualia, hypnosis should induce back projection as is

also obvious from the fact that hypnosis induces hallucinatory experiences. The occurrence of the back projection could be tested by using hypnosis in the absence of external light stimulus by testing what happens whether color receptors are active when person is hypnotized to see color.

2. That the left hemisphere is less gullible in ordinary wake-up consciousness supports the role of right hemisphere as the new-ageish entangler and of the left hemisphere as the skeptic loner. Parts of right brain would become more easier extensions for the brains of suggestive persons even without hypnosis. Right brain hemisphere could also be the the sensory artist, and thus the dominating generator of the inner light associated with the back projection. Right brain hemisphere could also generate the inner "voices" of auditory hallucinations as Jaynes proposes [J67] or be entanglement with some higher level of self hierarchy using right brain hemisphere to generate the hallucinations.

4. *Models for sensory organs and back projection*

The insights provided by the study of the structure of the retina encourage to think that a detailed data about various sensory receptors and their development during embryo period could provide a lot of insights about the mechanisms generating sensory qualia and about the mechanisms of the back projection and lead to testable predictions. This would however require a lot of professional knowhow. Also the possible role of bio-photons in back projection might be amenable to study.

6.4.4 Some examples about deficits of color vision as a test of the model for cognitive representations

The article "Quining the Qualia" by Daniel Dennett gives [J39] a good view about the difficulties encountered as one tries to understand qualia as a philosopher. Dennett's reaction to the problems is to give up the notion of qualia altogether. To me this is like denying the causal role of consciousness just because we do not have mathematical and conceptual tools to describe it. This is however not the main point now. Dennett lists some fascinating empirical findings related to deficits in color vision, which serve as excellent tests for any theory of qualia.

It is instructive to consider these examples in the framework provided by the model of cognitive representations just discussed. For this purposes let us list the basic general assumptions of the model in the case of color vision.

1. The paradoxical fact that receptor cells hyper-polarize rather than depolarize as they receive light is consistent with the requirement that incoming light must increase the color voltages between cone system and its magnetic body in order to generate color discharge. Rods would differ from cones in that the full color algebra $SU(3)$ to its sub-algebra $SU(2)$ so that only the increments of color isospin I_3 would be perceived and would give rise to black and white as primary qualia. Thus only charged $SU(2)$ gluons are exchanged between the magnetic body associated with the rod system.

In the case of cones the most natural assumption is that all 3+3 colors (black and white are counted as colors) are perceived and correspond to increments of color isospin and two generators carrying hyper charge. Single cone could be specialized to produce up the increment of color quantum numbers corresponding to a particular primary color. The increment of color quantum numbers should always have the same sign in the ideal situation (only quale which is red or green, blue or yellow, black or white is produced if the highest weight or lowest weight states of the representation of color algebra (or color Kac-Moody algebra) define the ground state of the system.

2. Cortex is assumed to participate actively to the coloring of the sensory map by using back projections to retina and the experienced color map is an outcome of a complex information processing.
3. The magnetic bodies of retina would contain regions where colors are cognitively represented as an analog of color circle so that the over all color sensation generates cognitive and emotional representations as a "somatosensory" experience at the magnetic body realized as cyclotron

phase transition patterns. Pure colors would correspond to patterns localized at single point of the magnetic body whereas mixed colors would correspond to delocalized patterns.

First example

Objects to the right of the vertical meridian appeared to be of normal hue, while to the left they were perceived only in shades of gray, though without distortions of form... He was unable to recognize or name any color in any portion of the left field of either eye, including bright reds, blues, greens and yellows. As soon as any portion of the colored object crossed the vertical meridian, he was able to instantly recognize and accurately name its color.

This finding could reduce the plausibility of the hypothesis that sensory organs are seats of sensory qualia and of primary cognitive and emotional representations. The hypothesis passes the test. Retina decomposes to nasal and temporal retina. This corresponds to the decomposition of the visual field of retina to right and left hemifields [J5]. The inability to recognize and name colors in the left visual could be simply due to the fact that cones sensitive to color are not functioning properly or at all in the left temporal and right nasal retina. A more complex situation would result if parts of cortex responsible for the back projections to the left visual field want to "see the world as grey" and actively reduce the color map to the shades of grey.

Second example

The patient failed in all tasks in which he was required to match the seen color with its spoken name. Thus, the patient failed to give the names of colors and failed to choose a color in response to its name. By contrast, he succeeded on all tasks where the matching was either purely verbal or purely nonverbal. Thus, he could give verbally the names of colors corresponding to named objects and vice versa. He could match seen colors to each other and to pictures of objects and could sort colors without error.

What was remarkable that the patient was not aware of any deficit.

There is an obvious analogy with the phenomenon of absolute ear. Almost anyone can tell whether two notes have the same pitch but only people with absolute ear learn to name the heard note. In the case of color vision almost all of us have "absolute eye" in the sense that we can recognize the perceived color and name it but in the above described case this ability would be lost. The analogy is weakened by the fact that musicians not possessing absolute ear are quite well aware of their "deficit".

Accepting the analogy, the TGD based model for absolute ear generalizes as such to the recent situation. The model of absolute ear is based on a comparison in which reference dark photon signal is sent from the temporal planum [J45] to the magnetic body assignable to the cochlea. Recognition relies on the constructive interference of the dark photon signals from cochlea and temporal planum enhancing the rate for the cyclotron phase transition. This model generalizes to a general model for how conscious pattern recognition occurs at the level of the magnetic body and applies in the case of vision too.

1. There should exist a region of visual or associative cortex analogous to the temporal planum sending a dark photon signal to the magnetic body of retina.
2. That the patient is not aware of the syndrome suggests that the reference signal representing given name of color as actual color is sent but goes to a "wrong address" at the magnetic body and is not compared with the real signal. If the cognitive "color circle" correspond to a small portion of the magnetic body as the general model for cognitive representations suggests, the resonance could indeed occur at wrong position of the magnetic body receiving different kind of cognitive input.

Third example

One morning in November 1977, upon awakening, she noted that although she was able to see details of objects and people, colors appeared "drained out" and "not true." She had no other complaint... her vision was good, 20/20 in each eye... The difficulty in color perception persisted, and she had to seek the advice of her husband to choose what to wear. Eight weeks later she noted that she could no longer recognize the faces of her husband and daughter... [So in] addition to achromatopsia, the patient had

prosopagnosia, but her linguistic and cognitive performances were otherwise unaffected. The patient was able to tell her story cogently and to have remarkable insight about her defects.

This case could be understood as the failure of the back projection mechanisms making possible coloring of the percept and the generation of the caricature like percept allowing recognition of faces. Also the recognition of faces could rely on the resonance mechanism in which signal is sent from cortex to an appropriate magnetic body.

These examples should demonstrate that the TGD based notion of qualia combined with the general model for cognitive and emotional representations can easily explain the findings discussed in [J39].

6.4.5 Odor perception and quantum coherence

In Discover magazine there is an article titled *Is Quantum Mechanics Controlling Your Thoughts?* [I49] telling among other things about the latest direct evidence of quantum effects provided by experiments related to odor perception. The article discusses the work of the biophysicist Luca Turin [J102] about odor perception as an additional support for quantum brain. Before going to the article it is good to summarize the basic ideas about sensory qualia (colors, odors, ...) in TGD inspired theory of consciousness.

1. In TGD framework the the identification of qualia follows from the identification of quantum jump as a moment of consciousness. Just as quantum numbers characterize the physical state, the increments of quantum numbers characterize the quantum jump between two states. This leads to a capacitor model of the sensory receptor in which the sensory perception corresponds to a generalized di-electric breakdown in which various particles carrying some quantum numbers flow between electrodes and the change of the quantum numbers at second electrodes gives rise to the sensory quale in question.
2. It is important that sensory qualia are assigned to the sensory receptors rather than to the neural circuitry of brain as in standard neuroscience. This leads to objections (phantom leg for instance) which are circumvented in TGD based vision about 4-D brain. For instance, phantom leg would correspond to sensory memory resulting by sharing the mental image about pain residing in the geometric past when the leg still existed. A massive back-projection generating virtual sensory input from brain (or from the magnetic body via brain) is needed to build the actual perception as a kind of art-work by filtrating from the actual sensory input a lot of unessential stuff and amplifying the essential features.
3. The discovery of Callahan [I58] that odor perception of insects seems to be based on IR light inspired my own the proposal that photons at IR frequencies could be involved with the odor perception so that odor perception would be at molecular level seeing by IR light. Even hearing could involve similar "seeing" in appropriate frequency range. Massless extremals (topological light rays) would serve as kind of wave guides parallel to axons along which light would propagate as kind of laser beams between receptor and brain. This would also explain why the mediation of auditory input takes so rapidly.
4. I have also proposed frequency coding for the sensory qualia. The first proposal which I dubbed as "Spectroscopy of Consciousness" stated that cyclotron frequencies assignable to various biologically important ions -much below IR range- associated with as such correspond to sensory qualia. Later I gave up this idea and proposed that frequencies code provide only a symbolic representations- define their names- as one might say. The information about qualia and more general sensory data would be represented in terms of cyclotron frequencies inducing dynamical patterns of the cyclotron Bose-Einstein condensates of biologically important ions residing at the magnetic body receiving the sensory information.

Vibrational theory of odor perception

I attach a small piece of the article here to give a popular summary about the work of Luca Turin [J103].

Quantum physics may explain the mysterious biological process of smell, too, says biophysicist Luca Turin, who first published his controversial hypothesis in 1996 while teaching at University College

London. Then, as now, the prevailing notion was that the sensation of different smells is triggered when molecules called odorants fit into receptors in our nostrils like three-dimensional puzzle pieces snapping into place. The glitch here, for Turin, was that molecules with similar shapes do not necessarily smell anything like one another. Pinanethiol [C₁₀H₁₈S] has a strong grapefruit odor, for instance, while its near-twin pinanol [C₁₀H₁₈O] smells of pine needles. Smell must be triggered, he concluded, by some criteria other than an odorants shape alone.

What is really happening, Turin posited, is that the approximately 350 types of human smell receptors perform an act of quantum tunneling when a new odorant enters the nostril and reaches the olfactory nerve. After the odorant attaches to one of the nerves receptors, electrons from that receptor tunnel through the odorant, jiggling it back and forth. In this view, the odorants unique pattern of vibration is what makes a rose smell rosy and a wet dog smell wet-doggy.

The article "A spectroscopic mechanism for primary olfactory perception" [J103] by Turin explains in detail his theory and various experimental tests. Here are the core ideas in more quantitative terms.

1. The theory originates from the proposal of Dyson proposed already 1938 that odor perception might rely on the vibrational spectrum of the odorant rather than its shape alone. The spectrum would be in the wave length range 2.5-10 μm corresponding to photon energies in the range .5 eV - .125 eV. This vibrational spectrum would be excited by the current of electrons tunneling from the receptor to the odorant molecule.
2. The proposal is that odor receptor can be regarded as a pair formed by a source and sink of electrons. If there is nothing between source and sink, tunneling can occur if there is electronic energy state with same energy in both source and sink. If there is an odorant molecule between source and sink with vibrational energy E, tunneling can occur indirectly: the electron can excite a vibrational state with this energy and tunneling can occur only if the difference of electron energies in source and sink is E. Therefore the presence of odor molecule would be detected from the occurrence of the tunneling and vibrational energy spectrum would characterize the odor molecule.

Comparison of Turin's model with TGD and Callahan's theory

One can compare the model of Turin with TGD based ideas.

1. The theory of Turin conforms at the general level with the receptor model. The "electrodes" of the sensory capacitor would correspond to the source and sink of electrons and the presence of the odorant molecule between the "electrodes" would induce the current. The current of electrons from the source to the sink should induce the change of total quantum numbers defining the odor quale.
2. The first thing to notice is that the upper bound .5 eV for IR energies corresponds to the nominal value of the metabolic energy quantum identified as the energy liberated as proton drops from the atomic space-time sheet with $k = 137$ to a very large space-time sheet or the same process for electron Cooper at $k = 149$ space-time sheet. If Cooper pairs are involved, the latter process would occur in the length scale defined by the thickness of the lipid layer of the cell membrane (5 nm). The lower bound corresponds to a metabolic energy quantum assignable to $k = 139$ for protons and $k = 151$ transition for electrons (thickness of cell membrane).
3. Second point to notice is that TGD predicts a fractal hierarchy of spectra of metabolic energy quanta [K8] coming as $E(\Delta k, n) = 2^{-\Delta k} E_0 (1 - 2^{-n})$, $n = 1, 2, \dots$, converging to $E(\Delta k, \infty) = 2^{-\Delta k} E_0$ for given p-adic length scale characterized by the difference $\Delta k = k - k_0$. E_0 denotes the zero point kinetic energy of particle at space-time sheet with p-adic length scale $k = k_0$ and is inversely proportional to the mass of the particle. The transfer of electrons and/or protons between different space-time sheets with any perception for purely metabolic reasons. The simplest option is that since the electrons at the side of the source receive their energy in this manner, their energy spectrum is given by $E(\Delta k, n)$ (there is of course some resolution meaning a cutoff in n). The specificity of the receptor would require preference of some specific metabolic energy quanta $E(\Delta k, n)$. If this spectrum characterizes the receptor independently of its chemistry, then not only metabolic energy quanta but also the mechanism of sensory

perception is universal. This proposal fails if the receptor has always same spectrum of $E(\Delta k, n)$ since all receptors would detect all odors.

It is interesting to relate the theory of Turin with the hypothesis of Callahan that the odor perception of insects uses IR light.

1. Callahan's work [I58] suggests that the IR photons emitted by the odorant in the transitions between the vibrational states and received by the odor receptor are basically responsible for the odor perception. Turin in turn proposes that the pattern of vibrational excitations in the odor molecule characterizes the perception. These views are consistent if the pattern of vibrational excitations is in 1-1 correspondence with the flow pattern of electrons between different space-time sheets at the receptors if a kind of self-organization pattern results: this is expected to take place in presence of a metabolic energy feed.
2. In Callahan's model for the odor perception of insects the simplest odor receptor would "see" the IR light emitted by the odor molecules. Also Turin explains -with different assumptions- that the situation is analogous to that prevailing in retina in that there are receptors sensitive to characteristic energy ranges of photons. One would expect that the odor perception of insects is something very simple. The so called vomeronasal organ [J3] is known to be responsible for the perception of socially important odors not generating conscious experience at our level of self hierarchy but having important effect on behavior (perfume industry has long ago realized this!). Vomeronasal organ could utilize this kind of primitive odor receptors.
3. The rate for the spontaneous transitions emitting IR light could be rather low. A more advanced receptor would induce more transitions by using tunneling electrons to excite vibrational energy levels in the odorant. This would be like using lamp to see better! The analogy with the transistor is also suggestive: the small base current induced by IR radiation generated by the odor molecule would be amplified in the process. Since the source contains electrons in excited states (at smaller space-time sheets), odor molecules could send negative energy photons dropping electrons to the large space-time sheet along which tunneling is possible. Induced emission would cause a domino like flow of electrons and excitations of the vibrational states of the odor molecule as the counterpart of di-electric breakdown would take place.
4. What could then the physical correlates for the primary odor qualia? The increments of some quantum numbers assignable to electrons at the source should be in question. Could the energies $E(k, n)$ characterizing the receptor define the primary odors? Odors and tastes are indeed very intimately related to metabolic activities. A natural consequence would be that besides the radiation generated by the transfer of electrons between space-time sheets would induce odor and perhaps also taste sensation. Organisms serve as food for other organisms so that an optimal detection of nutrients would be the outcome. The objection is that similar "metabolic qualia" would result in all receptors. This is not a problem if these qualia are qualia not conscious to us but conscious to neuronal selves. For instance, in TGD based model for visual colors color the increments of quantum numbers define the basic colors.

Could one assume that also other receptors use metabolic energy quanta as basic excitation energies?

1. The first objection is that similar "metabolic qualia" would result in all receptors. This is not a problem if these qualia are qualia not conscious to us but conscious to neuronal selves. For instance, in the TGD based model for visual colors the increments of color quantum numbers (in QCD sense!) define the basic colors, which means that colored particles must be in question (TGD variant of quark color implies the existence of scaled variants of QCD like physics and predicts that also electrons have colored excitations for which there is indeed a growing experimental evidence [K85]).
2. Second objection is that it does not seem possible to identify $E(k, n)$ as excitation energies in the case of vision. The relevant range of photon energies is [1.65,3.3] eV. By scaling the metabolic energy quantum by a power of 2, the nominal values of relevant maximal metabolic energy quanta $E(k, n = \infty)$ are 2 eV and 4 eV. The series of energies approaching 2 eV below 2 eV is 1,

1.5, 1.75, ..., 2 eV so that the range below 2 eV representing red light would be covered. Above 2 eV the series is 2, 3, 3.50, ..., 4 eV so that the region above 2 eV (orange, yellow, green, blue, indigo, violet) would contain only single line at 3 eV (violet). If the incoming photon can kick the electron to an excited state with energy E_0 at the smaller space-time sheet the spectrum contains also the energies $E(k, n) + E_0$. For $E_0 = 1.3$ eV these excitation energies would come as 2.3, 2.8, 3.05, ... 3.3 eV and cover this range.

Isotope effect of olfaction as an additional guideline

The above considerations are still rather speculative and leave a lot of room for alternatives. The additional guideline leading to a surprisingly simple TGD inspired model of odor perception comes from the observation that flies can smell the difference between normal hydrogen and deuterium [J20]. This is not in accordance with the standard theory of olfaction which says that olfaction relies on the shape of the molecule but conforms with the vibration theory of Luca Turin [J102, J103], who is one of the co-authors of the article [J73] reporting the discovery. The theory assumes that olfaction relies on molecular vibrational frequencies depending on the mass of the isotope.

1. Turin's theory

From Turin's video lecture and Wikipedia article [J15] about vibration theory of olfaction one learns why reductionism is so nice when it can be applied.

1. If the molecular vibrations in a reasonable approximation reduce to independent vibrations assignable to various chemical bonds, the problem of predicting the odor of the molecule reduces to the calculation or measurement of the oscillation frequencies associated with the chemical bonds of between two atoms or between two molecules forming a bigger molecule as a composite. Near IR frequencies in .8-2.5 μm wavelength range associated with vibrational spectrum are inversely proportional to the reduced mass of the pair of atoms or molecules connected by the chemical bond and the IR frequencies related to rotational-vibrational transitions depending on more complex manner on the molecular mass are good candidates for inducing the olfactory qualia at least in the case of insects.
2. Situation is also simplified by the fact that only a finite range of frequencies is expected to induce odor sensation just as only finite range of frequencies induces visual percept. Hence the engineering of odors becomes possible by considering only some basic bonds. One can test the model by replacing the hydrogen with deuterium in some constituent of the molecule and this was done in the article referred above.
3. The odor of the molecule should be a superposition of the basic odors assignable to the basic chemical bonds just like visual color is a superposition of primary colors. One must however remember that the quantum phase transition inducing the odor sensation itself need not have anything to do with the IR photons and many frequencies could induce the same quantum phase transition. The innocent novice is also allowed to ask whether the harmonics of the fundamental oscillation frequency could give rise to the olfactory analogy of timbre distinguishing between different musical instruments and whether octaves correspond to more or less similar odor sensation. The following considerations suggest that the answer to these questions is negative.

In Turin's theory vibrational frequencies are interpreted in terms of a model of receptor based on the idea that electron tunneling occurs between odor molecule and receptor and generates odor sensation if the energies of the electron states at the both sides are same. In general the ground state energies of the electron at the two sides are different but it can happen that the condition is satisfied for some excited state of electron of the acceptor so that odor perception is due to a tunneling to an excited state. The model requires the fusion of the odorant molecule to the receptor so that there is a close relationship with the standard theory assuming lock-and-key mechanism.

2. Callahan's theory

The finding conforms also with the old discovery of Callahan that the olfaction of insects is analogous to seeing at IR frequencies. This hypothesis explains among other things the finding that insects seem to love candles [I58].

If I have understood Callahan's theory correctly, the IR photons emitted by the odorant would induce transitions of electrons or Cooper pairs of the odor receptor. This would allow "radiative smelling" without a direct contact between odor molecules and olfactory receptors and at the first glance this seems like an unrealistic prediction. However, since the average power of radiation is proportional to $1/r^2$, where r is the distance between the receptor and molecule, radiative smelling would in practice be limited to rather short distances unless the radiation is guided. Maybe this could be tested experimentally by using coherent beam of IR light as a candidate for an artificial odorant.

3. TGD based theory

In TGD inspired theory of qualia one must distinguish between the sensory input inducing the quale and its secondary representation in terms of Josephson and cyclotron frequencies.

1. All qualia are coded (but not necessarily induced!) by various frequencies and communication using dark photons with various values of Planck constant meaning scaling down of visible basic frequencies is an essential element of communications at the level of biological body and between magnetic body and biological body. Josephson frequencies and cyclotron frequencies with so large Planck constant that energies are above thermal energy play a key role in these communications. Note that cyclotron frequencies are inversely proportional to the mass of the ion so that isotope effect also at this level is predicted.

Josephson frequencies are assignable to cell membrane and one ends up with a nice model for the visual qualia assuming some new physics predicted by TGD. Josephson frequencies and their modulation (as in the case of hearing) should be highly relevant for all qualia.

2. The capacitor model for sensory qualia assumes that all qualia are generated via the quantum analog of dielectric breakdown in which particles with given quantum numbers characterizing the quale flow between the plates of the capacitor. For sensory receptors the capacitor is obtained by a multi-layered structure obtained by a multiple folding of the cell membrane so that the efficiency of the sensory receptor increases.
3. In Turin's model the second plate of the capacitor model would correspond to the odorant molecule. This does not however allow anything resembling di-electric breakdown. It is difficult to imagine how to achieve a quantum phase transition involving simultaneous tunneling of a large number of electrons unless the receptor binds a large number of odorant molecules. Odor molecules should also form a quantum coherent state: a molecular analog of atomic Bose-Einstein condensate would be required. This would mean that only very special odor molecules could be smelled.
4. For the Callahan's variant of the theory the IR photons could excite the Cooper pairs of the other plate of the capacitor so that the tunneling becomes possible and quantum variant of di-electric breakdown can take place. This model is consistent also with the assumption that cell membrane acts as a Josephson junction and fundamental sensory capacitor. The energy of electron gained in the electric field of the cell membrane is in the range .04-.08 eV which indeed corresponds to IR frequencies. The variation of the membrane potential would give rise to the spectrum of basic odors. Roughly one octave of frequencies could be smelled if the cell membrane defines the fundamental nose smelling the energy of electron.

This option allows also the coding of odors by IR frequencies themselves so that brain could generate virtual odors by sending quantum coherent IR light to the odor receptors. This would explain odor hallucinations (and also other sensory hallucinations) as virtual percepts generated by brain itself. This sensory feedback would be absolutely essential for building up of standardized sensory percepts.

5. The difference between visual and odour receptors would be that the ground states of the cell membrane would correspond to near to vacuum extremals *resp.* far from vacuum extremals and therefore Josephson frequencies would be in visible *resp.* IR range respectively.

6.5 Flag-manifold qualia

Sensory mappings are basic aspect of what brain is doing and therefore one expects that this kind of mappings are performed routinely also at the level of brain. For instance, our tendency to visualize very abstract concepts as geometric objects suggests that they are indeed represented as sub-selves having definite positions inside brain (and as it seems also outside!).

I encountered this kind of mappings in rather early stage, much before the TGD inspired theory of consciousness allowed to even say much about this kind of mappings. The reason was the work of Barbara Shipman about honeybee dance [A13]. The strange findings of Shipman suggest that the color symmetry of hadron physics plays key role in sensory experiencing of the tiny honeybees, and led ultimately to the realization that classical color fields predicted by TGD are crucial for understanding visual qualia in TGD framework. Place and time coding by magnetic frequencies has been already considered in the section describing the general vision about the identification of qualia. In this section the attention will be focused to particular geometric qualia associated with the flag manifold defined by the possible choices of the quantization axes for the super-symplectic algebra and the findings of the Barbara Shipman will be discussed in TGD framework.

6.5.1 Basic structure of the configuration space

The basic mathematical structure of quantum TGD is the infinite-dimensional space of 3-surfaces. If Kähler action were deterministic, the configuration space would effectively reduce to the space of 3-surfaces on the light-cone boundary $\delta M_+^4 \times CP_2$ representing the moment of big bang. The classical non-determinism of the Kähler action however forces to consider also the spaces of 3-surfaces belonging to the light-like M_+^4 projections of the light-like boundaries of the massless extremals (MEs), which are thus extremely natural geometric correlates of selves. These selves could perhaps be called light-like selves. The fact that the M_+^4 projections of CP_2 extremal representing elementary particle is a random light-like curve, suggests strongly that one must also allow space-like three-surfaces as correlates of selves. In this respect theory does not yet say anything definite but magnetic flux tubes are very attractive candidates (certainly not the only ones) for what might be called space-like selves.

Configuration space degrees of freedom can be divided into quantum fluctuating degrees of freedom and zero modes which do not quantum fluctuate (being thus 'classical') and characterize the size and shape of 3-surface and are excellent candidate for representing information about the state of organism (3-surface itself) geometrically. The zero modes of the configuration space are special in the sense that in each quantum jump localization occurs in these degrees of freedom.

The hypothesis is that the sequence of events leading to experience geometric qualia involves localization in (measurement of) zero modes parametrizing among other things also the possible choices of quantization axes. One cannot assign geometric qualia to the flag-manifold of the entire isometry group since the localization occurs only in zero modes: rather the sub-group generated by canonical generators labelled by even conformal weights is in question. The flag-manifold in question corresponds to the extension of canonical group of $E^2 \times CP_2$ generated by generators of even conformal weight by CP_2 local conformal transformations of light-cone boundary generated by algebra generators having even conformal weight divided by the Cartan group of $SO(2) \times SU(3)$.

One must consider also the possibility that infinite-dimensional canonical flag-manifold actually reduces (at practical level at least) to finite-dimensional flag-manifold F_3 by the requirement that the choice of the quantization axes for the super-symplectic algebra is induced by the choice of the quantization axes for color. Note that in the case of MEs the quantization axis for spin is completely fixed for $E^2 \times CP_2$ whereas for $S^2 \times CP_2$ the sphere S^2 parametrizes the choices of the quantization. Thus the flag manifold F_3 encountered by Barbara [A13] [A13] emerges naturally for MEs.

6.5.2 Quantum honeybee

Barbara Shipman [A13] has made rather puzzling observation about the possible connection of the dance of honeybee with the color group $SU(3)$ appearing as the gauge group of strong interactions. The dance of honeybee, providing information of and depending on the distance and direction of the food source, could be regarded as a map of a certain path in the flag manifold $F_3 = SU(3)/U(1) \times U(1)$ mapped to a hexagon like plane region serving as a dance floor.

Barbara Shipman suggests a possible connection between biophysics and quantum physics at quark level. From the point of view of standard physics this suggestion looks implausible since color confinement should make dynamical effects related to color invisible above the hadronic length scale of order one fermi (10^{-9} times cellular length scale!). In TGD framework it is however possible to understand the observations of Barbara Shipman and these observations are also consistent with the general model for the universal submodalities of sensory qualia. In fact, the work of Barbara Shipman served as an important impetus during the process leading to the general TGD based model of sensory qualia.

Dance of the honeybee

The dance of the honeybee occurs at the vertical face of the honeycomb and codes the information about the distance and direction of the food source. Von Frisch discovered the choreographic syntax and interpretation of the dance and published the results of his work in his 1967 book 'Dance language and Orientation of Bees' [J105] .

The pattern of the dance is that of figure eight above certain critical distance to the food source and that of a circle below this distance.

1. The angle of the figure eight pattern with respect to the vertical codes the angle between the direction of the food source and the horizontal projection of Sun. For instance, when the food source is in the direction of Sun, figure eight pattern is vertical. The dancer waggles and produces buzzing sound during the first phase of the dance and then walks to the original position along the other circle of the figure eight. After that the dancer waggles again but now along the second circle of the figure eight so that the wagging phases of the dance form the pattern of a figure V in the middle of the figure 8. The buzzing sound produced by the wings of the dancer makes it possible for the audience to locate the dancer (dance occurs in darkness). The opening angle of the figure V codes the distance to the food source for distances above some critical distance.
2. Below the critical distance the pattern changes to a circle. Now the wagging parts of the dance correspond to two disjoint straight line portions located at the opposite sides of the hexagon.

What Barbara Shipman found [A13] was that the images of certain curves of 6-dimensional flag manifold under the so called momentum map reproduce the dancing pattern of the honeybee if the six initial values determining the curve are chosen suitably. Only two of these parameters code the information about the food source. The article about the model of honeybee dance is not published yet but on the basis of short abstract [A13] it is very plausible that the curves in question are solution curves associated with a completely integrable system known as a full Kostant-Toda lattice studied by Barbara Shipman [A12, A11]. The solutions of the $2(n-1)$ equations of motion associated with this model can be mapped to the solutions of certain completely integrable Hamiltonian system in the flag manifold $F_n = SL(n, C)/B$, where $SL(n, C)$ is the space of complex matrices with unit determinant and B is the space of upper triangular matrices with unit determinant. F_n is in turn isomorphic with $SU(n)/U(1)^n$ and this implies a connection with the quantum measurement theory of color charges in $n=3$ case.

The dance of honeybee should somehow map the some curve of the flag-manifold to a planar curve representing the dancing pattern. $SU(n)$ acts as Hamiltonian transformations of the flag manifold but not as symmetries of Kostant-Toda lattice: in particular, the Cartan algebra generators define Hamiltonians $H_I(x)$ and $H_Y(x)$ in F_3 . The so called momentum map associating to the point x of the flag manifold F_3 the point $(H_I(x), H_Y(x))$ characterizing the values of the isospin and hypercharge Hamiltonians at the point x . The image of F_3 under this map is hexagonal region of plane and the image of Kostant-Toda orbit under this map is identified as the dancing pattern of the honeybee. It is obvious that $SU(3)$ cannot act as symmetries of the Kostant-Toda system since in this case Hamiltonians would be constant along the solution curves and momentum map would map every orbit to single point.

To summarize the result concisely: *a) if the orbit of 3-surface in the flag manifold is characterized by Hamiltonian equations related to the so called Kostant-Toda lattice, which is a completely integrable system, b) if the hexagonal planar region defined by the image of the momentum map corresponds to the 'dance floor' and c) if the the orbit of the bee corresponds to the image of the orbit of flag manifold under the momentum momentum map,*

one can indeed understand the dance of honeybee as a representation for the information content of thought of the honeybee. What forces one to take the model seriously is that it reproduces also the dependence of the dancing pattern on bee community and predicts correctly the spectacular change of the V shaped dancing pattern to a union two disjoint lines on the opposite boundaries of the hexagon like region.

TGD based model of the honeybee dance

The concept of self and the TGD based model for sensory experiencing lead directly to the prediction that mental images, also those of tiny honeybee, should correspond to almost continuous curves of infinite-dimensional flag-manifold containing F_3 as sub-flag-manifold. If these orbits are solution curves of dynamical system defined by Kostant-Toda lattice, one can understand the observations of Barbara Shipman.

1. Why curves in flag-manifold?

1. Flag manifold F_3 characterizes especially interesting zero modes. If the contents of the sensory experience is determined by the localization in zero modes occurring in quantum jump, the coordinates of F_3 for mind like space-time sheet generated in sensory perception and representing object of perceptive field, should code some basic data about sensory experience. Since F_3 represents geometric qualia, it is associated with all senses, not only vision and that this role might be similar for all sensory qualia.
2. F_3 is indeed identical with the flag manifold $SL(3, C)/B$ studied by Barbara Shipman. The dimension of $SU(n)/H$, $H = U(1)^{n-1}$, is $D = n(n - 1)$ and same as the dimension of the flag-manifold and In $n = 2$ case the two spaces are identical as direct inspection shows. In the general case the isomorphy follows from the observation that arbitrary $SL(n, C)$ matrix s can be expressed as a product $s = b_1 u$, where u is $SU(n)$ matrix and b_1 belongs to the group $B_1 \subset B$ of the upper diagonal matrices with real elements on the diagonal. The elements of B in turn are expressible in the form $b = b_1 h$, where h is diagonal matrix belonging to Cartan group and b_1 belonging to B_1 . Therefore the flag manifold can be written as $F = SL(n, C)/B = B_1 SU(n)/B_1 H = SU(n)/H$.
3. Time development by quantum jumps means hopping in zero modes and since the increment of the geometric time in single quantum jump is expected to be very short, of order 10^4 Planck times, the time development should define an almost continuous curve in F_3 . In particular, subjective memory of self about quantum jump sequence corresponds to curve in F_3 defined by the averaged increments of zero modes represented by sub-selves.
4. In the ideal case honeybee could code the coordinates and velocities for entire fly path to the food source but this kind of feat is impossible even for us. In practice only the distance and direction of the food source is needed. This information must correspond to sub-self of the honeybee and sub-self in turn corresponds a curve of the flag-manifold F_3 . If the projection of this orbit to F_3 is determined by the dynamics of a completely integrable system known as full Kostant-Toda lattice, the physical foundations for the model of Barbara Shipman can be understood in TGD framework.

2. Why the projection of flag-manifold curve to hexagonal plane region

A possible explanation for the reduction of the path to a two-dimensional path is based on the following observations.

1. The simplest extremals of Kähler action have 2-dimensional CP_2 at a geodesic sphere of CP_2 , which can be homologically non-trivial or trivial. For the first option classical electromagnetic and W fields are non-vanishing. For the latter option electromagnetic and Z^0 fields are non-vanishing and proportional to each other. Almost vacuum extremals provide a detailed model for both sensory receptor and basic sensory qualia and will be discussed at the end of the chapter whereas far from vacuum extremals seem to provide a model for magnetic bodies. Also the simplest MEs can be classified to these two types.

2. The holonomy algebra of color group is Abelian and one can gauge rotate the color gauge algebra to some $U(1) \times U(1)$ subalgebra of $SU(3)$ and two CP_2 coordinates can serve as the coordinates of these space-time surfaces. Also the dance floor of honeybee can be coordinatized by two CP_2 coordinates.
3. Each space-time surface has by topological field quantization a unique Cartan algebra $U(1) \times U(1)$. Since the values of the color Hamiltonians are well defined functions in CP_2 , a very natural choice for the two coordinates is as Hamiltonians H_I and H_Y appearing also as the coordinates of the dance floor in Shipman's model. The region defined by H_I and H_Y has the hexagonal shape and since its boundaries naturally correspond to the boundaries of a mind like space-time sheet such as ME, the mapping of the sequence of increments of flag-manifold coordinates to space-time sheet to a curve inside diffeomorph of the hexagon in plane looks natural. It seems that honeybee really experiences these coordinates directly as imagined positions in plane.

3. How flag-manifolds emerge from first principles?

A deeper explanation for flag-manifold emerges in zero energy ontology combined with the hierarchy of Planck constants.

1. Zero energy states correspond to entangled pairs of positive and negative energy states located at the opposite light-like boundaries of a given causal diamond (CD) defined as the intersection of future and past directed light-cones. Strictly speaking a Cartesian product of CD with CP_2 is in question. CD s form a fractal hierarchy. In the ordinary ontology zero energy state corresponds to a physical event. The time-like entanglement between positive and negative energy states defines M -matrix generalizing the notion of S-matrix. Time-like entanglement must be fundamental also from the point of view of consciousness as a reduction of quantum state to a state with well defined values of observables for the initial (positive energy) and final (negative energy) states. The Cartesian product of causal diamond CD defined as the intersection of future and past directed light cones with CP_2 . CD is characterized by the positions of its tips so that one has M^4 valued cm coordinate plus relative coordinate between the tips. p-Adic length scale hypothesis follows if the proper time distance is quantized in powers of two. This suggests that also the of the tip at the hyperboloid with constant proper time is discrete and that discrete lattice like structure defined by some discrete subgroup of $SL(2,C)$ acting as boosts on given reference CD .
2. The hierarchy of Planck constants forces a generalization of the imbedding space to a book like structure [K29, K27, K25, K13, K14] . The pages of the Big Book are characterized by two numbers x_a and x_b assignable to M^4 and CP_2 degrees of freedom. The values of these numbers are either integers or their inverses depending on whether the page of the book is a singular covering or factor space defined by a discrete subgroup of $SU(2)$. For a given CD the sectors characterized by different integers are glued together along $M^2 \subset M^4$ defining quantization axis of energy and spin. In CP_2 degrees of freedom the gluing is along a homologically trivial geodesic sphere of CP_2 and also now a fixing of the quantization axes is involved. The positions of the tips of CD and preferred points of CP_2 at the two light-like boundaries of CD fix the quantization axis and moduli space for CD s. An attractive hypothesis is that the relative positions of tips and corresponding preferred points of CP_2 form discrete spaces. The quantization of the temporal distance between tips in powers of two implies p-adic length scale hypothesis.
3. The tips of CD define a preferred time coordinate, which together with M^2 defines the quantization axes of energy and spin. In the case of CP_2 has also a choice of color and isospin quantization axes implied by the choice of a pair of CP_2 points and the choice of S^2 . This means that one has a flag-manifold defined by the choices of quantization axes for energy and momentum one one hand and for color quantum numbers on the other hand. Therefore the model for the honeybee dance finds a justification from the first principles of quantum TGD.

4. Why solutions of full Kostant-Toda lattice?

The hexagonal shape of the dance floor is very strong qualitative prediction as such involving no dynamical models and the attempt to reduce the dynamics to Kostant-Toda lattice might be more

that one can desire. Certainly so, if honeybee represents its memories about entire non-deterministic path to the food source rather than just the minimum data abstracted from what honeybee remembers. Of course, honeybee dance might represent only the minimum information making possible to find the food source and this would be achieved if dance represents a deterministic dynamical system with a very high symmetry. Thus it makes sense to ask why just the solution curves of full Kostant-Toda lattice should approximate the almost continuous orbit of F_3 defined by quantum jump sequences summarizing the memories of honeybee.

1. A possible explanation is that the mental images of the honeybee are result of long evolution and self organization and that mental images with standardized content such as position of the food source, correspond to a solution of some very symmetrical dynamical system.
2. That the full Kostant-Toda lattice is needed can be partially understood. For the full Kostant-Toda lattice time evolution is not unitary transformation but similarity and $SU(3)$ does not in general act as symmetries: if this were the case Cartan group associated with the 3-surface would be a constant of motion. Rather, the eigenvalues of the traceless $SL(3, \mathbb{C})$ Lie-algebra matrix S (see appendix) are the needed two complex constants of motion. For instance, geodesic motion in flag manifold would have $SU(3)$ as symmetries and this would imply that Cartan algebra would define constants of motion and the momentum map would map the orbits to the points of plane. The breaking of $SU(3)$ symmetry is natural since also quantum jump sequence defining the memory of honeybee represents sequence of changes of color quantization axes.

Questions

There are several questions to be answered.

1. The representation curve in F_3 is determined by the initial values of six coordinates. The information coded into the dance fixes only two coordinates and the initial values of the remaining coordinates must be constants specific to hive or subspecies of honey bees. It would not be surprising that these parameters are somehow complementary to the 2 complex constants of motion (eigenvalues of S) associated with the Kostant-Toda dynamics.
2. Somehow the direction of food source and its distance should be coded into the initial values: perhaps the initial values of the flag manifold point develop in time during the flight of the honeybee from the food source to the nest according to a simple rule from initial values corresponding to vanishing distance and ill defined direction angle. The flight occurs along a straight line so that this mechanism looks plausible.
3. For the information to become properly interpreted, the dance should generate the original representation of the information as a flag manifold orbit in the minds of the audience. This requires that the direction with respect to vertical and opening angle are mapped to the initial values of the flag manifold orbit. One can also consider possibility is that the orbit of the flag manifold provides a mental representation for the shortest path to the food source. Magnetic fields are known to be important for the ability of the bee to fly in straight line and the fact that magnetic fields give rise to color magnetic fields suggests that quantum measurement of color charges during the flight might be an important factor in the orienteering of the honeybee. Perhaps the comparison of the measured real color charges with the measured color charges in the mental representation of the orbit is involved.

Some mathematical background

1. Complete Kostant-Toda lattice

Completely integrable systems [B4] allow quite generally a Hamiltonian formulation such that there exist maximal number of constants of motion in involution (having vanishing Poisson brackets). This makes the quantization of the completely integrable systems possible. The so called Lax pair allows to transform the dynamics of completely integrable systems to a time dependent unitary transformation of some tensorial or spinorial quantity and this leads to the so called inverse scattering method allowing to solve completely integrable models.

An example of a finite-dimensional completely integrable system is provided by the so called Toda lattice consisting of $n - 1$ lattice points on line (one can formally add the point at $Q_n = \infty$ to make equations more symmetrical. To each lattice point $a = 1, \dots, n$ a coordinate variable Q^a is attached. The interaction potential is non-vanishing for the nearest neighbors only and has exponential dependence on the coordinate difference $Q^a - Q^b$. The Hamiltonian of the system can be written as

$$H = \sum_{a=1}^n \left[\frac{1}{2} (P^a)^2 + \exp(-Q^{a+1} + Q^a) \right] . \quad (6.5.1)$$

Toda equations allow group theoretical interpretation [B4] . The change of variables $q^a = Q^a - Q^{a-1}$ allows to cast the Lagrangian associated with the action into the form

$$L = \frac{1}{2} \sum_{a,b=1}^{n-1} \frac{dq^a}{dt} K_{ab}^{-1} \frac{dq^b}{dt} - \sum_{a=1}^{n-1} \exp(-q_a) . \quad (6.5.2)$$

The equations of motion for S read as

$$\frac{dS}{dt} - [S, U] = \frac{1}{2} \sum_{a,b=1}^{n-1} H_a K_{ab}^{-1} \left[\frac{d^2 q^b}{dt^2} - \sum_{c=1}^{n-1} K_{bc} \exp(-q_c) \right] = 0 , \quad (6.5.3)$$

and by the unitarity requirement are equivalent with the original equations of motion for the Toda lattice.

The Lax pair of the so called full Kostant-Toda lattice (presumably relevant to the model of the dance of honeybee) is defined in the following manner (for a detailed and very technical description see the articles [A12, A11]). The dynamical variable S belongs to the space $B_- + \varepsilon$ of matrices belonging to $SL(n, C)$ Lie algebra. ε is a matrix having units only above the diagonal: $\varepsilon_{ij} = \delta_{j,i+1}$. B_- consists of the lower triangular matrices with trace zero. The equations of motion read

$$\begin{aligned} \frac{dS}{dt} &= i[H, S] , \\ S &= b_- + \varepsilon , \\ H &= \Pi_{N_-} S . \end{aligned} \quad (6.5.4)$$

$H = \Pi_{N_-} S$ is the strictly lower triangular part of S , which is nilpotent, and acts as a nonhermitian Hamiltonian in the quantum form of the equations of motion. The time development is not unitary but corresponds to a similarity preserving the eigenvalues of S , which in fact define $2(n - 1)$ constants of motion.

There exists a natural imbedding of the space $B_- + \varepsilon$ to the flag manifold $F_n = SL(n, C)/B$, where B consists of upper diagonal matrices with units in diagonal. The mapping is obtained by first identifying $B_- + \varepsilon$ with B_- and then noticing that the complement of B_- represent the Lie-algebra elements of $Sl(2, C)$ modulo matrices having upper triangular part with vanishing diagonal elements. The standard exponential mapping of Lie-algebra to the group maps B_- to $SL(n, C)/B$. The equations of motion in F_n reduce to Hamiltonian equations of motion generated by the Hamiltonian $H = \frac{1}{2} Tr(S^2)$ [A11]. The simplest constants of motion are the eigenvalues of the matrix S and give four constants of motion. In the case of $SL(n, C)$ the eigenvalues span the space C^{n-1} .

$SL(n, C)$ Cartan algebra action induces Hamiltonian flow in the flag manifold and one can associate with the $SU(n)$ Cartan algebra Hamiltonian functions $H_i(x)$, $i = 1, \dots, n - 1$ defined in the entire flag manifold. Since Kostant-Toda dynamics is not unitary, the Cartan algebra of $SU(n)$ does not act as symmetries and the corresponding Hamiltonians are not constants of motion. The Toda flows associated with the diagonal traceless matrices are trivial so that the points in the image of C^{n-1} are fixed points of the Hamiltonian evolution associated with the Cartan algebra. The level sets of the Kostant-Toda Hamiltonian consist of unions of $(n - 1)$ -dimensional complex tori.

The values H_1, H_2, \dots, H_{n-1} of the compact Cartan algebra Hamiltonians at given point x of the flag manifold F_n define a map of the flag manifold to $(n - 1)$ -dimensional convex polytope known as momentum map. For $n = 3$ the polytope is hexagon. Since the solutions of the Toda equations correspond to certain curves in flag manifold they are mapped to curves inside this hexagon. If Cartan algebra would act as symmetries, the momentum map would map the flag manifold to a single point.

2. Flag manifold F_3 from topological field quantization

A less general manner to end up with the flag-manifold concept is based on what I call topological field quantization. The first approach is certainly more attractive in its generality and by its close relationship with the basic concepts of TGD inspired theory of consciousness (entanglement has interpretation as attention in TGD inspired theory of consciousness) and topological field quantization could at best provide a concrete realization of the picture based on the quantum measurement theory.

1. Topological field quantization corresponds to the formation of 3-surfaces of a finite spatial size with a choice of a preferred 'quantization axes' for rotations (say z -axis) and color hyper charge and color isospin. One can express the angle coordinates Ψ and Φ associated with hyper charge and isospin in terms of the angle coordinate ϕ associated with the rotations around z -axis as

$$\begin{aligned}\Psi &= n_1\phi + k_1z + \text{Fourier expansion} \\ \Phi &= n_2\phi + k_2z + \text{Fourier expansion}\end{aligned}$$

n_1 and n_2 are almost topological quantum numbers expressing the change of angles Ψ and Φ in a rotation around z -axis. In the case of nonvacuum space-time sheets one can say that there are hypercharge and isospin currents rotating in the direction of ϕ . The choice of the hyper charge and isospin quantization axes leads naturally to the possibility to associate to a given 3-surface a point of the flag manifold encountered in the work of Barbara Shipman.

2. The requirement that the Cartan group H fixing the quantization axes corresponds to the subgroup of $SU(3)$ determined by quantum entanglement fixes uniquely topological field quantization and implies the equivalence of the topological field quantization approach with the picture based on quantum measurement theory.
3. The choice of the quantization axes with constant values of n_i over the entire 3-surface is *not* possible for an arbitrary 3-surface globally: rather the 3-surface decomposes into several regions with varying values of n_i . It might however happen that only 3-surfaces consisting of only single region are dynamically stable. On the other hand, the assumption that the choice is global in general fixes the choice uniquely since small change in the direction of the rotational quantization axes implies that a region where the change of angle variable around closed curve around the new z -axis is trivial. Same applies to the change of quantization axes in color degrees of freedom. Note however that for a general closed curve around z -axes, small change in the direction of quantization axes does not change the value of the phase increment. When 3-surface allows global choice of n_i , one can associate to the 3-surface a unique point of the flag manifold. Physical intuition suggests that this point is same as that determined by the quantum entanglement. In the general case one can decompose the 3-surface into several regions, such that each of them has different values of topological quantum numbers for a given choice of quantization axes. It is tempting to interpret the maximal region with fixed values of n_i as a maximal sub-system for which it makes sense to perform the measurement of color charges with given quantization axes.

6.5.3 Quantum honeybee and DNA as topological quantum computer

The model for the dance of honeybee was an idea before its time and remained in a dormant state for several years. The increased understanding of quantum TGD proper making possible to develop a model for how DNA could act as a topological quantum computer eventually provided a fresh perspective to the problem.

The progress in understanding of quantum TGD

It is appropriate to make a list of new concepts and ideas which are prerequisites for the model of DNA as topological quantum computer.

1. "The world of classical worlds" can be identified as the space of light-like 3-surfaces identifiable also as partonic orbits with dynamics which is not completely deterministic so that 3-dimensionality in discretized sense and local effective 2-dimensionality are obtained [K20]. A considerable generalization of the conformal symmetries of string models and a formulation of quantum TGD as almost topological quantum field theory emerged.

2. The evidence that planetary orbits are identifiable as Bohr orbits led to a generalization of the notion of imbedding space obtained by replacing it with a union of infinite number of sectors labeled by different values of Planck constant [K72, K56, K29] . The generalization explains dark matter as phases in which Planck constant differs from its value for the visible matter (visible to us, the notion of darkness is relative). Phases of matter with arbitrarily large values of Planck constant are predicted and give rise to macroscopic quantum phases even in astrophysical length scales. These phases are especially important in living matter. The value of Planck constant characterizes topological field quanta serving as space-time correlates for the interactions between particles. Dark matter residing at magnetic flux quanta of field body having large value Planck constant would be responsible quantum control of living matter [K8, K26] . Magnetic body would have an onion like structure consisting of layers with increasing value of Planck constant. The highest layer determines the evolutionary level of system and great leaps in evolution would correspond to the emergence of a new layer with larger value of \hbar to the magnetic body.
3. A more precise characterization for the fundamental notion of quantum criticality emerges from the generalization of the notion of imbedding space. The sectors intersect along $M^4 \times S^2$ and $M^2 \times CP_2$ and maximal quantum criticality corresponds to $M^2 \times S^2$. The geodesic sphere S^2 of CP_2 with trivial homology plays key role in this picture and vacuum extremals $X^4 \subset M^4 \times S^2$ define one particular example of quantum critical surfaces. The isometries of S^2 correspond to $SO(3) \subset SU(3)$. Notice that the flag manifold $F = SU(3)/U(1) \times U(1)$ reduces naturally to $F_{red} = SO(3)/U(1) = S^2$ for almost vacuum extremals.
4. In TGD positive energy ontology must be replaced with what I have christened zero energy ontology [K20, K19] . In zero energy ontology physical states correspond to zero energy states decomposable to pairs of positive and negative energy states localizable at the future and past directed boundaries of a pair of light cones forming a causal diamond. Zero energy ontology allows to identify time-like entanglement coefficients - M-matrix - as a "complex square root" of the density matrix decomposing to a product of positive square root of density matrix and unitary S-matrix so that thermodynamics becomes part of quantum theory.
5. Von Neumann algebras known as hyper-finite factors of type II₁ [K92, K29] play a fundamental role in the formulation of quantum TGD [K20, K19] . This means a profound deviation from standard quantum field theories and ordinary quantum mechanics. The notion of quantum group whose physical interpretation has remained poorly understood represents a key aspect of this difference. Finite measurement resolution [K19] becomes the key notion of the quantum measurement theory in this framework. It can be represented as an inclusion of von Neumann algebras with included algebra defining the measurement resolution. More concretely, complex rays of state space are replaced with sub-spaces generated by the included algebra and the Hermitian elements of this algebra represent symmetries of the M-matrix. These enormous symmetries allow to fix the possible M-matrices highly uniquely in terms of Connes tensor product. Thus the mere fact that measurement resolution is finite fixes the quantum dynamics of the theory almost completely and leads to a new kind of description of coupling constant evolution allowing also to understand the origin of p-adic length scale hypothesis.

General model for DNA as topological quantum computer

The progress in the understanding of quantum TGD led to various biological applications. The presence of dark matter with the properties predicted by TGD can be deduced from the strange findings about the behavior of cell membrane [I113] . These properties are not quite the same as they are believed to be: dark matter has classical interactions with ordinary matter - in particular electromagnetic interactions - but only particles with same value of \hbar (belonging to same sector of imbedding space) can appear in interaction vertices. This is enough to achieve consistency with what is really known about dark matter. Detailed models for nerve pulse [K62] and EEG [K26] emerge. One of the most fascinating applications is the model of DNA - cell membrane system as a topological quantum computer (tqc) [K28] : this model leads to a further insights about findings of Shipman.

1. The model for DNA as topological quantum computer [K28] assumes that magnetic flux tubes connecting DNA nucleotides to lipids of nuclear/cell membrane define braid strands. To be

precise, wormhole magnetic fields consisting of two parallel magnetic flux tubes with opposite fluxes are in question. Wormhole magnetic flux tubes have at their ends wormhole contacts with quark and antiquark at their throats (these defining light-like 3-surfaces) [K93]. Braid strands are "colored" and the four colors correspond to the four nucleotides A,G,T,C. Coloring corresponds physically to a map of nucleotides to quarks u,d and their antiquarks at the upper throat of wormhole contact at the DNA end of wormhole magnetic field (second end contains the conjugate of this state). Kind of 1-1 genetic code is in question and has profound implications for the understanding of the selectivity of bio-catalysis. Quarks have large \hbar and obey a scaled up variant of QCD like dynamics. Note that in this framework the proposal of Barbara Shipman that quarks are involved with honeybee dance begins to make sense.

2. Tqc program is coded by the "dance" of lipids defining a time-like braiding. Since the lipids are connected to nucleotides, their dance defines also space-like braiding coding tqc program to memory: an extremely general mechanism of memory storage is in question which might be present already during pre-biotic era. The braiding is generated by the motion of lipids in liquid crystal phase forced by the motion of cellular water in gel phase because the hydrophobic ends of lipids are anchored to the moving water molecules. Dissipation in the presence of metabolic energy feed means that the liquid flow approaches to an asymptotic self organization pattern depending only weakly on the initial conditions: the interpretation is as a Darwinian selection of tqc programs. There is actually a fractal hierarchy of tqc programs and each sub-program appears as an ensemble of similar copies so that tqc gives automatically probability distributions as an outcome represented as a four-dimensional pattern of classical fields and various rates (chemical rates, firing rates for nerve pulses,...).
3. The basic braiding operation - a twist permuting the position of lipids- defines the universal 2-gate. Besides this 1-gates are needed and $SU(2)$ rotation is enough. Here one can consider several candidates: since quarks and antiquarks are in crucial role in tqc, one of them corresponds to color $SU(3)$ or its subgroup. This could explain the mysterious looking discovery of Barbara Shipman. This aspect is described in more detail below.

Realization of 1-gates of tqc in terms of color rotations and connection with honeybee dance

The realization of single particle gates as $U(2)$ transformations leads naturally to the extension of the braid group by assigning to the strands sequences of group elements satisfying the group multiplication rules. The group elements associated with a n^{th} strand commute with the generators of braid group which do not act on n^{th} strand. G would be naturally subgroup of the covering group of rotation group acting in spin degrees of spin 1/2 object. Since $U(1)$ transformations generate only an overall phase to the state, the presence of this factor might not be necessary. A possible candidate for $U(1)$ factor is as a rotation induced by a time-like parallel translation defined by the electromagnetic scalar potential $\Phi = A_t$.

One of the challenges is the realization of single particle gates representing $U(2)$ rotation of the qubit. The first thing to come mind was that $U(2)$ corresponds to $U(2)$ rotation induced by magnetic field and electric fields. A more elegant realization is in terms of $SU(3)$ rotation, where $SU(3)$ is color group associated with strong interactions and this suggests connection with the findings of Shipman.

1. The realization of qubit as ordinary spin

A possible realization for single particle gate $s \subset SU(2)$ would be as $SU(2)$ rotation induced by a magnetic pulse. This transformation is fixed by the rotation axis and rotation angle around this axes. This kind of transformation would result by applying to the strand a magnetic pulse with magnetic field in the direction of rotation axes. The duration of the pulse determines the rotation angle. Pulse could be created by bringing a magnetic flux tube to the system, letting it act for the required time, and moving it away. $U(1)$ phase factor could result from the electromagnetic gauge potential as a non-integrable phase factor $\exp(i e \int A_t dt / \hbar)$ coming from the presence of scale potential $\Phi = A_t$ in the Hamiltonian.

One can criticize this model. The introduction of magnetic pulses does not look an attractive idea and seems to require additional structures besides magnetic flux tubes (MEs?). It would be much nicer to assign the magnetic field with the flux tubes defining the braid strands. The rotation of

magnetic field would however require changing the direction of braid strands. This does not look natural. Could one do without this rotation by identifying spin like degree of freedom in some other manner? This is indeed possible.

2. *The realization of 1-gate in terms of color rotations*

TGD predicts a hierarchy of copies of scaled up variants of both weak and color interactions and these play a key role in TGD inspired model of living matter. Both weak isospin and color isospin could be considered as alternatives for the ordinary spin as a realization of qubit in TGD framework. Below color isospin is discussed but one could consider also a realization in terms of nuclei and their exotic counterparts [L7], [L7] differing only by the replacement of neutral color bond between nuclei of nuclear string with a charged one. Charge entanglement between nuclei would guarantee overall charge conservation.

1. Each space-time sheet of braid strands contains quark and antiquark at its ends. Color isospin and hypercharge label their states. Two of the quarks of the color triplet form doublet with respect to color isospin and the third is singlet and has different hyper charge Y . Hence qubit could be realized in terms of color isospin I_3 instead of ordinary spin but third quark would be inert in the Boolean sense. Qubit could be also replaced with qutrit and isospin singlet could be identified as a statement with ill-defined truth value. Trits are used also in ordinary computers. In TGD framework finite measurement resolution implies fuzzy qubits and the third state might relate to this fuzziness. Note that hyper-charge would induce naturally the $U(1)$ factor affecting the over all phase of qubit but affecting differently to the third quark.
2. Magnetic flux tubes are also color magnetic flux tubes carrying non-vanishing classical color gauge field in the case that they are non-vacuum extremals. The holonomy group of classical color field is an Abelian subgroup of the $U(1) \times U(1)$ Cartan subgroup of color group. Classical color magnetic field defines the choice of quantization axes for color quantum numbers. For instance, magnetic moment is replaced with color magnetic moment and this replacement is in key role in simple model for color magnetic spin splittings between spin 0 and 1 mesons as well as spin 1/2 and 3/2 baryons.
3. There is a symmetry breaking of color symmetry to subgroup $U(1)_{I_3} \times U(1)_Y$ and color singletness is in TGD framework replaced by a weaker condition stating that physical states have vanishing net color quantum numbers. This makes possible the measurement of color quantum numbers in the manner similar to that for spin. For instance, color singlet formed by quark and antiquark with opposite color quantum numbers can in the measurement of color quantum numbers of quark reduce to a state in which quark has definite color quantum numbers. This state is a superposition of states with vanishing Y and I_3 in color singlet and color octet representations. Strong form of color confinement would not allow this kind of measurement. The almost vacuum extremal property suggests also the reduction of $SU(3)$ to $SO(3)$ with ensuing reduction of F to S^2 .
4. Color rotation in general changes the directions of quantization axis of I_3 and Y and generates a new state basis. Since $U(1) \times U(1)$ leaves the state basis invariant, the space defined by the choices of quantization axes is 6-dimensional flag manifold $F = SU(3)/U(1) \times U(1)$. The original belief was that -in contrast to standard model- color rotations in general do not leave classical electromagnetic field invariant. There are however good arguments based on the Abelian holonomy of the classical gluon fields showing that color rotation only induces an Abelian gauge transformation so that the induced gauge field remains a superposition of gauge transformed em field and W boson field *resp.* em field and Z^0 field corresponding to the two kinds of geodesic spheres. This also conforms with the general vision about electro-weak symmetry breaking taking place already at the level of CP_2 geometry. Hence color rotations are not visible at the level of classical interactions as was the original belief inspiring the idea that color rotation would affect the resting potential of cell membrane and have thus a direct neuronal correlate.
5. If color isospin defines the qubit or qutrit in topological quantum computation, color quantum numbers and the flag manifold F should have direct relevance for cognition. If nearly vacuum extremals are involved one might understand also the reduction of parameters from 6 to two as the effective replacement of F with $S^2 = SO(3)/SO(2)$; this is actually rather natural if

the information communicated is the 2-D coordinates of the food source. Color rotations of the the lipid ends of the magnetic flux tubes would define 1-gates representing this geometric information. Subsequent state function reduction would provide conscious representations in terms of trits characterizing for instance sensory input symbolically.

To sum up, this picture suggests that 1-gates of DNA topological quantum computation (understood as "dance of lipids") are defined by color rotations of the ends of space-like braid strands and at lipids. The color rotations would be induced by sensory and other inputs to the system. Topological quantum computation would be directly related to conscious experience and sensory and other inputs would fix the directions of the color magnetic fields. The findings of Barbara Shipman give support this picture.

6.6 TGD based model for cell membrane as sensory receptor

The emergence of zero energy ontology, the explanation of dark matter in terms of a hierarchy of Planck constants requiring a generalization of the notion of imbedding space, the view about life as something in the intersection of real and p-adic worlds, and the notion of number theoretic entanglement negentropy lead to the breakthrough in TGD inspired quantum biology and also to the recent view of qualia and sensory representations including hearing allowing a precise quantitative model at the level of cell membrane.

Also in the recent view long range weak forces however play a key role. They are made possible by the exotic ground state represented as almost vacuum extremal of Kähler action for which classical em and Z^0 fields are proportional to each other whereas for standard ground state classical Z^0 fields are very weak. Neutrinos are present but it seems that they do not define cognitive representations in the time scales characterizing neural activity. Electrons and quarks for which the time scales of causal diamonds correspond to fundamental biorhythms - one of the key observations during last years- take this role.

6.6.1 Could cell correspond to almost vacuum extremal?

The question whether cell could correspond almost vacuum extremal of Kähler action was the question which led to the realization that the frequencies of peak sensitivity for photoreceptors correspond to the Josephson frequencies of biologically important ions if one accepts that the value of the Weinberg angle equals to $\sin^2(\theta_W) = .0295$ instead of the value .23 in the normal phase, in which the classical electromagnetic field is proportional to the induced Kähler form of CP_2 in a good approximation. Another implication made possible by the large value of Planck constant is the identification of Josephson photons as the counterparts of biophotons one one hand and those of EEG photons on the other hand. These observation in turn led to a detailed model of sensory qualia and of sensory receptor. Therefore the core of this argument deserves to be represented also here although it has been discussed in [K62].

Cell membrane as almost vacuum extremal

Although the fundamental role of vacuum extremals for quantum criticality and life has been obvious from the beginning, it took a long time to realize how one could model living cell as this kind of system.

1. Classical electric fields are in a fundamental role in biochemistry and living biosystems are typically electrets containing regions of spontaneous electric polarization. Fröhlich [I85] proposed that oriented electric dipoles form macroscopic quantum systems with polarization density serving as a macroscopic order parameter. Several theories of consciousness share this hypothesis. Experimentally this hypothesis has not been verified.
2. TGD suggests much more profound role for the unique di-electric properties of the biosystems. The presence of strong electric dipole fields is a necessary prerequisite for cognition and life and could even force the emergence of life. Strong electric fields imply also the presence of the charged wormhole BE condensates: the surface density of the charged wormholes on the boundary is

essentially equal to the normal component of the electric field so that wormholes are in some sense 'square root' of the dipole condensate of Fröhlich! Wormholes make also possible pure vacuum polarization type dipole fields: in this case the magnitudes of the em field at the two space-time sheets involved are same whereas the directions of the fields are opposite. The splitting of wormhole contacts creates fermion pairs which might be interpreted as cognitive fermion pairs. Also microtubules carry strong longitudinal electric fields. This formulation emerged much before the identification of ordinary gauge bosons and their superpartners as wormhole contacts.

Cell membrane is the basic example about electret and one of the basic mysteries of cell biology is the resting potential of the living cell. Living cell membranes carry huge electric fields: something like 10^7 Volts per meter. For neuron resting potential corresponds to about .07 eV energy gained when unit charge travels through the membrane potential. In TGD framework it is not at all clear whether the presence of strong electromagnetic field necessitates the presence of strong Kähler field. The extremely strong electric field associated with the cell membrane is not easily understood in Maxwell's theory and almost vacuum extremal property could change the situation completely in TGD framework.

1. The configuration could be a small deformation of vacuum extremal so that the system would be highly critical as one indeed expects on basis of the general vision about living matter as a quantum critical system. For vacuum extremals classical em and Z^0 fields would be proportional to each other. The second half of Maxwell's equations is not in general satisfied in TGD Universe and one cannot exclude the presence of vacuum charge densities in which case elementary particles as the sources of the field would not be necessarily. If one assumes that this is the case approximately, the presence of Z^0 charges creating the classical Z^0 fields is implied. Neutrinos are the most candidates for the carrier of Z^0 charge. Also nuclei could feed their weak gauge fluxes to almost non-vacuum extremals but not atomic electrons since this would lead to dramatic deviations from atomic physics. This would mean that weak bosons would be light in this phase and also Weinberg angle could have a non-standard value.
2. There are also space-time surfaces for CP_2 projection belongs to homologically non-trivial geodesic sphere. In this case classical Z^0 field can vanish [L6] , [L6] and the vision has been that it is sensible to speak about two basic configurations.
 - (a) Almost vacuum extremals (homologically trivial geodesic sphere).
 - (b) Small deformations of non-vacuum extremals for which the gauge field has pure gauge Z^0 component (homologically non-trivial geodesic sphere).

The latter space-time surfaces are excellent candidates for configurations identifiable as TGD counterparts of standard electroweak physics. Note however that the charged part of electroweak fields is present for them.

3. To see whether the latter configurations are really possible one must understand how the gauge fields are affected in the color rotation.
 - (a) The action of color rotations in the holonomy algebra of CP_2 is non-trivial and corresponds to the action in $U(2)$ sub-group of $SU(3)$ mapped to $SU(2)_L \times U(1)$. Since the induced color gauge field is proportional to Kähler form, the holonomy is necessary Abelian so that also the representation of color rotations as a sub-group of electro-weak group must correspond to a local $U(1)$ sub-group local with respect to CP_2 point.
 - (b) Kähler form remains certainly invariant under color group and the right handed part of Z^0 field reducing to $U(1)_R$ sub-algebra should experience a mere Abelian gauge transformation. Also the left handed part of weak fields should experience a local $U(1)_L$ gauge rotation acting on the neutral left handed part of Z^0 in the same manner as it acts on the right handed part. This is true if the $U(1)_L$ sub-group does not depend on point of CP_2 and corresponds to Z^0 charge. If only Z^0 part of the induced gauge field is non-vanishing as it can be for vacuum extremals then color rotations cannot change the situation. If Z^0 part vanishes and non-vacuum extremal is in question, then color rotation rotation of W components mixing them but acts as a pure $U(1)$ gauge transformation on the left handed component.

- (c) It might not be without importance that for any partonic 2-surface induced electro-weak gauge fields have always U(1) holonomy, which could allow to define what neutral part of induced electroweak gauge field means locally. This does not however hold true for the 4-D tangent space distribution. In any case, the cautious conclusion is that there are two phases corresponding to nearly vacuum extremals and small deformations of extremals corresponding to homologically non-trivial geodesic spheres for which the neutral part of the classical electro-weak gauge field reduces to photon field.
4. The unavoidable presence of long range Z^0 fields would explain large parity breaking in living matter, and the fact that neutrino Compton length is of the order of cell size would suggest the possibility that within neutrino Compton electro-weak gauge fields or even longer scales could behave like massless fields. The explanation would be in terms of the different ground state characterized also by a different value of Weinberg angle. For instance, of the p-adic temperature of weak bosons corresponds to $T_p = 1/2$, the mass scale would be multiplied by a factor $\sqrt{M_{89}}$ and Compton lengths of weak bosons would be around 10^{-4} meters corresponding to the size scale of a large neuron. If the value of Planck constant is also large then the Compton length increases to astrophysical scale.
 5. From the equations for classical induced gauge fields in terms of Kähler form and classical Z^0 field [L6] , [L6]

$$\gamma = 3J - \frac{p}{2}Z^0 \quad , \quad Q_Z = I_L^3 - pQ_{em} \quad , \quad p = \sin^2(\theta_W) \quad (6.6.1)$$

it follows that for the vacuum extremals the part of the classical electro-weak force proportional to the electromagnetic charge vanishes for $p = 0$ so that only the left-handed couplings to the weak gauge bosons remain. The absence of electroweak symmetry breaking and vanishing or at least smallness of p would make sense below the Compton length of dark weak bosons. If this picture makes sense it has also implications for astrophysics and cosmology since small deformations of vacuum extremals are assumed to define the interesting extremals. Dark matter hierarchy might explain the presence of unavoidable long ranged Z^0 fields as being due to dark matter with arbitrarily large values of Planck constant so that various elementary particle Compton lengths are very long.

6. The simplest option is that the dark matter -say quarks with Compton lengths of order cell size and Planck constant of order $10^7 \hbar_0$ - are responsible for dark weak fields making almost vacuum extremal property possible. The condition that Josephson photons correspond to EEG frequencies implies $\hbar \sim 10^{13} \hbar_0$ and would mean the scaling of intermediate gauge boson Compton length to that corresponding to the size scale of a larger neuron. The quarks involved with with DNA as topological quantum computer model could be in question and membrane potential might be assignable to the magnetic flux tubes. The ordinary ionic currents through cell membrane -having no coupling to classical Z^0 fields and not acting as its source- would be accompanied by compensating currents of dark fermions taking care that the almost vacuum extremal property is preserved. The outcome would be large parity breaking effects in cell scale from the left handed couplings of dark quarks and leptons to the classical Z^0 field. The flow of Na^+ ions during nerve pulse could take along same dark flux tube as the flow of dark quarks and leptons. This near vacuum extremal property might be fundamental property of living matter at dark space-time sheets at least.

1. Could nuclei and neutrinos couple to light variants of weak gauge fields in the critical phase?

One of the hard-to-kill ideas of quantum TGD inspired model of quantum biology is that neutrinos might have something do with hearing and cognition. This proposal looks however unrealistic in the recent vision. I would be more than happy to get rid of bio-neutrinos but the following intriguing finding does not allow me to have this luxury.

1. Assume that the endogenous magnetic field $B_{end} = .2$ Gauss is associated with a nearly vacuum extremal and therefore accompanied by $B_Z = 2B_{end}/p$. Assume for definiteness $m_\nu = .3$ eV and $p = \sin^2(\theta_W) = .23$. The neutrino cyclotron frequency is given by the following expression

$$f_\nu = \frac{m_e}{m_\nu} \frac{1}{2\sin^2(\theta_W)} f_e .$$

From $f_e \simeq .57 \times \text{MHz}$ and $p = \sin^2(\theta_W) = .23$ one obtains $E_\nu = 1.7 \times 10^{-2}$ eV, which is roughly one third to the Josephson frequency of electron assignable to cell membrane. Could Josephson frequency of cell membrane excite neutrino cyclotron transitions?

2. The model for photoreceptors to be discussed below forces to conclude that the value of Weinberg angle in the phase near vacuum extremal must be $p = .0295$ if one wants to reproduce the peak energies of photoreceptors as Josephson frequencies of basic biological ions. This would predict $E_\nu = .41$ eV, which is rather near to the metabolic energy quantum. The non-relativistic formula however fails in this case and one must use the relativistic formula giving

$$E = \sqrt{g_Z Q_Z B_Z 2\pi} \simeq .48 \text{ eV}$$

giving the metabolic energy quantum. Does this mean that Z^0 cyclotron frequency for neutrino is related to the transfer of metabolic energy using Z^0 MEs in the phase near vacuum extremals.

3. Josephson frequency is proportional to $1/\hbar$, whereas neutrino cyclotron frequency does not depend on \hbar at non-relativistic energies. For larger values of \hbar the neutrino becomes relativistic so that the mass in the formula for cyclotron frequency must be replaced with energy. This gives

$$E = \sqrt{nr^{1/2}} \sqrt{g_Z Q_Z B_Z 2\pi} \simeq r^{1/2} \times .48 \text{ eV} , \quad r = \sqrt{\hbar/\hbar_0} .$$

Here n refers to the cyclotron harmonic.

These observations raise the question whether the three frequencies with maximum response assignable to the three different types of receptors of visible light in retina could correspond to the three cyclotron frequencies assignable to the three neutrinos with different mass scales? The first objection is that the dependence on mass disappears completely at the relativistic limit. The second objection is that the required value value of Planck constant is rather small and far from being enough to have electroweak boson Compton length of order cell size. One can of course ask whether the electroweak gauge bosons are actually massless inside almost vacuum extremals. If fermions -including neutrino- receive their masses from p-adic thermodynamics then massless electroweak gauge bosons would be consistent with massive fermions. Vacuum extremals are indeed analogous to the unstable extrema of Higgs potential at which the Higgs vacuum expectation vanishes so that this interpretation might make sense.

2. Ionic Josephson frequencies defined by the resting potential for nearly vacuum extremals

If cell membrane corresponds to an almost vacuum extremal, the membrane potential potential is replaced with an effective resting potential containing also the Z^0 contribution proportional to the ordinary resting potential. The surprising outcome is that one could understand the preferred frequencies for photo-receptors [J11] as Josephson frequencies for biologically important ions. Furthermore, most Josephson energies are in visible and UV range and the interpretation in terms of biophotons is suggestive. If the value of Planck constant is large enough Josephson frequencies are in EEG frequency range so that biophotons and EEG photons could be both related to Josephson photons with large \hbar .

1. One must assume that the interior of the cell corresponds to many fermion state -either a state filled with neutrinos up to Fermi energy or Bose-Einstein condensate of neutrino Cooper pairs creating a harmonic oscillator potential. The generalization of nuclear harmonic oscillator model so that it applies to multi-neutrino state looks natural.

2. For exact vacuum extremals elementary fermions couple only via left-handed isospin to the classical Z^0 field whereas the coupling to classical em field vanishes. Both K^+, Na^+ , and Cl^- $A - Z = Z + 1$ so that by p-n pairing inside nucleus they have the weak isospin of neutron (opposite to that of neutrino) whereas Ca^{++} nucleus has a vanishing weak isospin. This might relate to the very special role of Ca^{++} ions in biology. For instance, Ca^{++} defines an action potential lasting a time of order .1 seconds whereas Na^+ defines a pulse lasting for about 1 millisecond [J4] . These time scales might relate to the time scales of CDs associated with quarks and electron.
3. The basic question is whether only nuclei couple to the classical Z^0 field or whether also electrons do so. If not, then nuclei have a large effective vector coupling to em field coming from Z^0 coupling proportional to the nuclear charge increasing the value of effective membrane potential by a factor of order 100. If both electrons and nuclei couple to the classical Z^0 field, one ends up with difficulties with atomic physics. If only quarks couple to the Z^0 field and one has $Z^0 = -2\gamma/p$ for vacuum extremals, and one uses average vectorial coupling $\langle I_L^3 \rangle = \pm 1/4$ with + for proton and - for neutron, the resulting vector coupling is following

$$\begin{aligned} \left(\frac{Z-N}{4} - pZ\right)Z^0 + q_{em}\gamma &= Q_{eff}\gamma , \\ Q_{eff} &= -\frac{Z-N}{2p} + 2Z + q_{em} . \end{aligned} \quad (6.6.2)$$

Here γ denotes em gauge potential. For K^+, Cl^-, Na^+, Ca^{++} one has $Z = (19, 17, 11, 20)$, $Z - N = (-1, -1, -1, 0)$, and $q_{em} = (1, -1, 1, 2)$. Table 1 below gives the values of Josephson energies for some values of resting potential for $p = .23$. Rather remarkably, they are in IR or visible range.

$E(Ion)/eV$	$V = -40 \text{ mV}$	$V = -60 \text{ mV}$	$V = -70 \text{ mV}$
Na^+	1.01	1.51	1.76
Cl^-	1.40	2.11	2.46
K^+	1.64	2.47	2.88
Ca^{++}	1.68	2.52	2.94

Table 2. Values of the Josephson energy of cell membrane for some values of the membrane voltage for $p = .23$. The value $V = -40 \text{ mV}$ corresponds to the resting state for photoreceptors and $V = -70 \text{ mV}$ to the resting state of a typical neuron.

Are photoreceptors nearly vacuum extremals?

In Hodgkin-Huxley model ionic currents are Ohmian currents. If one accepts the idea that the cell membrane acts as a Josephson junction, there are also non-dissipative oscillatory Josephson currents of ions present, which run also during flow equilibrium for the ionic parts of the currents. A more radical possibility is that that the dominating parts of the ionic currents are oscillatory Josephson currents so that no metabolic energy would be needed to take care that density gradients for ions are preserved. Also in this case both nearly vacuum extremals and extremals with nearly vanishing Z^0 field can be considered. Since sensory receptors must be highly critical the natural question is whether they could correspond to nearly vacuum extremals. The quantitative success of the following model for photoreceptors supports this idea.

Photoreceptors can be classified to three kinds of cones responsible for color vision and rods responsible for black-white vision. The peak sensitivities of cones correspond to wavelengths (405, 535, 565) nm and energies (3.06, 2.32, 2.19) eV. The maximum absorption occurs in the wave length range 420-440 nm, 534-545 nm, 564-580 nm for cones responsible for color vision and 498 nm for rods responsible black-white vision [J5, J11] . The corresponding photon energies are (2.95, 2.32, 2.20) eV for color vision and to 2.49 eV for black-white vision. For frequency distribution the maxima are shifted from these since the maximum condition becomes $dI/d\lambda + 2I/\lambda = 0$, which means a shift to

a larger value of λ , which is largest for smallest λ . Hence the energies for maximum absorbance are actually lower and the downwards shift is largest for the highest energy.

From Table 2 above it is clear that the energies of Josephson photons are in visible range for reasonable values of membrane voltages, which raises the question whether Josephson currents of nuclei in the classical em and Z^0 fields of the cell membrane could relate to vision.

Consider first the construction of the model.

1. Na^+ and Ca^{++} currents are known to present during the activation of the photoreceptors. Na^+ current defines the so called dark current [J11] reducing the membrane resting potential below its normal value and might relate to the sensation of darkness as eyes are closed. Hodgkin-Huxley model predicts that also K^+ current is present. Therefore the Josephson energies of these three ion currents are the most plausible correlates for the three colors.
2. One ends up with the model in the following manner. For Ca^{++} the Josephson frequency does not depend on p and requiring that this energy corresponds to the energy 2.32 eV of maximal sensitivity for cones sensitive to green light fixes the value of the membrane potential during hyperpolarization to $V = .055$ V, which is quite reasonable value. The value of the Weinberg angle parameter can be fixed from the condition that other peak energies are reproduced optimally. The result of $p = .0295$.

The predictions of the model come as follows summarized also by the Table 3 below.

1. The resting potential for photoreceptors is $V = -40$ mV [J12]. In this case all Josephson energies are below the range of visible frequencies for $p = .23$. Also for maximal hyperpolarization Na^+ Josephson energy is below the visible range for this value of Weinberg angle.
2. For $V = -40$ mV and $p = .0295$ required by the model the energies of Cl^- and K^+ Josephson photons correspond to red light. 2 eV for Cl^- corresponds to a basic metabolic quantum. For Na^+ and Ca^{++} the wave length is below the visible range. Na^+ Josephson energy is below visible range. This conforms with the interpretation of Na^+ current as a counterpart for the sensation of darkness.
3. For $V = -55$ mV - the threshold for the nerve pulse generation- and for $p = .0295$ the Josephson energies of Na^+ , Ca^{++} , and K^+ correspond to the peak energies for cones sensitive to red, green, and blue respectively. Also Cl^- is in the blue region. Ca^{++} Josephson energy can be identified as the peak energy for rods. The increase of the hyperpolarization to $V = -59$ mV reproduces the energy of the maximal wave length response exactly. A possible interpretation is that around the criticality for the generation of the action potential ($V \simeq -55$ mV) the qualia would be generated most intensely since the Josephson currents would be strongest and induce Josephson radiation inducing the quale in other neurons of the visual pathway at the verge for the generation of action potential. This supports the earlier idea that visual pathways defines a neural window. Josephson radiation could be interpreted as giving rise to biophotons (energy scale is correct) and to EEG photons (for large enough values of \hbar the frequency scales is that of EEG).
4. In a very bright illumination the hyperpolarization is $V = -65$ mV [J12], which the normal value of resting potential. For this voltage Josephson energies are predicted to be in UV region except in case of Ca^{++} . This would suggest that only the quale 'white' is generated at the level of sensory receptor: very intense light is indeed experienced as white.

The model reproduces basic facts about vision assuming that one accepts the small value of Weinberg angle, which is indeed a natural assumption since vacuum extremals are analogous to the unstable extrema of Higgs potential and should correspond to small Weinberg angle. It deserves to be noticed that neutrino Josephson energy is 2 eV for $V = -50$ mV, which correspond to color red. 2 eV energy defines an important metabolic quantum.

Ion	Na^+	Cl^-	K^+	Ca^{++}
$E_J(.04 \text{ mV}, p = .23)/eV$	1.01	1.40	1.51	1.76
$E_J(.065 \text{ V}, p = .23)/eV$	1.64	2.29	2.69	2.73
$E_J(40 \text{ mV}, p = .0295)/eV$	1.60	2.00	2.23	1.68
$E_J(50 \text{ mV}, p = .0295)/eV$	2.00	2.49	2.79	2.10
$E_J(55 \text{ mV}, p = .0295)/eV$	2.20	2.74	3.07	2.31
$E_J(65 \text{ mV}, p = .0295)/eV$	2.60	3.25	3.64	2.73
$E_J(70 \text{ mV}, p = .0295)/eV$	2.80	3.50	3.92	2.94
$E_J(75 \text{ mV}, p = .0295)/eV$	3.00	3.75	4.20	3.15
$E_J(80 \text{ mV}, p = .0295)/eV$	3.20	4.00	4.48	3.36
$E_J(90 \text{ mV}, p = .0295)/eV$	3.60	4.50	5.04	3.78
$E_J(95 \text{ mV}, p = .0295)/eV$	3.80	4.75	5.32	3.99
Color	R	G	B	W
E_{max}	2.19	2.32	3.06	2.49
energy-interval/eV	1.77-2.48	1.97-2.76	2.48-3.10	

Table 3. The table gives the prediction of the model of photoreceptor for the Josephson energies for typical values of the membrane potential. For comparison purposes the energies E_{max} corresponding to peak sensitivities of rods and cones, and absorption ranges for rods are also given. R,G,B,W refers to red, green, blue, white. The values of Weinberg angle parameter $p = \sin^2(\theta_W)$ are assumed to be .23 and .0295. The latter value is forced by the fit of Josephson energies to the known peak energies.

It interesting to try to interpret the resting potentials of various cells in this framework in terms of the Josephson frequencies of various ions.

1. The maximum value of the action potential is +40 mV so that Josephson frequencies are same as for the resting state of photoreceptor. Note that the time scale for nerve pulse is so slow as compared to the frequency of visible photons that one can consider that the neuronal membrane is in a state analogous to that of a photoreceptor.
2. For neurons the value of the resting potential is -70 mV. Na^+ and Ca^{++} Josephson energies 2.80 eV and 2.94 eV are in the visible range in this case and correspond to blue light. This does not mean that Ca^{++} Josephson currents are present and generate sensation of blue at neuronal level: the quale possibly generated should depend on sensory pathway. During the hyperpolarization period with -75 mV the situation is not considerably different.
3. The value of the resting potential is -95 mV for skeletal muscle cells. In this case Ca^{++} Josephson frequency corresponds to 4 eV metabolic energy quantum as the table below shows.
4. For smooth muscle cells the value of resting potential is -50 mV. In this case Na^+ Josephson frequency corresponds to 2 eV metabolic energy quantum.
5. For astroglia the value of the resting potential is -80/-90 mV for astroglia. For -80 mV the resting potential for Cl^- corresponds to 4 eV metabolic energy quantum. This suggests that glial cells could also provide metabolic energy as Josephson radiation to neurons.
6. For all other neurons except photo-receptors and red blood cells Josephson photons are in visible and UV range and the natural interpretation would be as biophotons. The biophotons detected outside body could represent sensory leakage. An interesting question is whether the IR Josephson frequencies could make possible some kind of IR vision.

6.6.2 General model for qualia and sensory receptor

The identification of quantum number increments in quantum jump for a subsystem representing subself and the capacitor model of sensory receptor are already more than decade old ideas.

The concrete realization of this vision is based on several ideas that I have developed during last five years.

1. The vision about dark matter as a hierarchy of phases partially labeled by the value of Planck constant led to the model of DNA as topological quantum computer [K28]. In this model magnetic flux tubes connecting DNA nucleotides with the lipids of the cell membrane define strands of the braids defining topological quantum computations. The braid strand corresponds to so called wormhole flux tube and has quark and antiquark at its ends. u and d quarks and their antiquarks code for four DNA nucleotides in this model.
2. Zero energy ontology assigns to elementary particles so called causal diamonds (CD s). For u and d quarks and electron these time scales are (6.5, .78, 100) ms respectively, and correspond to fundamental biorhythms. Electron time scale corresponds to 10 Hz fundamental biorhythm defining also the fundamental frequency of speech organs, .78 ms to kHz cortical synchrony [J46], and 160 Hz to cerebellar synchrony [J50]. Elementary particles therefore seem to be directly associated with neural activity, language, and presumably also hearing. One outcome was the modification of the earlier model of memetic code involving the notion of cognitive neutrino pair by replacing the sequence of cognitive neutrino pairs with that of quark sub- CD s within electron CD . Nerve pulses could induce the magnetization direction of quark coding for bit but there are also other possibilities. The detailed implications for the model of nerve pulse [K62] remain to be disentangled.
3. The understanding of the Negentropy Maximization Principle [K46] and the role of negentropic entanglement in living matter together with the vision about life as something in the intersection of real and p -adic worlds was a dramatic step forward. In particular, space-like and time-like negentropic entanglement become basic aspects of conscious intelligence and are expected to be especially important for understanding the difference between speech and music.
4. The most important implication concerning the model of sensory receptors however relate to the vacuum degeneracy of Kähler action. It has been clear from the beginning that the nearly vacuum extremals of Kähler action could play key role in living systems. The reason is their criticality making them ideal systems for sensory perception. These extremals carry classical em and Z^0 fields related to each other by a constant factor and this could explain the large parity breaking effects characterizing living matter. The assumption that cell membranes are nearly vacuum extremals and that nuclei can feed their Z^0 charges to this kind of space-time sheets (not true for atomic electrons) in living matter leads to a modification of the model for the cell membrane as Josephson junction [K62]. Also a model of photoreceptors explaining the frequencies of peak sensitivity as ionic Josephson frequencies and allowing the dual identifications Josephson radiation as biophotons (energies) [I64] and EEG radiation (frequencies) emerge since the values of Planck constant can be very large. The value of the Weinberg angle in this phase is fixed to $\sin^2(\theta_W) = .0295$, whereas in standard phase the value is given by $\sin^2(\theta_W) = .23$. The significance of this quantitative success for TGD and TGD inspired quantum biology cannot be over-estimated.

6.6.3 Some implications of the model of cell membrane as sensory receptor

The ensuing general model of how cell membrane acts as a sensory receptor has unexpected implications for the entire TGD inspired view about biology.

1. DNA as topological quantum computer model plus certain simplifying assumption leads to the conclusion that the spectrum of net quantum numbers of quark antiquark pair define the primary qualia assignable to a nucleotide-lipid pair connected by a magnetic flux tube. The most general prediction is that the net quantum numbers of two quark pairs characterize the qualia. In the latter case the qualia would be assigned to a pair of receptor cells.
2. Composite qualia result when one allows the nucleotide-lipid pairs of the membrane to be characterized by a distribution of quark-antiquark pairs. Cell membrane -or at least the axonal parts of neurons- would define a sensory representation in which is a pair of this kind defines a pixel characterized by primary qualia. Cells would be sensory homunculi and DNA defines a sensory hologram of body of or of part of it. Among other things this would give a precise content to the notion of grandma cell.

3. Josephson frequencies of biologically important ions are in one-one correspondence with the qualia and Josephson radiation could re-generate the qualia or map them to different qualia in a one-one and synesthetic manner in the neurons of the sensory pathway. For large values of Planck constant Josephson frequencies are in EEG range so that a direct connection with EEG emerges and Josephson radiation indeed corresponds to both biophotons and EEG. This would realize the notion of sensory pathway which originally seemed to me a highly non-realistic notion and led to the vision that sensory qualia can be realized only at the level of sensory organs in TGD framework.
4. At the level of brain motor action and sensory perception look like reversals of each other. In zero energy ontology motor action can be indeed seen as a time reversed sensory perception so that the model of sensory representations implies also a model for motor action. Magnetic body serves as a sensory canvas where cyclotron transitions induced by Josephson frequencies induce conscious sensory map entangling the points of the magnetic body with brain and body.

6.6.4 A general model of qualia and sensory receptor

The identification of sensory qualia in terms of quantum number increments and geometric qualia representing geometric and kinematic information in terms of moduli of CD , the assignment of sensory qualia with the membrane of sensory receptor, and capacitor model of qualia are basic ideas behind the model. The communication of sensory data to magnetic body using Josephson photons is also a key aspect of the model.

A general model of qualia

It is good to start by summarizing the general vision about sensory qualia and geometric qualia in TGD Universe.

1. The basic assumption is that sensory qualia correspond to increments of various quantum numbers in quantum jump. Standard model quantum numbers- color quantum numbers, electromagnetic charge and weak isospin, and spin are the most obvious candidates. Also cyclotron transitions changing the integer characterizing cyclotron state could correspond to some kind of quale- perhaps 'a feeling of existence'. This could make sense for the qualia of the magnetic body.
2. Geometric qualia could correspond to the increments of zero modes characterizing the induced CP_2 Kähler form of the partonic 2-surface and of the moduli characterizing the causal diamonds serving as geometric correlates of selves. This moduli space involves the position of CD and the relative position of tips as well as position in CP_2 and relative position of two CP_2 points assigned to the future and past boundaries of CD . There are good motivations for proposing that the relative positions are quantized. This gives as a special case the quantization of the scale of CD in powers of two. Position and orientation sense could represent this kind of qualia. Also kinematical qualia like sensation of acceleration could correspond to geometric qualia in generalized 4-D sense. For instance, the sensation about motion could be coded by Lorentz boosts of sub- CD representing mental image about the object.
3. One can in principle distinguish between qualia assignable to the biological body (sensory receptors in particular) and magnetic body. The basic question is whether sensory qualia can be assigned only with the sensory receptors or with sensory pathways or with both. Geometric qualia might be assignable to the magnetic body and could provide third person perspective as a geometric and kinematical map of the body and its state of motion represented using the moduli space assignable to causal diamonds (CD). This map could be provided also by the body in which case the magnetic body would only share various mental images. The simplest starting assumption consistent with neuro-science is that sensory qualia are assigned with the cell membrane of sensory receptor and perhaps also with the neurons receiving data from it carried by Josephson radiation coding for the qualia and possibly partially regenerating them if the receiving neuron has same value of membrane potential as the sensory receptor when active. Note that during nerve pulse also this values of membrane potential is achieved for some time.

Could some sensory qualia correspond to the sensory qualia of the magnetic body?

Concerning the understanding of a detailed model for how sensory qualia are generated, the basic guideline comes from the notion of magnetic body and the idea that sensory data are communicated to the magnetic body as Josephson radiation associated with the cell membrane. This leaves two options: either the primary sensory qualia are generated at the level of sensory receptor and the resulting mental images negentropically entangle with the "feeling of existence" type mental images at the magnetic body or they can be also generated at the level of the magnetic body by Josephson radiation -possibly as cyclotron transitions. The following arguments are to-be-or-not-to-be questions about whether the primary qualia must reside at the level of sensory receptors.

1. Cyclotron transitions for various cyclotron condensates of bosonic ions or Cooper pairs of fermionic ions or elementary particles are assigned with the motor actions of the magnetic body and Josephson frequencies with the communication of the sensory data. Therefore it would not be natural to assign qualia with cyclotron transitions. On the other hand, in zero energy ontology motor action can be regarded formally as a time reversed sensory perception, which suggests that cyclotron transitions correlated with the "feeling of existence" at magnetic body entangled with the sensory mental images. They could also code for the pitch of sound as will be found but this quale is strictly speaking also a geometric quale in the 4-D framework.
2. If Josephson radiation induces cyclotron transitions, the energy of Josephson radiation must correspond to that of cyclotron transition. This means very strong additional constraint not easy to satisfy except during nerve pulse when frequencies varying from about 10^{14} Hz down to kHz range are emitted the system remains Josephson contact. Cyclotron frequencies are also rather low in general, which requires that the value of \hbar must be large in order to have cyclotron energy above the thermal threshold. This would however conform with the very beautiful dual interpretation of Josephson photons in terms of biophotons and EEG. One expects that only high level qualia can correspond to a very large values of \hbar needed.

For the sake of completeness it should be noticed that one might do without large values of \hbar if the carrier wave with frequency defined by the metabolic energy quantum assignable to the kicking and that the small modulation frequency corresponds to the cyclotron frequency. This would require that Josephson frequency corresponds to the frequency defined by the metabolic quantum. This is not consistent with the fact that very primitive organisms possess sensory systems.

3. If all primary qualia are assigned to the magnetic body, Josephson radiation must include also gluons and light counter parts of weak bosons are involved besides photons. This is quite a strong additional assumption and it will be found that the identification of sensory qualia in terms of quantum numbers of quark pair restricts them to the cell membrane. The coding of qualia by Josephson frequencies is however possible and makes it possible to regenerate them in nervous system. The successful model explaining the peak frequencies of photoreceptors in terms of ionic cyclotron frequencies supports this view and provides a realization for an old idea about spectroscopy of consciousness which I had already been ready to give up.

Capacitor model of sensory qualia

In capacitor model of sensory receptor the increments of quantum numbers are amplified as particles with given quantum numbers flow between the plates of capacitor like system and the second plate defines the subself responsible for the mental image. The generation of complementary qualia assignable to the two plates and bringing in mind complementary colors is predicted. The capacitor is at the verge of di-electric breakdown. The interior and exterior of the receptor cell are the most plausible candidates for the capacitor plates with lipid layers defining the analog of di-electric able to changes its properties. Josephson currents generating Josephson radiation could communicate the sensory percept to the magnetic body but would not generate genuine sensory qualia there (the pitch of sound would be interpreted as a geometric quale). The coding is possible if the basic qualia correspond in one-one manner to ionic Josephson currents. There are sensory receptors which themselves do not fire (this is the case for hair cells for hearing and tactile receptor cells) and in this case the neuron next to the receptor in the sensory pathway would take the role of the quantum critical system.

The notion of sensory capacitor can be generalized. In zero energy ontology the plates could be effectively replaced with positive and negative energy parts of zero energy state or with cyclotron Bose-Einstein condensates corresponding to two different energies. Plates could also correspond to a pair of space-time sheets labeled by different p -adic primes and the generation of quale would correspond in this case to a flow of particles between the space-time sheets or magnetic flux tubes connected by contacts defining Josephson junctions.

The TGD inspired model for photoreceptors [K62] relies crucially on the assumption that sensory neurons at least and probably all cell membranes correspond to nearly vacuum extremals with the value of Weinberg angle equal to $\sin^2(\theta_W) = .0295$ and weak bosons having Compton length of order cell size and ordinary value of Planck constant. This also explains the large parity breaking effects in living matter. The almost vacuum extremal property conforms with the vision about cell membrane as a quantum critical system ideal for acting as a sensory receptor.

6.6.5 Detailed model for the qualia

The proposed vision about qualia requires a lot of new physics provided by TGD. What leads to a highly unique proposal is the intriguing coincidence of fundamental elementary particle time scales with basic time scales of biology and neuro science and the model of DNA as topological quantum computer [K28] .

1. Zero energy ontology brings in the size scale of CD assignable to the field body of the elementary particle. Zero energy states with negentropic time-like entanglement between positive and negative energy parts of the state might provide a key piece of the puzzle. The negentropic entanglement between positive energy parts of the states associated with the sub- CD assignable to the cell membrane and sub- CD at the magnetic body is expected to be an important factor.
2. For the standard value of \hbar the basic prediction would be 1 ms second time scale of d quark, 6.5 ms time scale of u quark, and .1 second time scale of electron as basic characterizes of sensory experience if one accept the most recent estimates $m(u) = 2$ MeV and $m(d) = 5$ MeV for the quark masses [C2] . These time scales correspond to 10 Hz, 160 Hz, and 1280 Hz frequencies, which all characterize neural activity (for the identification of 160 Hz frequency as cerebellar resonance frequency see [J50]). Hence quarks could be the most interesting particles as far as qualia are considered and the first working hypothesis would be that the fundamental quantum number increments correspond to those for quark-anti-quark pair. The identification in terms of quantum numbers of single quark is inconsistent with the model of color qualia.
3. The model of DNA as topological quantum computer led to the proposal that DNA nucleotides are connected to the lipids of the cell membrane by magnetic flux tubes having quark and antiquark at its ends such that the u and d quarks and their antiquarks code for the four nucleotides. The outer lipid layer was also assumed to be connected by flux tubes to the nucleotide in some other cell or in cell itself.
4. The model for DNA as topological quantum computer did not completely specify whether the flux tubes are ordinary flux tubes or wormhole flux tubes with possibly opposite signs of energy assigned with the members of the flux tube pair. Although it is not necessary, one could assume that the quantum numbers of the two parallel flux tubes cancel each other so that wormhole flux tube would be characterized by quantum numbers of quark pairs at its ends. It is not even necessary to assume that the net quantum numbers of the flux tubes vanish. Color confinement however suggests that the color quantum at the opposite ends of the flux tube are of opposite sign.
 - (a) The absence of a flux tube between lipid layers was interpreted as an isolation from external world during the topological quantum computation. The emergence of the flux tube connection means halting of topological quantum computation. The flux tube connection with the external world corresponds to sensory perception at the level of DNA nucleotide in consistency with the idea that DNA plays the role of the brain of cell [K70] . The total color quantum numbers at the ends of the flux tubes were assumed to sum up to zero. This means that the fusion of the flux tubes ending to the interior and exterior cell membrane

to single one creates a flux tube state not localized inside cell and that the interior of cell carries net quantum numbers. The attractive interpretation is that this process represents the generation of quale of single nucleotide.

- (b) The formation of the flux tube connection between lipid layers would involve the transformation of both quark-antiquark pairs to an intermediate state. There would be no kinematic constraints on the process nor to the mass scales of quarks. A possible mechanism for the separation of the two quark-antiquark pairs associated with the lipids from the system is double reconnection of flux tubes which leads to a situation in which the quark-antiquark pairs associated with the lipid layers are connected by short flux loops and separated to a disjoint state and there is a long wormhole flux tube connecting the nucleotides possibly belonging to different cells.
 - (c) The state of two quark pairs need not have vanishing quantum numbers and one possibility is that the quantum numbers of this state code for qualia. If the total numbers of flux tubes are vanishing also the net quantum numbers of the resulting long flux tube connecting two different cells provide equivalent coding. A stronger condition is that this state has vanishing net quantum numbers and in this case the ends of the long flux tube would carry opposite quantum numbers. The end of flux tube at DNA nucleotide would characterize the quale.
5. Two identification of primary qualia are therefore possible.
 - (a) If the flux tubes have vanishing net quantum numbers, the primary sensory quale can be assigned to single receptor cell and the flow of the quantum numbers corresponds to the extension of the system with vanishing net quantum numbers in two-cell system.
 - (b) If the net quantum numbers of the flux tube need not vanish, the resulting two cell system carries non-vanishing quantum numbers as the pair of quark-antiquark pairs removes net quantum numbers out of the system.
 6. If the net quantum numbers for the flux tubes vanish always, the specialization of the sensory receptor membrane to produce a specific quale would correspond to an assignment of specific quantum numbers at the DNA ends of the wormhole flux tubes attached to the lipid layers of the cell membrane. The simplest possibility that one can imagine is that the outer lipid layer is connected to the conjugate DNA nucleotide inside same cell nucleus. This option would however assign vanishing net quantum number increments to the cell as whole and is therefore unacceptable.
 7. The formation of a temporary flux tube connection with another cell is necessary during the generation of quale and the question is what kind of cell is in question. The connection of the receptor to cells along the sensory pathway are expected to be present along the entire sensory pathway from DNA nucleotide to a nucleotide in the conjugate strand of second neuron to DNA nucleotide of the third neuron.... If Josephson photons are able to regenerate the quale in second neuron this would make it possible to replicate the quale along entire sensory pathway. The problem is that Josephson radiation has polarization orthogonal to axons and must propagate along the axon whereas the flux tube connection must be orthogonal to axon. Hence the temporary flux tube connection is most naturally between receptor cells and would mean horizontal integration of receptor cells to a larger structure. A holistic process in directions parallel and orthogonal to the sensory pathway would be in question. Of course, the flux tube could be also curved and connect the receptor to the next neuron along the sensory pathway.
 8. The specialization of the neuron to sensory receptor would require in the framework of positive energy ontology that -as far as qualia assignable to the electro-weak quantum numbers are considered - all DNA nucleotides are identical by the corresponds of nucleotides with quarks and antiquarks. This cannot be the case. In zero energy ontology and for wormhole flux tubes it is however enough to assume that the net electroweak quantum numbers for the quark antiquark pairs assignable to the DNA wormhole contact are same for all nucleotides. This condition is easy to satisfy. It must be however emphasized that there is no reason to require that all nucleotides involved generate same quale and at the level of neurons sensory maps assigning different qualia

to different nucleotides and lipids allowing DNA to sensorily perceive the external world are possible.

The model should be consistent with the assignment of the fundamental bio-rhythms with the *CDs* of electron and quarks.

1. Quark color should be free in long enough scales and cellular length scales are required at least. The QCD in question should therefore have long enough confinement length scales. The first possibility is provided by almost vacuum extremals with a long confinement scale also at the flux tubes. Large \hbar for the cell membrane space-time sheet seems to be unavoidable and suggests that color is free in much longer length scale than cell length scale.
2. Since the length of the flux tubes connecting DNA and cell membrane is roughly 1 micrometer and by a factor of order 10^7 longer than the d quark Compton length, it seems that the value of Planck constant must be of this order for the flux tubes. This however scales up the time scale of d quark *CD* by a factor of 10^{14} to about 10^4 years! The millisecond and 160 ms time scales are much more attractive. This forces to ask what happens to the quark-anti-quark pairs at the ends of the tubes.
3. The only possibility seems to be that the reconnection process involves a phase transition in which the closed flux tube structure containing the two quark pairs assignable to the wormhole contacts at lipid layers is formed and leaks to the page of the Big Book with pages partially labeled by the values of Planck constant. This page would correspond to the standard value of Planck constant so that the corresponding d quark *CDs* would have a duration of millisecond. The reconnection leading to the ordinary situation would take place after millisecond time scale. The standard physics interpretation would be as a quantum fluctuation having this duration. This sequence of quark sub-*CDs* could define what might be called memetic codon representation of the nerve pulse sequence.
4. One can also consider the possibility is that near vacuum extremals give rise to a copy of hadron physics for which the quarks associated with the flux tubes are light. The Gaussian Mersennes corresponding to $k = 151, 157, 163, 167$ define excellent p-adic time scales for quarks and light variants of weak gauge bosons. Quark mass 5 MeV would with $k = 120$ would be replaced with $k = 163$ (167) one would have mass 1.77 eV (.44 eV). Small scaling of both masses gives 2 eV and .5 eV which correspond to basic metabolic quanta in TGD framework. For quark mass of 2 MeV with $k = 123$ $k = 163$ (167) one would give masses .8 eV (.05 eV). The latter scale correspond to Josephson energy assignable with the membrane potential in the ordinary phase.

In this case a phase transition transforming almost vacuum extremal to ordinary one takes place. What this would mean that the vacuum extremal property would hold true below much shorter p-adic length scale. In zero energy ontology the scaling up of quark masses is in principle possible. This option looks however too artificial.

6.6.6 Overall view about qualia

This picture leads to the following overall view about qualia. There are two options depending on whether single quark-antiquark pair or two of them labels the qualia. In the following only the simpler option with single quark-antiquark pair is discussed.

1. All possible pairings of spin and electroweak isospin (or em charge) define 16 basic combinations if one assumes color singletness. If arbitrary color is allowed, there is a nine-fold increase of quantum numbers decomposable to color singlet and octet qualia and further into 3×15 qualia with vanishing increments of color quantum numbers and 6×16 qualia with non-vanishing increments of color quantum numbers. The qualia with vanishing increments for electroweak quantum numbers could correspond to visual colors. If electroweak quantum numbers of the quark-anti-quark pair vanish, one has 3×7 *resp.* 6×8 combinations of colorless *resp.* colored qualia.
2. There is a huge number of various combinations of these fundamental qualia if one assumes that each nucleotide defines its own quale and fundamental qualia would be analogous to constant

functions and more general qualia to general functions having values in the space with $9 \times 16 - 1$ points. Only a very small fraction of all possible qualia could be realized in living matter unless the neurons in brain provide representations of body parts or of external world in terms of qualia assignable to lipid-nucleotide pairs. The passive DNA strand would be ideal in this respect.

3. The basic classification of qualia is as color qualia, electro-weak quale, and spin quale and products of these qualia. Also combinations of color qualia and and electroweak and spin quale are possible and could define exotic sensory qualia perhaps not yet realized in the evolution. Synesthesia is usually explained in terms of sensory leakage between sensory pathways and this explanation makes sense also in TGD framework if there exists a feedback from the brain to the sensory organ. Synesthesia cannot however correspond to the product qualia: for "quantum synesthesia" cross association works in both directions and this distinguishes it from the ordinary synesthesia.
4. The idea about brain and genome as holograms encourages to ask whether neurons or equivalently DNA could correspond to sensory maps with individual lipids representing qualia combinations assignable to the points of the perceptive field. In this framework quantum synesthesia would correspond to the binding of qualia of single nucleotide (or lipid) of neuron cell membrane as a sensory representation of the external world. DNA is indeed a holographic representation of the body (gene expression of course restricts the representation to a part of organism). Perhaps it is this kind of representation also at the level of sensory experience so that all neurons could be little sensory copies of body parts as holographic quantum homunculi. In particular, in the associative areas of the cortex neurons would be quantum synesthetes experiencing the world in terms of composite qualia.
5. The number of flux tube connections generated by sensory input would code for the intensity of the quale. Josephson radiation would do the same at the level of communications to the magnetic body. Also the temporal pattern of the sequence of quale mental images matters. In the case of hearing this would code for the rhythmic aspects and pitch of the sound.

6.6.7 About detailed identification of the qualia

One can make also guesses about detailed correspondence between qualia and quantum number increments.

1. Visual colors would correspond to the increments of only color quantum numbers. Each biologically important ion would correspond to its own color increment in one-one correspondence with the three pairs of color-charged gluons and these would correspond to blue-yellow, red-green, and black white [K62]. Black-white vision would mean a restriction to the $SU(2)$ subgroup of color group. The model for the cell membrane as a nearly vacuum extremal assigns the peak frequencies corresponding to fundamental colors with biologically important ions. Josephson radiation could induce artificially the same color qualia in other neurons and this might provide a manner to communicate the qualia to the brain where they could be re-experienced at neuronal level. Some organisms are able to perceive also the polarization of light. This requires receptors sensitive to polarization. The spin of quark pair would naturally code for polarization quale.
2. Also tastes and odours define qualia with "colors". Certainly the increments of electroweak numbers are involved but since these qualia do not have any directional flavor, spin is probably not involved. This would give $c 3 \times 4$ basic combinations are possible and can certainly explain the 5 or 6 basic tastes (counted as the number of different receptors). Whether there is a finite number of odours or not has been a subject of a continual debate and it might be that odours already correspond to a distribution of primary qualia for the receptor cell. That odours are coded by nerve pulse patterns for a group of neurons [J76] would conform with this picture.
3. Hearing seems to represent a rather colorless quale so that electroweak isospin suggests again itself. If we had a need to hear transversely polarized sound also spin would be involved. Cilia are involved also with hair cells acting as sensory receptors in the auditory system and vestibular system. In the case of hearing the receptor itself does not fire but induces a firing of the higher

level neuron. The temporal pattern of qualia mental images could define the pitch of the sound whereas the intensity would correspond to the number of flux tube connections generated.

The modulation of Josephson frequencies -rather than Josephson frequencies as such- would code for the pitch and the total intensity of the Josephson radiation for the intensity of the sound and in fact any quale. Pitch represents non-local information and the qualia subselves should be negentropically entangled in time direction. If not, the experience corresponds to a sequence of sound pulses with no well-defined pitch and responsible for the rhythmic aspects of music. Right brain sings-left brain talks metaphor would suggest that right and left brain have different kind of specializations already at the level of sensory receptors.

4. Somato-sensory system gives rise to tactile qualia like pain, touch, temperature, proprioception (body position). There are several kinds of receptors: nociceptors, mechanoreceptors, thermoreceptors, etc... Many of these qualia have also emotional coloring and it might be that the character of entanglement involved (negentropic/entropic defines the emotional color of the quale. If this is the case, one might consider a pure quale of touch as something analogous to hearing quale. One can argue that directionality is basic aspect of some of these qualia -say sense of touch- so that spin could be involved besides electroweak quantum numbers. The distribution of these qualia for the receptor neuron might distinguish between different tactile qualia.

6.7 Constraints on the fermionic realization of genetic code from the model for color qualia

The original model for DNA as topological quantum computer assigns to DNA nucleotides quarks at ends of flux tubes or quark pairs at the ends of wormhole flux tubes. This is only the realization that came first to my mind in TGD Universe where dark variants of quarks can define QCD like physics even in cellular length scales. One can actually imagine several realizations of the genetic code and the first realization is far from being the simplest one. It is enough to have four different particles or many-particle quantum states to build at least formally a map from A,T,C, G to four states. It is obvious that the number of possible formal realizations is limited only by the imagination of the theoretician. Additional conditions are required to fix the model.

6.7.1 Fermionic representation

Consider first the fermionic representations in the general case without specifying what fermions are.

1. The original proposal was that DNA nucleotides correspond to flux tubes with quark q and antiquark \bar{q} at the ends of the parallel flux sheets extremely near to each other. Second option relies on wormhole magnetic flux tubes in which case quark pair $q\bar{q}$ is at both ends. Quarks u, d and their antiquarks would code for A,T,C,G. The spin of quarks is not taken into account at all in this coding: why not restrict the consideration to single quark. The total quark charge at given end of flux tube pair vanishes and flux tube ends carry opposite quark charges.

The nice feature of this option is that one could understand the generation of color qualia in the model of sensory receptor in simple manner to be discussed below. Even if one accepts the arguments supporting the view that dark quarks in cell scale are natural outcome of the hierarchy of Planck constants, one could argue that the presence of both quarks and antiquarks does not conform with matter antimatter asymmetry (not that one can however identify the analog of matter antimatter asymmetry at DNA level).

2. Spin states for fermion pairs assigned with two parallel magnetic flux tubes with the magnetic field generated by spin provide much simpler representation for nucleotides. Similar fermion pair would reside at the second end of flux tube pair.
 - (a) It is essential that rotational symmetry is broken and reduces to rotational symmetry around the direction of flux tubes so that spin singlet and spin 0 state of triplet mix to form states for which each fermion is in spin eigenstate. The states must be antisymmetric under exchange of the protons and spin 1/0 states are antisymmetric/symmetric in spatial

degrees of freedom (wave functions located to the ends of flux tubes). The states with definite spin for given flux tube are mixtures of $s=1$ states with vanishing spin projection and $s=0$ state.

- (b) It is not quite clear whether one should treat fermion pairs as identical bosons with 3+1 spin states since in TGD framework one considers disjoint partonic 2-surfaces and the situation is not that of QFT in M^4 . This interpretation would require total symmetry of the states under permutations of bosonic states defined by the 3+1 spin states. Coding by spin requires that each nucleotide corresponds to a state with a well defined spin. In field theory language the state would be obtained by applying bosonic oscillator operators generating states of given spin localized to a given nucleotide position.
- (c) The classical correlate for the permutations of coordinates of fermions has interpretation as braiding for the flux tubes of the flux tube pair. In the similar manner the permutation of the flux tube pairs associated with nucleotides has interpretation as braiding of the 3-braids formed from flux tube pairs. Braiding therefore gives a representation of spin analogous to the well-known orientation entanglement relation invented by Dirac and providing geometric representation of spin 1/2 property.

6.7.2 Various options for the fermionic representation of A,T,C,G

Fermionic representations allows several options since fermion can be electron, u or d quark, or proton. Wormhole magnetic fields would not be needed in this case.

1. The problem of electron and proton options is that it does not allow realization of color qualia. There is also the well-known problem related to the stability of DNA caused by the phosphate charge of -2 units per nucleotide. Somehow this charge should be screened. In any case, the charge -2 should correspond to the electron pair at the DNA end of the flux tube for electron option. For proton option the charge would be screened completely. One could of course consider also the large \hbar color excitations of ordinary protons instead of quark at its nucleotide ends. This option would however require the modification of quark wave functions inside proton and this option will not be discussed here.
2. Quark option would give rise to both color and allow also to reduce the electronic charge of -2 units by 4/3 units to -2/3 units in the case of u quark pair. This would help to stabilize DNA. In the case of d quarks the charge would increase to -10/3 units and is not favored by stability argument. Flux tube pairs assigned to single nucleotide define diquarks with spin 1 or spin 0.
 - (a) Diquarks behave as identical bosons with 3+1 spin states and 3×3 color states. They form formally super-multiplet of $\mathcal{N} = 2$ SUSY. The states with well defined symmetry properties in spin degrees of freedom have such properties in spatial degrees of freedom. This means that one obtains a superposition of flux tube pairs with are either braided or unbraided. Triplet/singlet state is symmetric/antisymmetric and total asymmetry could be guaranteed by assuming symmetry/antisymmetry in spatial degrees of freedom and antisymmetry/symmetry in color degrees of freedom. This would give anti-triplet/6-plet in color degrees of freedom. Spatial symmetry would favor antitriplet and diquark would behave like antiquark with respect to color. Let us assume antitriplet state for definiteness.
 - (b) DNA codon corresponds to three-di-quark state. This state must be totally symmetric under the exchange of bosons. One can have total symmetry in both spatial and color degrees of freedom or total antisymmetry/symmetry in spatial and total antisymmetry/symmetry in color degrees of freedom. The first option gives 10-dimensional color multiplet and the second one color singlet. Braiding is maximal and symmetric/antisymmetric in these case. One can consider also mixed symmetries. In this case one has color octet which is antisymmetric with respect to the first nucleotide pair and symmetric with respect to first nucleotide pair and third nucleotide. The braiding of the first two nucleotides must be antisymmetric and the braiding of this pair with third nucleotide. The conclusion would be that color multiplets correspond to well defined braidings and one would therefore have directed connection with topological quantum computation. Color octet is especially interesting concerning the representation of color qualia.

The challenge of all these options (note that the representability of color selects quark option) is to find a good justification for why the assignment of A,T,C,G to quark states or spin states is unique dynamically. Stability argument is expected to help here.

6.7.3 Realization of color qualia for quark option

Consider now how one could understand the generation of qualia for quark option.

1. The generation of qualia involves interaction with external world giving rise to a sensory percept. In the case of visual colors it should correspond to a measurement of quark color and should give rise to eigenstages of color at the ends of flux tubes at DNA nucleotides for a nucleus or cell of photoreceptor. A modification of capacitor model is needed. Color polarization is still essential but now polarization in nucleus or cell scale is transformed in the generation of color quale to a polarization in longer length scale by the reconnection of flux tubes so that their ends attach to "external world". The nucleus/cell becomes color and state function reduction selects well defined quantum numbers. It is natural to assume that the entanglement in other degrees of freedom after color measurement is negentropic.
2. Does the "external world" corresponds to another cell or to the inner lipid layers of the cell membrane containing the nucleus. In the first case flux tubes would end to another cell. If the nuclei of receptor cells are integrate to a larger structure by magnetic flux sheets traversing through them one can also consider the possibility that the polarization in the scale of cell nucleus (recall that the nucleus has also double lipid layer) is transformed to a polarization in cell scale so that similar process in cell scale gives rise to qualia.

The entire receptor unit must have net color charge before the state function reduction. This requires that there are flux tubes connecting the receptor unit to a unit representing "external world and having vanishing color charge. If second cell is the "external world" these flux tubes must go through the pair of lipid layers of both cell membrane and end up to the nucleus of cell in the environment. If external world correspond to the complement of nucleus inside cell the inner layers of cell membrane represents external world. Cell membrane indeed serves as sensory receptor in cell length scale. One can of course have sensory qualia in various length scales so that both options are probably correct and a kind of fractal hierarchy is very natural giving rise also to our qualia at some higher level. Living matter as conscious hologram metaphor suggests a fractal hierarchy of qualia.

After state function reduction reducing the entanglement the flux tubes split and the receptor becomes un-entangled with external world and has vanishing color charges. At the level of conscious experience this means that there can be only memory about the quale experience. The sensation of quale lasts with respect to subjective time as long as the negentropic entanglement prevails. There is an obvious analogy with Orch OR proposal of Hameroff and Penrose in which also conscious experience ends with state function reduction.

3. Consider now how the color qualia are generated.
 - (a) There must be two flux tube states. In the first state there are two flux tube beginning from cell nucleus A and ending to the inner lipid layer a_1 and flux tube beginning from the outer lipid layer a_2 and ending cell nucleus B. Both flux tubes have vanishing net color so that cells have vanishing net colors. This could be regarded as the resting state of the receptor. The lipids in layers a_1 and a_2 are connected by another short flux tube. Same for b_1 and b_2 .
 - (b) The second flux tube state corresponds to long flux tubes connecting the nuclei of cells A and B. The ends carry opposite color charges. In this case the net color of both A and B is non-vanishing. This state would be an outcome of a reconnection process in which the flux tubes from A to a_1 and B to a_2 re-connect with the short flux tube connecting lipid layers a_1 and a_2 .
 - (c) When these flux tubes carry opposite colors numbers at their ends, the cell possess net color charge and can represent color quale. Or rather, creation of this kind of flux tube connections would give rise to the color charging of the receptor cell with external world carrying opposite color charge.

One can argue that this mechanism is not quite in spirit with color capacitor model. Polarization is still essential but now polarization in receptor scale is transformed to polarization in longer length scale by the reconnection of flux tubes. The analog of di-electric breakdown however still applies in the sense that its analog induces large polarization. Several mechanisms generating larger polarization are of course possible. One can ask how essential the electromagnetic polarization of cell membrane is for the generation of qualia at cell level. Note also that biomolecules are quite generally polar molecules.

The unexpected prediction of the model is that braiding would correlate directly with qualia. This would mean also a connection between quantum computation and qualia. This condition emerges from Fermi/Bose-Einstein statistics correlating braiding with symmetric properties of color states and spin states. Quite generally, the correlation of braiding with the symmetries of wave functions as functions of points of braid end points would allow to have direct geometric correlate between induced entanglement and braiding as naive intuitive expectations have suggested.

This model is not consistent with the naive expectation that the quale is generated after state function reduction. Rather, the beginning of sensation of quale means beginning of negentropic entanglement and fusion with external world and state function usually associated with the quantum measurement would mean the end of the sensation and separation from the external world! Maybe one can say that state function reduction means that experience is replaced with a memory "I had the sensation of quale"! Krishnamurti would certainly agree!

6.8 The roles of Josephson radiation, cyclotron radiation, and of magnetic body

Before representing any detailed model for hearing, it is good to summarize the vision about the roles of Josephson radiation, cyclotron radiation, and of magnetic body on basis of the proposed general view about qualia and sensory receptors.

6.8.1 The role of Josephson currents

The general vision is that Josephson currents of various ions generate Josephson photons having dual interpretations as bio-photons and EEG photons. Josephson photons can in principle regenerate the quale in the neurons of the sensory pathway. In the case of motor pathways the function would be different and the transfer of metabolic energy by quantum credit card mechanism using phase conjugate photons is suggested by the observation that basic metabolic quanta 2 eV *resp.* 4 eV are associated with smooth muscle cells *resp.* skeletal muscle cells.

As already found in the previous section, the energies of Josephson photons associated with the biologically important ions are in general in visible or UV range except when resting potential has the value of -40 mV which it has for photoreceptors. In this case also IR photons are present. Also the turning point value of membrane potential is +40 mV so that one expects the emission of IR photons.

Josephson photons could be used to communicate the qualia to the magnetic body.

1. If Josephson currents are present during the entire action potential, the entire range of Josephson photons down to frequencies of order 2 kHz range is emitted for the standard value of \hbar . The reason is that lower frequencies corresponds to cycles longer than the duration of the action potential. The continuum of Josephson frequencies during nerve pulse makes it possible to induce cyclotron transitions at the magnetic body of neuron or large structure. This would make possible to communicate information about spatial and temporal behavior of the nerve pulse pattern to the magnetic body and build by quantum entanglement a sensory map.
2. The frequencies below 2 kHz could be communicated as nerve pulse patterns. When the pulse rate is above $f = 28.57$ Hz the sequence of pulses is experienced as a continuous sound with pitch f . f defines the minimum frequency for which nerve pulses could represent the pitch and there remains a 9 Hz long range to be covered by some other communication method.
3. The cyclotron frequencies of quarks and possibly also of electron would make possible a selective reception of the frequencies emitted during nerve pulse. Same applies also to the Josephson frequencies of hair cell (, which does not fire). If the value of Planck constant is large this makes possible to communicate the entire range of audible frequencies to the magnetic body.

Frequency would be coded by the magnetic field strength of the flux tube. Two options are available corresponding to the standard ground state for which Z^0 field is very weak and to almost vacuum extremals. For the first option one as ordinary cyclotron frequencies. The cyclotron frequency scales for them differ by a factor

$$r(q) = \frac{Q_{eff}(q)}{Q_{em}(q)} = \frac{\epsilon(q)}{2pQ_{em}(q)} + 1, \quad \epsilon(u) = -1, \quad \epsilon(d) = 1$$

from the standard one. For $p = .0295$ one obtains $(r(u), r(d), r(e)) = (24.42, 49.85, 15.95)$. The cyclotron frequencies for quarks and electron with masses $m(u)=2$ MeV, $m(d)=5$ MeV, and $m(e)=.5$ MeV are given the table below for the two options. If one assumes that B_{end} defines the upper bound for field strength then the standard option would require both d quark and electron. For d quark with kHz CD the upper bound for cyclotron frequencies would be 20 kHz which corresponds to the upper limit of audible frequencies.

fermion	$f_c(e)/MHz$	$f_c(u)/MHz$	$f_c(d)/MHz$
standard	.564	.094	.019
nearly vacuum extremal	8.996	2.275	.947

Table 4. Cyclotron frequencies of quarks and electron in magnetic field $B_{end} = .2$ Gauss for standard vacuum with very small Z^0 field and nearly vacuum extremal.

- Besides cyclotron frequencies also the harmonics of the fundamental frequencies assignable to quark and electron CD s could be used and in case of musical sounds this looks a highly attractive option. In this case it is now however possible to select single harmonics as in the case of cyclotron transitions so that only the rate of nerve pulses can communicate single frequency. Lorentz transform sub- CD scales up the frequency scale from the secondary p-adic time scale coming as octave of 10 Hz frequency. Also the scaling of \hbar scales this frequency scale.

6.8.2 What is the role of the magnetic body?

The basic vision is that magnetic body receives sensory data from the biological body- basically from cell membranes and possibly via genome - and controls biological body via genome. This leaves a huge amount of details open and the almost impossible challenge of theoretician is to guess the correct realization practically without any experimental input. The following considerations try to clarify what is involved.

Is magnetic body really needed?

Libet's findings and the model of memory based on time mirror hypothesis suggests that magnetic body is indeed needed. What is the real function of magnetic body? Is it just a sensory canvas? The previous considerations suggest that it is also the seat of geometric qualia, in particular the pitch of sound should be coded by it. It would be relatively easy to understand magnetic body as a relatively passive sensory perceiver defining sensory map. If one assumes that motor action is like time reversed sensory perception then sensory and motor pathways would be just sensory pathways proceeding in opposite time directions from receptors to the various layers of the magnetic body. Brain would perform the information processing.

Certainly there must exist a region in which the motor and sensory parts of the magnetic body interact. What comes in mind is that these space-time sheets (or actually pairs of space-time sheets) are parallel and generate wormhole contacts between them. This interaction would be assignable to the region of the magnetic body could receive positive energy signals from associative sensory areas and send negative energy signals to motor neurons at the ends of motor pathways wherefrom they would propagate to premotor cortex, supplementary motor cortex and to frontal lobes where the abstract plans about motor actions are generated.

Is motor action time reversal of sensory perception in zero energy ontology?

One could argue that the free will aspect of motor actions does not conform with the interpretation as sensory perception in reversed direction of time. On the other hand, also percepts are selected -say in binocular rivalry [J46] . Only single alternative percept need to be realized in a given branch of the multiverse. This makes possible metabolic economy: for instance, the synchronous firing at kHz frequency serving as a correlate for the conscious percept requires a lot of energy since dark photons at kHz frequency have energies above thermal threshold. Similar selection of percepts could occur also at the level of sensory receptors but quantum statistical determinism would guarantee reliable perception. The passivity of sensory perception and activity of motor activity would reflect the breaking of the arrow of time if this interpretation is correct.

What magnetic body looks like?

What magnetic body looks like has been a question that I have intentionally avoided as a question making sense only when more general questions have been answered. This question seems how unavoidable now. Some of the related questions are following. The magnetic flux lines along various parts of magnetic body must close: how does this happen? Magnetic body must have parts of size at least that defined by EEG wavelengths: how do these parts form closed structures? How the magnetic bodies assignable to biomolecules relate to the Earth sized parts of the magnetic body? How the personal magnetic body relates to the magnetic body of Earth?

1. The vision about genome as the brain of cell would suggest that active and passive DNA strands are analogous to motor and sensor areas of brain. This would suggest that sensory data should be communicated from the cell membrane along the passive DNA strand. The simplest hypothesis is that there is a pair of flux sheet going through the DNA strands. The flux sheet through the passive strand would be specialized to communicate sensory information to the magnetic body and the flux sheet through the active strand would generate motor action as DNA expression with transcription of RNA defining only one particular aspect of gene expression. Topological quantum computation assignable to introns and also electromagnetic gene expression would be possible.
2. The model for sensory receptor in terms of Josephson radiation suggests however that flux tubes assignable to axonal membranes carry Josephson radiation. Maybe the flux tube structures assigned to DNA define the magnetic analog of motor areas and flux tubes assigned with the axons that of sensory areas.
3. A complex structure of flux tubes and sheets is suggestive at the cellular level. The flux tubes assignable to the axons would be parallel to the sensory and motor pathways. Also microtubules would be accompanied by magnetic flux tubes. DNA as topological quantum computer model assumes and the proposed model of sensory perception and cell membrane level suggests transversal flux tubes between lipids and nucleotides. The general vision about DNA as brain of cell suggest flux sheets through DNA strands.

During sensory perception of cell and nerve pulse the wormhole flux tube connecting the passive DNA strand of the first cell to the inner lipid layer would recombine with the flux tube connecting outer lipid layer to some other cell to form single flux tube connecting two cells. In the case of sensory organs these other cells would be naturally other sensory receptors. This would give rise to a dynamical network of flux tubes and sheets and axonal sequences of genomes would be like lines of text at the page of book. This structure could have a fractal generalization and would give rise to an integration of genome to super-genome at the level of organelles, organs and organism and even hypergenome at the level of population. This would make possible a coherent gene expression.

4. This vision gives some idea about magnetic body in the scale of cell but does not say much about it in longer scales. The *CDs* of electrons and quarks could provide insights about the size scale for the most relevant parts of the magnetic body. Certainly the flux tubes should close even when they have the length scale defined by the size of Earth.

Additional ideas about the structure follow if one assumes that magnetic body acts a sensory canvas and that motor action can be regarded as time reversed sensory perception.

1. If the external world is represented at part of the magnetic body which is stationary, the rotation of head or body would not affect the sensory representation. This part of the magnetic body would be obviously analogous to the outer magnetosphere, which does not rotate with Earth.
2. The part of the magnetic body at which the sensory data about body (posture, head orientations and position, positions of body parts) is represented, should be fixed to body and change its orientation with it so that bodily motions would be represented as motions of the magnetic , which would be therefore analogous to the inner magnetosphere of rotating Earth.
3. The outer part of the personal magnetic body is fixed to the inner magnetosphere, which defines the reference frame. The outer part might be even identifiable as the inner magnetosphere receiving sensory input from the biosphere. This magnetic super-organism would have various life forms as its sensory receptors and muscle neurons. This would give quantitative ideas about cyclotron frequencies involved. The wavelengths assignable to the frequencies above 10 Hz would correspond to the size scale of the inner magnetosphere and those below to the outer magnetosphere. During sleep only the EEG communications with outer magnetic body would remain intact.
4. Flux quantization for large value of \hbar poses an additional constraint on the model.
 - (a) If Josephson photons are transformed to a bunch of ordinary small \hbar photons magnetic flux tubes can correspond to the ordinary value of Planck constant. If one assumes the quantization of the magnetic flux in the form

$$\int BdA = n\hbar$$

used in super-conductivity, the radius of the flux tube must increase as $\sqrt{\hbar}$ and if the Josephson frequency is reduced to the sound frequency, the value of \hbar codes for the sound frequency. This leads to problems since the transversal thickness of flux tubes becomes too large. This does not however mean that the condition might not make sense: for instance, in the case of flux sheets going through DNA strands the condition might apply.

- (b) The quantization of magnetic flux could be replaced by a more general condition

$$\oint (p - ZeA)dl = n\hbar , \quad (6.8.1)$$

where p represents momentum of particle of super-conducting phase at the boundary of flux tube. In this case also $n = 0$ is possible and poses no conditions on the thickness of the flux tube as a function of \hbar . This option looks reasonable since the charged particles at the boundary of flux tube would act as sources of the magnetic field.

- (c) Together with the Maxwell's equation giving $B = ZeNv$ in the case that there is only one kind of charge carrier this gives the expression

$$N = \frac{2m}{RZ^2e^2} \quad (6.8.2)$$

for the surface density N of charge carrier with charge Z . R denotes the radius of the flux tube. If several charge carriers are present one has $B = \sum_k N_k Z_k e v_k$, and the condition generalizes to

$$N_i = \frac{2m_i v_i}{RZ_i \sum_k Z_k v_k e^2} . \quad (6.8.3)$$

It seems that this condition is the most realistic one for the large \hbar flux sheets at which Josephson radiation induces cyclotron transitions.

What are the roles of Josephson and cyclotron photons?

The dual interpretation of Josephson radiation in terms of bio-photons and EEG photons seems to be very natural and also the role of Josephson radiation seems now relatively clear. The role of cyclotron radiation and its interaction with Josephson radiation are not so well understood.

1. At least cell membrane defines a Josephson junction (actually a collection of them idealizable as single junctions). DNA double strand could define a series of Josephson junctions possibly assignable with hydrogen bonds. This however requires that the strands carry some non-standard charge densities and currents- I do not know whether this possibility is excluded experimentally. Quarks and antiquarks assignable to the nucleotide and its conjugate have opposite charges at the two sheets of the wormhole flux tube connective nucleotide to a lipid. Hence one could consider the possibility that a connection generated between them by reconnection mechanism could create Josephson junction.
2. The model for the photoreceptors leads to the identification of biophotons as Josephson radiation and suggests that Josephson radiation propagates along flux tubes assignable to the cell membranes along sensory pathways up to sensory cortex and from there to motor cortex and back to the muscles and regenerates induced neuronal sensory experiences.
3. Josephson radiation could be used quite generally to communicate sensory data to/along the magnetic body: this would occur in the case of cell membrane magnetic body at least. The different resting voltages for various kinds of cells would select specific Josephson frequencies as communication channels.
4. If motor action indeed involves negative energy signals backwards in geometric time as Libet's findings suggest, then motor action would be very much like sensory perception in time reversed direction. The membrane resting potentials are different for various types of neurons and cells so that one could speak about pathways characterized by Josephson frequencies determined by the membrane potential. Each ion would have its own Josephson frequency characterizing the sensory or motor pathway.

The basic questions concern the function of cyclotron radiation and whether Josephson radiation induces resonantly cyclotron radiation or vice versa.

1. Cyclotron radiation would be naturally associated with the flux sheets and flux tubes. The simplest hypothesis is that at least the magnetic field $B_{end} = .2$ Gauss can be assigned with the some magnetic flux quanta at least. The model for hearing suggests that B_{end} is in this case quantized so that cyclotron frequencies provide a magnetic representation for audible frequencies. Flux quantization does not pose any conditions on the magnetic field strength if the above discussed general flux quantization condition involving charged currents at the boundary of the flux quantum are assumed. If these currents are not present, $1/\hbar$ scaling of B_{end} for flux tubes follows.
2. The assumption that cyclotron radiation is associated with the motor control via genome is not consistent with the vision that motor action is time reversed sensory perception. It would also create the unpleasant question about information processing of the magnetic body performed between the receipt of sensory data and motor action.
3. The notion of magnetic sensory canvas suggests a different picture. Josephson radiation induces resonant cyclotron transitions at the magnetic body and induces entanglement of the mental images in brain with the points of the magnetic body and in this manner creates sensory maps giving a third person perspective about the biological body. There would be two kind of sensory maps. Those assignable to the external world and those assignable to the body itself. The Josephson radiation would propagate along the flux tubes to the magnetic body.
4. There could be also flux tube connections to the outer magnetosphere of Earth. It would seem that these reconnections could be flux tubes traversing through inner magnetosphere to poles and from there to the outer magnetosphere. These could correspond to rather low cyclotron frequencies. Especially interesting structure in this respect is the magnetic flux sheet at the Equator.

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Part III

**WATER MEMORY AND
METABOLISM**

Chapter 7

Homeopathy in Many-Sheeted Space-time

7.1 Introduction

The considerations of this chapter are partly inspired by the talk of Cyril Smith in CASYS'2001 conference [I123] summarizing various empirical findings about the effects of electromagnetic fields at specific resonance frequencies on water and living matter. A second source of inspiration came from discussions with Lian Sidoroff and her article summarizing what is known about remote viewing and healing [J93] as well as from the very process of writing articles to the web journal founded by Lian Sidoroff. A third source of inspiration came from the evolution of ideas about dark matter hierarchy few years later [K26] .

7.1.1 Frequency imprinting and entrainment

The claimed mechanisms of homeopathic healing and the method of manufacturing homeopathic potencies are not the only paradoxical aspects of homeopathy. Also the reported frequency imprinting and entrainment, codes based on field patterns, and associative learning of water look mysterious in the framework of standard physics.

Frequency imprinting and entrainment at preferred frequencies serving as a visit card of a given molecule are believed to be fundamental for homeopathy and acupuncture. The results of Smith and Benveniste [I39, I69] provide strong constraints on the model of the magnetic homeostasis and on the general structure of the super-conducting part of the circuitry realized by using magnetic flux tubes as current carrying elements.

The data of [I123] suggests also that water builds representations for the chemicals it contains as space-time sheets containing water in liquid crystal form. These space-time sheets reproduce relevant part for the spectrum of rotational frequencies of the molecule in rigid rotor approximation. Also the mimicry of vibrational spectrum using sound waves is possible. Liquid crystal property of water blobs makes them ideal also for communications. More exotic, and in fact ideal mimicry would be based on dark super-nuclei of protons formed by closed string like structures of dark protons [K25] . Magnetic mirrors consisting of magnetic flux tube plus parallel MEs pop up naturally in the original model of frequency imprinting and entrainment. Magnetic mirrors and LC water blobs seem to provide the long sought for connection of exotic aspects of many-sheeted physics with bio-chemistry.

The basic objection against this scenario is that if the space-time sheets are in thermal equilibrium it partially fails in the case of fundamentally important rotational and conformational spectra which are in microwave region. Conformal and vibrational degrees of freedom would be thermalized and could not provide metabolic energy nor represent biological information.

A possible resolution of this problem relates to an important open problem concerning the understanding of dark matter hierarchy. The question is whether inherently dark atoms and molecules with thermally stable spectrum are possible or not. The simplest model predicts that atomic energy spectrum scales as $1/\hbar^2$ so that dark atomic energies would be below thermal threshold and not significant for the functioning of living systems.

TGD however suggests that also inherently dark atoms identifiable as anyonic counterparts of ordinary atoms are possible. They would have essentially the same energy spectrum as ordinary atoms, and the notion of atom and molecule generalizes to what might be called N -atom/molecule having energy spectrum scaled up by a factor $1 \leq N \leq r$. In this case various vibrational and rotational frequencies would define a hierarchy of dark energies which can be above thermal threshold. In particular, rotational and conformational microwave spectra of bio-molecules have dark counterparts with energies above thermal threshold. Otherwise only cyclotron energies and plasma oscillation energies can be above thermal threshold at sufficiently high levels of dark matter hierarchy.

7.1.2 Scaling laws

Homeopathy seems to involve two kinds of scaling laws. What I call scaling law of homeopathy states that homeopathic frequencies appear in pairs (f_h, f_l) of high and low frequencies such that their ratio is given by $f_h/f_l \simeq 2 \times 10^{11}$. TGD approach explains this ratio as ratio of zero point kinetic frequencies and cyclotron frequencies and predicts also a generalization of the law involving large number of this kind ratios.

$v = Lf_l$ scaling law is also discussed by Smith [I123] and tells in TGD framework how the frequencies associated with generalized EEG code for the velocities of physiological waves and their frequencies $f_h = cf_l/v$. The general model for motor control by magnetic body allows to understand the origin of this scaling law.

A much deeper explanation for the scaling law of homeopathy is based on the quantization of Planck constant. Number theoretical arguments suggest a general formula for the allowed values of r [K29] as $r = n$ where n characterizes the quantum phase $q = \exp(i\pi/n)$ characterizing Jones inclusion [K92]. The values of n for which quantum phase is expressible using only iterated square root operation are number theoretically preferred and correspond to integers n expressible as $n = 2^k \prod_n F_{s_n}$, where $F_s = 2^{2^s} + 1$ is Fermat prime and each of them can appear only once. The lowest Fermat primes are $F_0 = 3, F_1 = 5, F_2 = 17, F_3 = 257, F_4 = 2^{16} + 1$. The prediction is that also n -multiples of p -adic length scales are possible as preferred length scales.

The scaling factor 2×10^{11} corresponds with 1.5 per cent accuracy to the integer $n_F = 2^{36} \times 3 \simeq 2.03 \times 10^{11}$ defining a Fermat polygon. This suggests an interpretation in terms of a decay of dark photon with a given wave-length to a bundle of n_F ordinary photons with the same wavelength. The energy of the dark photon would be by a factor n_F higher. This process could serve as an effective tool of bio-control. Dark photon could also transform to an ordinary photon with wavelength shorter by factor $1/n_F$.

Quite generally, integers n_F defining Fermat polygons are a reasonable guess for the generalization of the scaling law of homeopathy and the search for these scaling factors could provide an experimental means of identifying the values of Planck constant relevant for living matter.

The time units of everyday life could reflect the properties of the dark matter hierarchy responsible for the control of living matter, in particular those of the sub-hierarchy defined by Fermat polygons. Indeed, one year corresponds to $n_F = 4 \times 3$ months, one month to $n_F = 2 \times 3 \times 5$ days, one day to $n_F = 8 \times 3$ hours, one hour to $n_F = 60 = 4 \times 3 \times 5$ minutes, and one minute to $n_F = 60$ seconds.

TGD inspired quantum biology and number theoretical considerations suggest preferred values for $r = \hbar/\hbar_0$. p -Adic length scale hypothesis favors powers of two as values of r . Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1 + i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241, \dots\}$ are expected to be physically highly interesting and up to $k = 127$ indeed correspond to elementary particles. The number theoretical miracle is that all the four p -adic length scales with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm). The question has been whether these define scaled up copies of electro-weak and QCD type physics with ordinary value of \hbar . The proposal that this is the case and that these physics are in a well-defined sense induced by the dark scaled up variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$. This proposal will be referred to as Mersenne hypothesis.

7.1.3 A model for homeopathy

The model of homeopathy must explain the effectiveness of homeopathic remedies manufactured by a repeated dilution and succussion of a solution containing the molecules causing the symptoms of the

disease. This can be understood if part of the chemical involved is transformed to dark phase and is also mimicked by water clusters or dark super-nuclei formed from protons. The minimal representation involves cyclotron frequencies such that corresponding dark cyclotron energy is thermally stable. If inherently dark atoms and molecules with essentially same energy spectrum as ordinary ones are possible, also the mimicry using dark vibrational and rotational spectrum is possible by clusters of dark water molecules.

One must also understand why homeopathic remedies are manufactured from molecules which basically cause the symptoms to be cured. The explanation is that the presence of molecules mimicking the poisonous molecule makes it possible to sweep the poisonous molecules "under the rug" if they enter the organism. In the presence of Bose-Einstein condensates of dark photons generated by the mimicking particles, the poisonous molecules drop to dark space-time sheets where they are harmless: the mechanism is a generalization of induced emission.

Homeopathy does not reduce to mere frequency imprinting and entrainment. There is evidence that the modulation patterns of carrier frequencies are also involved and define what might be called field codes [I68, I69, I123]. There is also evidence that water can learn associatively.

The presence of a hierarchy of dark matter levels leads to a model for how magnetic body performs motor control in terms of dark plasmoids and their quantal plasma oscillation patterns and receives sensory input from the biological body and experiences it as a kind of somatosensory representation along the entire magnetic body (actually hierarchy of them). The learning and memory of water can be assigned to the magnetic bodies at various levels of the dark matter hierarchy rather than water as such. Context sensitive field codes emerge very naturally as codes involved with all bio-control which as a special case activate gene expression.

The charge entanglement by W MEs is an essentially new element in the model for generalized motor actions by magnetic body. Also the telepathic sharing of mental images could rely on charge entanglement. The notion was originally applied in the model of nerve pulse generation [K62]. Neutral MEs would in turn be related to communications and memory. The reduction of charge entanglement can induce a quantum jump to a state in which local Bose-Einstein condensates become exotically ionized with certain probability depending on the intensity of W field. Bose-Einstein condensates define pixels of generalized motor maps.

Exotic ionization induces dark Plasma oscillations in turn generating various physiological responses such as Ca^{++} , Mg^{++} waves, and nerve pulse patterns giving rise to the motor action as an asymptotic self-organization pattern. Plasma oscillation patterns utilize typically dark microwave photons as metabolic energy. Field code is the correspondence between the spatio-temporal pattern of plasma oscillations and generalized motor action and the number theoretical model for genetic code [K22] generalizes to this context.

7.1.4 Some applications

The model of the magnetic body and the mechanism of motor control based on plasma oscillations of plasmoids can be tested by finding whether it allows to understand various enigmatic findings. Priore's machine which is a device demonstrated to induce a cure of cancer by somehow stimulating the immune system defines one such application [I107]. The findings of Sue Benford about intentionally produced tracks and dots in nuclear emulsions [I55], and microwave hearing [I95] and closely related taos hum [I125] define further applications.

The mysteries revolving around genetic code are especially fascinating challenges for the model since the control of gene expression is one of the most important actions of magnetic body. For instance, there is experimental evidence that electromagnetic stimulation can be used to transfer genetic information between organisms belonging to different species [J10]. The idea about genes responsible for genetic self engineering and responding to field patterns to which information about foreign genes is imprinted pops up naturally in dark matter inspired vision inspiring also the notions of super gene and hyper gene [K26].

The general model for the magnetic body allows also to sharpen the model of remote mental interactions [J93]. These effects would be only a scaled-up exogenous versions of the effects appearing endogenously in cellular length scales and also in astrophysical length scales in communications between magnetic bodies and corresponding biological bodies. In TGD framework the problem is actually not to explain why and how remote mental interactions are possible but why they are so rare and there is a natural explanation. The evolution of consciousness is basically individualization and

this requires that fields codes involved with the control of biological body by magnetic body must be personal so that outsiders do not have access to the biological body.

7.2 General view about homeostasis

For the benefit of the reader a general view about homeostasis a la TGD is first described before the construction of a model for homeopathy. First the general picture prior to the ideas about dark matter hierarchy is discussed and then the modifications implied by dark matter hierarchy are considered briefly.

7.2.1 Super-conducting part of the ionic flow circuitry

The observations described in [I123] provide important clues about the general structure of the super-conducting part of the ionic flow circuitry assumed to be realized as a fractal structure of magnetic flux tubes. The following scenario is consistent with the basic observations.

Magnetic circulation

Magnetic circulation is analogous to blood circulation and emerges during the development of the organism. Magnetic flux tubes form the super-conducting part of a many-sheeted ionic flow circuitry. Supra currents flow along magnetic flux tubes and are transformed to dissipating Ohmic currents when they flow to the atomic space-time sheets.

According to [I123] , the frequencies associated with the acupuncture meridian lines remain in a good accuracy invariant during the life cycle of the organism [I123] . If the ELF frequencies correspond to magnetic transition frequencies, they characterize the thicknesses of the magnetic flux tubes carrying the ions and at least part of the magnetic flux tube circuitry could be closely related with the acupuncture meridian lines. There are very many ions and the magnetic frequency scale varies by a factor of order 100 over the periodic table. Homeopathy demonstrates that also ELF frequencies below those associated with atomic ions are important and this leads to the conclusion that also the magnetic transitions for space-time sheets containing water in liquid crystal form contribute to the ELF spectrum. The work of Mae Wan-Ho suggests a close correlation of flux tube circuitry with collagen circuitry [I93] . The DC current circuitry discovered by Becker [J23] could correspond to the dissipative part of the circuitry.

According to [I123] , the endogenous frequencies vary only by ± 2 per cent. This would mean that endogenous magnetic flux tube thickness varies only by ± 1 per cent.

Frequency entrainment suggests magnetic homeostasis

Super-conducting magnetic flux tubes inside water and inside body body contain large number of ions, molecules, etc.. and there is large variety of magnetic transition frequencies which could be controlled by varying the magnetic flux tube thickness to stay in resonance with the exogenous frequency.

The phenomenon of frequency entrainment supports the notion of magnetic homeostasis. Endogenous frequencies indeed tend to follow the variation of an exogenous stimulating frequency initially sufficiently near to the endogenous frequency up to ± 30 per cent relative change after which they jump back to their endogenous values. The entrainment of the endogenous frequencies to external frequencies suggest that the thickness of the magnetic flux tubes in water and living matter is subject to a bio-control and that it makes sense to speak about magnetic homeostasis. The above data would mean that the thickness of the magnetic flux tube can change at most ± 15 per cent. The observed variation of the high-to-low frequency ratios along meridians deviation of ± 15 per cent. This would mean that the thicknesses of various magnetic flux tubes are with high accuracy scaled by a same factor in the endogenous magnetic homeostasis.

Self-organization by quantum jumps might automatically lead to the selection of preferred values of the magnetic flux tube thickness guaranteing entrainment in healthy organism. The precise mechanism inducing the variation of the magnetic flux tube thickness remains however unidentified at this moment. The return of the entrained frequencies to their endogenous values does not seem

to occur with the normal rate for electromagnetically hypersensitive persons [I123] : perhaps em hypersensitivity means that the mechanism controlling magnetic flux tube thickness does not function properly.

Why magnetic homeostasis?

There are good reasons why for the magnetic homeostasis.

1. Magnetic homeostasis with parallel MEs makes it possible for the system to entrain to the frequencies of various chemical transitions occurring in living matter. This would make possible endogenous spectroscopies allowing the organism to consciously (not necessarily at level of entire organism) detect various chemical concentrations by magnetic quantum phase transitions induced at these frequencies. Also the entrainment of neurons to external frequencies could rely on this mechanism.
2. Magnetic transitions could participate bio-control. 'Stimulation of chakras' would translate to resonant generation of magnetic phase transitions at super-conducting magnetic flux tubes. If magnetic transitions affect the structure and properties of the bio-molecules, this in turn can induce strong control effects at the atomic space-time sheets. For instance, if super-conducting enzyme molecule suffers a magnetic transition at super-conducting space-time sheet, its enzymatic properties could change dramatically. Magnetic transitions at resonance frequencies at super-conducting space-time sheets could induce protein conformations somehow. They do not directly affect net supra currents essential for ionic flow equilibrium. Spin flip could however induce change of the direction of the electric dipole moment and induce chirality changes, etc.. Conformations of enzymes could change and their catalytic properties could be affected dramatically.
3. Also non-magnetic transitions induced by MEs parallel to the magnetic flux tubes could occur coherently for BE condensates of atoms and even molecules at super-conducting space-time sheets and optimize the effectiveness of the bio-chemical control. A possible explanation for the necessity of the immune system is that quantum coherence of protein Bose-Einstein condensates is reduced if organism contains alien proteins with same function so that the rates for transformations of the protein (say enzyme) conformations at super-conducting space-time sheets are reduced.
4. Magnetic transitions for the space-time sheets containing water in liquid-crystal form and having size smaller than the transversal thickness of the magnetic flux tube have spectrum extending to $1/f = 1000$ years. This means that all biological rhythms relevant for life at the level of single organism could be coded to these structures. In particular, the representation of long term memories (not at the geometric now but at the moment of the actual event) might involve this kind of structures.

Are wormhole magnetic fields involved?

'Wormhole magnetic fields' are pairs of magnetic flux tube space-time sheets with vanishing net energy (in TGD framework space-time sheets with negative energy are possible because space-time is 4-surface rather than an abstract Riemann space) and carrying opposite magnetic fields. Wormhole contacts, whose throats carry opposite classical em charges, connect the two space-time sheets, and if they rotate, they generate opposite currents at the two space-time sheets involved in turn giving rise to magnetic fields of same magnitude but opposite sign. No elementary particles are required to generate these magnetic fields. Vacuum polarization effect is in question in a well defined sense.

At least the positive energy space-time sheet could contain supra phases of ions and an open question is whether super-conducting magnetic flux tube circuit consists of ordinary magnetic flux tubes only or whether it contains also parts which are wormhole magnetic fields. Wormhole magnetic fields could be regarded as a simulation of ordinary magnetic structures and homeopathy might involve also the generation of wormhole magnetic fields mimicking the magnetic structures associated with the homeopathic remedy. Wormhole magnetic fields might replicate and diffuse from homeopathic potency to body without any external energy feed and could be regarded as a life form of their own.

There is an obvious analogy between wormhole magnetic field and DNA double strand: similar analogy holds true for double -sheeted MEs which could also be present. Both double-sheeted MEs and wormhole magnetic fields would be structures carrying pure information.

7.2.2 How water represents?

The general model for how water can represent in its own dynamical structure the chemicals is inspired by various experimental findings (especially by the findings challenging the notions of ionic channels and pumps) is roughly the following.

1. The magnetic flux tube structure is fractal and thus contains flux tubes inside flux tubes and gives rise to what might be called magnetic circulation analogous to blood circulation. The magnetic field of Earth is important but not necessarily the only part of the structure. The thickness of the flux tube, and thus also magnetic transition frequency scale, is under bio-control. Also the length of flux tube is variable and under control.
2. MEs parallel to the magnetic flux tubes are also involved. The ends of magnetic flux tube could act effectively as laser mirrors and MEs would thus define zigzag path in space-time between the ends of the magnetic flux tube. Similar structures are involved with the model of long term memory and the structures in question could quite generally give rise to conscious memory in the time scale determined by the frequency involved. The characteristic frequencies associated with MEs are given by $f = c/L$, where L is the length of ME. There are thus *two branches* in the spectrum of important characteristic frequencies: magnetic transition frequencies in ELF range and the high frequency branch of the frequencies associated with MEs with lengths not above than the size of organism. For length scale of .1 meters the frequency scale of ME frequencies is of order GHz.
3. Positive/negative energy MEs could be even classical correlates for photon emission/absorption. Quite generally, MEs with typical length $L = c/f$ are presumably necessary for a complete TGD based description of atomic and molecular transitions at given transition frequency f . One can even consider the possibility that p-adic ME in presence of charged particle could transform to real ME and charged particle such that energy momentum conservation is satisfied. In this manner intention would be transformed to action at elementary particle level. One could also think that MEs at these frequencies could perform bio-control and also detect radiation emitted by various molecules.
4. Frequency imprinting and entrainment are generic phenomena. Both endogenous and exogenous frequencies can be entrained by varying the thickness and length of the magnetic flux tubes. This suggest that bio-system is performing kind of endogenous spectroscopy by detecting important bio-chemicals at magnetic flux tubes and even elsewhere. In ELF part of spectrum NMR or its generalizations to other than spin flip transitions would be involved. Also the sensing of important em frequencies as such could be performed routinely by bio-system in this manner. An interesting possibility is that also p-adic variants of MEs are involved so that this process could be seen as mimicry by singing in the same tune.
5. Weak magnetic fields affect the super currents running in the circuitry and this in turn affects dramatically the ionic concentrations at the atomic space-time sheets so that chemical control becomes possible. Magnetic transitions at super-conducting space-time sheets can affect the catalytic properties of enzymes and thus make possible more refined quantum level chemical control. Also *other* than magnetic transitions could occur coherently (rate proportional to number of ions squared) at super-conducting space-time sheets and even atomic space-time sheets and be induced by MEs at the high frequency portion of the spectrum. Perhaps the rates for the transitions inducing protein conformations affecting the catalytic properties of the protein could be optimized in this manner. The performance of this kind of bio-control at super-conducting space-time sheets would be like performing surgery inside a specialized hospital instead of doing it on the street.

The above considerations do not answer the question about the role of the atomic space-time sheets in the representations of frequencies provided by MEs and magnetic flux tubes. What this role might

be is suggested by the fact that the matter at the atomic space-time sheets should have the role of an amplifier of em fields associated with MEs.

1. The generation of space-time sheets containing water in liquid crystal form with a rotational frequency spectrum mimicking that of the homeopathic potency is a further aspect of this mimicry and could amplify the otherwise weak signal provided by chemical by amplifying the em fields associated with MEs. The water domain could be also seen as a mental image (sub-self) about the chemical at atomic space-time sheet. In principle all the rigid body aspects of the molecule can be mimicked in this manner. Mimicking water domains can also control the transitions of the bio-molecules or vice versa.
2. Not only rotational spectrum but also vibrational spectrum (such as conformal vibrations of molecules) can be mimicked since any system near equilibrium reduces to a collection of harmonic oscillators: now sound waves propagating in LC water blobs would provide the representation. It is known that the water in cell interior and near to the cell membrane transforms routinely between sol and gel (LC) states in response to various stimuli: this transformation would have interpretation as a formation of a conscious representation for something, perhaps some event or object outside the cell.
3. Note that by scaling law $f_h/f_l = 2 \times 10^{11}$, the characteristic neuronal frequency $f_l = 1$ kHz corresponds to $f_h = 2 \times 10^5$ GHz and to a ME with a length of 1.5 micro-meters, which roughly corresponds to the thickness of the magnetic flux tube. Thus kHz frequency is maximal if ME is required to extend outside the magnetic flux tube. Perhaps this ME could be involved with the sensory representations at the cell level. Note that an alternating voltage at kHz frequency is used also to generate Kirlian effect. For human vision the wave lengths of photons are in the range of $10^{-6} - 10^{-7}$ meters and corresponding ELF length scale is $10^4 - 10^5$ meters if scaling law is assumed.
4. The requirement that LC water blob has size not larger than about one micro-n implies that that the lowest ELF frequency corresponds to a time period of about $T = 1000$ years so that all time scales relevant for human consciousness are covered and MEs with frequencies relevant to human long term memories can be amplified by intracellular LC water space-time sheets. If the scaling law $f_h/f_{EEG} = 2 \times 10^{11}$ is taken literally, one obtains $f_h = 20$ Hz at the upper bound: this corresponds to the lowest audible frequency which suggests that also sound waves serve representative purposes.
5. Fractality suggests that LC water space-time sheets form in turn liquid crystals in larger length scale give rise to secondary representations and that there exists entire hierarchy of these representations.

7.2.3 The role of micro-waves in homeostasis

Plasmoids (or plasmoids) consisting of closed magnetic flux tube structures carrying supra currents plus atomic space-time sheets associated with them, are good candidates for primitive electromagnetic life-forms, in particular plasmoids identified as UFOs. It has been found that plasmoids indeed satisfy the basic definitions of a life form [I103]. Ordinary bio-matter is assumed to self-organize around these structures and nerve circuit represents a good example of a structure resulting in this manner.

Also the magnetic life forms need energy feed to self-organize and stay awake. The basic metabolic mechanism would be the same as in the case of living matter [K38]. Energetic super-conducting ions must be somehow driven from the magnetic flux tubes to the atomic space-time sheets, where they collide with atoms, ionize them, and generate visible light in the atomic transitions giving thus rise to the observed luminous phenomena interpreted as UFOs. The ions would eventually 'drop' back to super-conducting space-time sheet and liberate the zero point kinetic energy as a quantum of metabolic energy defining what is often referred to as a universal energy currency. Essentially identical energetic cycle of Karma would be realized also in living matter but involve a complex molecular organization and many-sheeted current circuitry responsible for the control of homeostasis. For the proton the quantum is predicted to be of order .5 eV liberated also when a single molecule of ATP is used.

The realization of this primitive metabolic cycle requires the breaking of super-conductivity: some mechanism must generate join along boundaries bonds serving as bridges connecting magnetic flux

tubes with atomic space-time sheets along their boundaries so that supra current leakage becomes possible. The gap energy of super-conductors, typically measured in 10^{-4} eV as a unit (corresponding to temperature of order Kelvin), would naturally correspond to the energy needed to build up this bond (note that the temperature at the magnetic flux tubes would be much lower). Interestingly enough, a gap energy would 10^{-5} eV corresponds to the frequency ~ 3 GHz. This suggests that micro-wave photons could induce these bridges, break super-conductivity, and induce energy feed and self-organization. A similar breaking of super-conductivity might be also involved with the driving of the super-conducting ions to the atomic space-time sheets in the living matter. Proteins could generate the needed micro-wave photons by coherently occurring conformational transitions. Also rotational transitions of clusters of water molecules could emit micro-waves and perhaps mimic and amplify the micro-waves generated by proteins.

The clusters of water molecules forming liquid crystals can mimic the conformational and rotational spectrum of various molecules, and that the ability to reproduce the rotational frequency spectrum of the medicine molecule is an essential element of homeopathic healing. The level of self-organization of water would thus be measured by how complex mimicry it is able to perform. Why rotational micro-wave energy spectrum is so important for healing, could be understood as follows. The many-sheeted current circuitry, involving atomic space-time sheets and magnetic flux tubes and also other space-time sheets, is extremely complex control structure [K57, K58]. The continual regeneration of bridges between, say, atomic space-time sheets and magnetic flux tubes by micro-waves emitted by proteins is necessary to sustain this circuitry. An important category of diseases is due to the failure to generate the bridges between super-conducting and atomic space-time sheets so that this control circuitry suffers shortcuts. Perhaps the genetic expression of some proteins responsible for the micro-waves generating particular bridges fails.

The medicine or its homeopathic counterpart would help to generate (or even re-establish the generation of) the micro-wave spectrum responsible for the generation of the lacking bridges in the circuitry. A further piece to the puzzle comes from the scaling law of homeopathy. The law states that high and low frequencies accompany each other, the frequency ratio being $f_{high}/f_{low} \simeq 2 \times 10^{11}$ in the simplest situation (the ratio can actually vary). The TGD based interpretation is that ELF MEs are responsible for quantum entanglement in macroscopic, even astrophysical, length scales. Micro-wave MEs propagating effectively as mass-less particles along ELF MEs in turn induce self-organization by serving effectively as 'food' of the plasmoidic life forms at the receiving end. This mechanism is behind both the endo- and exogenous realizations of intentions as actions, that is ordinary motor actions and phenomena like remote healing and psychokinesis. Also sensory representations at the personal magnetic canvas and magnetosphere rely on this mechanism, and in this case life-forms are mental images getting at least partially their metabolic energy from brain.

7.2.4 How the vision about dark matter hierarchy affects the picture?

The picture discussed in previous subsections is essentially that before the ideas about dark matter hierarchy emerged. The basic implication of the dark matter hierarchy is that there is no need to assume that temperatures at different space-time sheets are widely different since the scaling of \hbar can scale up the energies above thermal threshold. The simplest model of dark hydrogen atom however predicts that the energies of the hydrogen atom are scaled down by $1/r^2$, $r = \hbar/\hbar_0$, which means that inherently dark atoms and molecules would not be thermally stable at room temperatures.

In topological condensation of ordinary atoms and molecules at dark space-time sheets cyclotron energies and plasma oscillation energies are scaled up and can be above thermal threshold. This leads to a very restrictive model. For instance, the conformal and rotational spectra of bio-molecules correspond to microwave frequencies and would be below thermal threshold and thus of no importance. This would also reduce the importance of liquid crystals known to be of crucial importance for the functioning of living matter. There is also a feeling that the role of fermionic bio-ions such as Na^+ , K^+ , and Cl^- should be more important than this picture allows.

One can however consider a modification of the notion of dark atom in which the dark energy spectra are essentially same as the ordinary ones. This would mean that the original vision about water blobs as being able to mimic molecules using their rotational and vibrational spectra is modified only by replacing these structures with their dark variants. Of course, at this stage only experiment can decide whether atoms and molecules can be inherently dark. In the following the two models of dark atom are discussed to give an overall view about what is involved.

An alternative model for inherently dark atoms

The attempts to understand dark matter hierarchy led to an alternative model of dark atoms in which the energy spectra of dark atoms and molecules are nearly the same as their ordinary counterparts.

1. The original model for dark atoms relies on the scaling of Planck constant by $r = 2^{k_d}$ at the k_d^{th} level of the dark matter hierarchy. In the case of hydrogen atom the model predicts that the energies of hydrogen atom proportional to $1/r^2$ so that dark atoms would not be thermally stable at room temperature. In practice this would exclude dark atoms and molecules as biologically interesting inherently dark systems. The topological condensation of ordinary atoms and molecules at r -sheeted (now in the sense of "Riemann surfaces" over M^4) dark magnetic flux quanta is however possible and means scaling up of the cyclotron energy by r making possible cyclotron Bose-Einstein condensates at high temperatures identifiable as dark quantum plasmas. The same scaling occurs to the energy of dark plasma oscillations so that their energies can be above thermal threshold. Dark plasmoids and plasma oscillations are indeed fundamental in the TGD based model of quantum control in living matter.
2. One must be however very cautious in drawing conclusions since the model for the dark matter is not precise enough to exclude the possibility that the notion of dark atom and molecules makes also sense. For instance, dark atoms having ordinary size and ordinary energy spectrum could be possible if the principal quantum number n is fractionized to $n \rightarrow n/r$. The fractionization could make sense if the atomic space-time sheet is r -folded and atoms become radial anyons. The corresponding Bohr orbits would close in the radial direction only after r turns. The formation of dark atoms could be interpreted as a transition to chaos by period r -folding in radial and angular degrees of freedom. This option would differ from the first one in that radial scaling in M^4 by a factor r^2 is replaced by a radial r -folding so that the M^4 projection of dark atom has the same size as in the case of ordinary atom.

This picture is favored by the requirement that four-momenta and angular momenta remain invariant in the transition to the dark matter phase but does not conform with the first model of dark atoms which assumes that n is integer. This model was formulated before the realization of the r -fold Riemann surface like structure of dark space-time sheets following from the conservation of angular momentum.

3. Since dark atom would define a r -fold covering of M^4 , one expects a degeneracy of states corresponding to the phase factors $\exp(ikn2\pi/r)$, $k = 0, \dots, r - 1$, where n labels the sheets of the r -fold covering of M^4 . The nuclei and electrons of $N \leq r$ dark atom could form many-particle states separately and fermionic statistics becomes effectively para-statistics for the resulting N -atoms. Note that the N electrons and nuclei would be in identical states in ordinary sense of the word since Bohr orbits must be identical: kind of fermionic Bose-Einstein condensates become thus possible.
4. The quantum transitions of N -atoms for $N = r$ would give rise to dark counterparts of the photons emitted in the ordinary atomic transitions. For $N \leq r$ the energies of dark photons would be N times higher than the energies liberated in the ordinary transitions. The claims of Mills [D17] about the scaling up of the binding energy of the hydrogen ground state by a square k^2 of an integer in plasma state might be understood as being due to the formation of dark $N = k^2$ -atoms emitting dark photons with k^2 -fold energies de-cohering to ordinary photons. The plasma phase would contain a fraction which is in dark plasma state. The chemistry of bio-molecules identified as N -molecules would definitely differ from the ordinary chemistry.

The fractionization $n \rightarrow n/r$ of integer n labelling vibrational modes and cyclotron states would be unavoidable. Single particle cyclotron states having $E = \hbar(k)\omega$ of the earlier picture would in this framework correspond to single particle states having $n = r$ or to $N = r$ -ion states. Fermionic $N = r$ -states are expected to have a special role since these configurations are analogous noble gas atoms with full shells of electrons and to magic nuclei with full cells of nucleons. Most biologically important ions are fermions and $N = r$ states would give rise to what might be regarded as fermionic analogs of Bose-Einstein condensates. For bosonic ions there is no restriction to the occupation numbers of r single particle states involved.

5. The phase $q = \exp(i2\pi/r)$ brings unavoidably in mind the phases defining quantum groups and playing also a key role in the model of topological quantum computation [K91]. Quantum groups indeed emerge from the spinor structure in the "world of classical worlds" realized as the space of 3-surfaces in $M^4 \times CP_2$ and being closely related to von Neumann algebras known as hyper-finite factors of type II₁ [K92]. Unfortunately, the integer n characterizing the phase cannot be identified as r . Could it be that quantum groups emerge in two different manners in TGD framework?

If so, living matter could perhaps be understood in terms of quantum deformations of the ordinary matter, which would be characterized by the quantum phases $q = \exp(i2\pi/r)$. Hence quantum groups, which have for long time suspected to have significance in elementary particle physics, might explain the mystery of living matter and predict an entire hierarchy of new forms of matter.

Are both options for dark matter realized?

For $N = r$ molecules which dark photons emitted in the rotational and conformational transitions would be above thermal threshold. It is of course quite possible that both options are realized. The fact that also fermionic ions (such as Na^+ , K^+ , Cl^-) are important for living system suggests that this is the case. This would also provide a justification for the hypothesis that microtubular conformations represent bits and allow conformational dynamics to serve as metabolic controller by providing microwave dark photons with energies above thermal threshold.

As demonstrated in [K43], the notion of N -particle leads to an amazingly elegant model for the lock and key mechanism of bio-catalysis as well as the understanding of the DNA replication based on the spontaneous decay and completion of fermionic $N < r$ -particles to r -particles. Optimal candidates for the N -particles are N -hydrogen atoms associated with bio-molecules appearing as letters in the "pieces of text" labelling the molecules. Lock and key would correspond to conjugate names in the sense that N_1 and N_2 for the letters in the name and its conjugate satisfy $N_1 + N_2 = r$: as the molecules combine, a full fermion shell represented by r -fermion is formed.

7.3 TGD based model for homeopathy

Homeopathy is regarded by skeptics as a fringe science, kind of promised land of crackpots. My own views about homeopathy changed after I heard the excellent lecture of Cyril Smith in Liege about frequency imprinting and entrainment as mechanisms of homeopathy [I123]. After that I learned about the work of Benveniste [I68, I69] and encountered once again the pattern which I had encountered so many times before. When empirical discovery does not fit the dogmas of the reductionistic science, it is simply forgotten and the unlucky experimentalist is labeled as a swindler or crackpot.

7.3.1 Basic claims about homeopathy

The basic assumption of homeopathy is that the homeopathic remedy manufactured from the substance causing the illness also heals the illness. The preparation of the homeopathic remedy occurs by a repeated dilution so that for instance 1 part of homeopathic remedy already obtained is diluted in 99 parts of water. The dilution can be continued arbitrarily many times, say 30 times so that the ratio of substance to water is 10^{-60} : obviously no molecules of the original substance can be present anymore in the probabilistic sense if one accepts the standard view about space-time.

The notion of water memory [I68] crucial for the explanations of acupuncture and homeopathy has received a considerable empirical support quite recently [I39]. It seems that basic mechanisms of both homeopathy and acupuncture are frequency imprinting and entrainment. Somehow water learns the some fundamental frequencies characterizing the molecules of the homeopathic remedy during the manufacturing process and when it has learned these frequencies it acts as the desired healing effect. Even more: just this frequency imprinting of water without any need for the remedy could be enough to achieve the healing effect.

7.3.2 Frequency signatures for the homeopathic remedies and endogenous frequencies in acupuncture

The homeopathic remedies seem to be characterized by frequencies varying in the range containing at least the range $10^{-3} - 10^9$ Hz suggesting that electromagnetic fields at specific frequencies characterize the homeopathic remedy. These frequencies can be imprinted into water and also erased. The imprinting of frequencies is induced by the presence of the homeopathic potency or by irradiating pure water by using either the ELF or far infrared frequencies associated with the potency. Very importantly, the removal of Earth's magnetic field erases the imprinted frequencies [I123].

The frequencies appear as pairs (f_h, f_l) of high and low frequencies in the sense that the imprinting of f_h implies the imprinting of f_l and vice versa [I123]. The first branch is at GHz range: in particular the frequencies 2.664 GHz, 1.42 GHz (21 cm line of hydrogen) and 384 MHz have unexpected properties. The second branch of frequencies is in the ELF range, in particular Schumann frequency 7.8 Hz accompanies 384 MHz. The ratio of high and low frequencies is in good approximation constant and equal to $f_h/f_l = 2 \times 10^{11}$: this result gives strong constraint on possible models.

The studies of acupuncture support the existence of certain highly coherent endogenous frequencies [I123] associated with the acupuncture meridians at which em radiation has strong effects. Also these frequencies appear as pairs and the ratio $f_h/f_l \simeq 2 \times 10^{11}$ is constant over all acupuncture meridians with a deviation of ± 15 per cent. The fact that these frequencies can entrain to exogenous frequencies suggests a mechanism of homeopathy based on entrainment and mimicry. It would be the characteristic frequencies associated with the homeopathic potency molecule, which would help to achieve the healing effect rather than the chemical structure of the potency molecule.

Quite generally, frequency imprinting and entrainment could be a basic representational mechanism in living matter. The important chemicals present in living matter would be represented by their frequencies and water would construct representations. These representations can explain why bio-system can recognize also chemicals usually not present in organism (such as poisonous molecules).

7.3.3 What could be the mechanism behind the homeopathic healing

Both the claimed healing using the agent causing the disease and the manufacturing process seemingly removing every trace of the remedy are paradoxical enough to induce strongly emotional reactions in the average skeptic. The notions of many-sheeted space-time and dark matter hierarchy however suggest a rational explanation for these claims. Several mechanisms can be imagined and I have indeed done this before finding the most convincing option.

Bose-Einstein condensation of molecules of homeopathic remedy to magnetic flux tubes as a basic mechanism

The manufacturing of the homeopathic remedy could induce dropping of some fraction of the homeopathic remedy to magnetic flux tubes of the Earth's magnetic field. This assumption conforms with the crucial role of the Earth's magnetic field in the erasure of the imprinted frequencies. Also the importance of 7.8 Hz Schumann frequency [I123] can be understood.

If the molecules in question are bosons or if they combine with some other particles to form bosons in water environment, they can form Bose-Einstein condensates in cyclotron states. At $k_d = 40$ level of dark matter hierarchy they cyclotron energy scale would be above the thermal threshold for cyclotron frequencies above 1 Hz: the charge/mass ratio corresponds to that for DNA.

Could protonic super nuclei perform mimicry of ions?

One of the first discoveries in the process leading to the understanding of dark matter was the direct evidence for the fact that one fourth of protons of water is in dark phase [D10, D9, D13, D35] in time scale of attosecond (these protons are not visible using neutron diffraction or electron scattering). This phase could correspond to some level of dark matter hierarchy.

The simplest model for the dark phase [K27] is as "super nuclei" formed by closed protonic strings (for the analogous model of nuclei see [K76]) with nearby protons connected by color bonds with exotic dark quark and anti-quark at ends of the bond. These protonic strings can develop also exotic em charge when the quark and anti-quark at the ends of the bond are replaced by u and \bar{d} or d and \bar{u} .

Thus a protonic super-nucleus containing A protons with a proper exotic charge can mimic ion with mass number A and charge Z .

Dark protonic super-nuclei could perform mimicry of those characteristics of molecules which are crucial for the macroscopic quantum coherence. Frequency imprinting and entrainment would be based on the formation of protonic super-nuclei plus magnetic homeostasis allowing to vary the value of the magnetic field around the nominal value $B_E = .5$ Gauss in such a manner that entrainment is achieved for almost any ELF frequency.

Conservation of the magnetic flux implies that the variation of field strength corresponds to the variation of the thickness of the magnetic flux tube. Magnetic homeostasis could therefore be regarded also as a motor action of the magnetic body containing dark matter and to some extent behaving like an intelligent conscious system. The magnetic flux quanta assignable to the homeopathic potency would carry the information about the molecules of the homeopathic remedy. Also p-adic scaling of flux tube dimensions by scaling factor which is power of $\sqrt{2}$ can be considered.

Could also clusters of water molecules perform mimicry?

Dark protons are not the only option. The original proposal was that clusters of water molecules are ideal for mimicking cyclotron, rotational, and vibrational spectra of molecules. The recent view about dark matter suggests that the internal properties of particles are unaffected in the dropping to r -fold magnetic flux tubes so that only cyclotron energy spectrum is scaled by r and can be thermally stable. Hence water molecule clusters could also mimic molecules. Without magnetic homeostasis the accuracy of the mimicry would not be very impressive since mass number would be a multiple of 18. For heavy molecules the relative accuracy would be $\Delta f_c/f_c = 18/A$ and could be compensated by the control of magnetic field strength.

Homeopathic healing mechanism as sweeping of harmful molecules to magnetic flux quanta?

Also the homeopathic healing mechanism could be understood. Usually the immune system prevents the access of the harmful molecule or organism to the system by chemical means. Also in the homeopathic healing similar elimination mechanism would work but now magnetic body would perform the elimination. One can imagine several mechanisms. The harmful molecules could be simply dropped to the magnetic flux quanta. The dropping of these molecules would liberate zero point kinetic energy (which brings in mind the old saying "the disease that does not kill you, strengthens you!"), and if the process involves emission of photons with frequencies f_h and f_l , the rate of the process would be enhanced by the presence of the Bose-Einstein condensates of dark photons of frequency f_l emitted in cyclotron transitions by the standard mechanism of induced emission. It would not matter whether the Bose-Einstein condensate of ELF photons causing the induced dropping is generated by the molecules of homeopathic remedy or by the protonic super-nuclei mimicking them.

Stealing of the magnetic bodies of molecules

If magnetic bodies of harmful molecules are responsible for the harmful effects, then it would be enough to steal magnetic bodies of the harmful molecules and provide clusters of water molecules with them. The shaking of the water in the manufacturing of the homeopathic remedy would facilitate this process. This option allows to understand the fact that the presence of biomolecules can be mimicked by using suitable patterns of low frequencies identifiable as cyclotron frequencies. The domains of water with size scale of 10 nm proposed by Smith could be the thieves of the magnetic coats defining the biological role of the molecule. This option is definitely the most elegant and minimal one and seems to explain what is known about homeopathic action and water memory.

7.3.4 TGD counterparts for the propagation and diffusion of coherence

Cyril Smith [I123] assigns the endogenous frequency pairs (f_h, f_l) with the coherent domains of water with size of 75 nm interacting with external em fields as coherent units. The origin of the scaling law $f_h/f_l = 2 \times 10^{11}$ claimed by Smith has been discussed in previous section. These coherent domains are predicted by the theory of Giudice and Preparata [D21]. On basis of empirical data Smith associates

two kinds of dynamical phenomena to the coherence regions: diffusion of coherence with low velocity and propagation of coherence with light velocity.

On dimensional grounds one expects that for a coherent domain of size L dispersion relation for the low velocity excitations (not only diffusion of coherence) could be given by the scaling law $v \sim Lf$. According to Smith the observed diffusion velocities are of order few m/s $\sim m/s$ and of the same order of magnitude as nerve pulse conduction velocity and phase velocities for EEG waves. From this the size of coherent domains for the high frequency branch would be of the same order as that predicted for the coherence domains of water. For the low energy branch the size of the coherence domains would be of order .1 m.

The $v = K$ relationship proposed by Smith is of the same form as the scaling law discussed in the previous section and representing the coding of generalized EEGs to the velocities of physiological waves. In TGD framework the counterparts of these domains would be various linear structures, say space-time sheets formed by water in liquid crystal form. The propagation of coherence with light velocity would correspond to the propagation of the classical signal inside ME whereas the diffusion of coherence would basically correspond to the phase velocity assignable to ME in direction along the linear structure and fixed by the boundary condition so that it obeys the generalization of the scaling law from its original form $v = Lf_l$ to $v = Lf_l/n_h$. f_h would be given by $f_h = (c/v) \times f_l$.

7.3.5 Frequency imprinting and de-imprinting

In the following a more detailed comparison of TGD based model with the data discussed in [I123] is carried out. The effect of several methods allowing frequency imprinting and erasure could be understood if imprinting involves the variation of thickness of magnetic flux tubes carrying superconducting ions.

Some facts about imprinting

I learned the basic facts about frequency imprinting from Cyril Smith's excellent lecture in Liege.

1. Cyril Smith represents detailed empirical data about n-alkane imprinting. In this case ELF frequencies were in Hz range and the ratio of the high and low frequencies was roughly 2×10^{11} as also in other experiments. This is consistent with the assumption that cyclotron frequencies serve as a representation of of the molecule.
2. Smith has studied also frequency memory of bulk water (no potency present) in ELF frequency range .001 – .01 Hz. Bulk water showed resonances between 200 MGz and 2GHz with a mean frequency ratio of about 2×10^{11} as also in case of n-alkanes. If very low ELF frequencies correspond to magnetic transition frequencies in Earth's magnetic field, then the atomic numbers of the space-time sheets involved must be quite high: 10^{-3} Hz corresponds to $A = 3 \times 10^5$ and thermal stability of cyclotron energies requires at least $k_d = 53$ level of the dark matter hierarchy.
3. ELF frequency imprinting by frequency f_l was also found to induce splitting $f \rightarrow f \pm f_l$ of other inherent ELF frequencies associated with water. A similar splitting was observed in high energy branch. The explanation is that the resulting MEs interact with the MEs associated with these frequencies and induce amplitude modulation. Interaction could be due to MEs inside MEs mechanism.
4. There might be a connection with the work of Gariaev's group [I74] demonstrating that the irradiation of DNA with a coherent light generates radiation at radio frequencies discussed in [K38] . The method inducing these radio frequencies is based on the use of two orthogonally polarized laser beams interacting with DNA in liquid crystal state and can be also used to detect imprinted frequencies [I123] .

Frequency imprinting of 'clean' water

Typical example of imprinting involves the transfer of imprinted frequencies through the glass of a vial containing 'clean' (no chemical impurities nor imprinted frequencies) water immersed to the imprinted water serving as the frequency source. Higher ELF frequencies are transferred quickly whereas the transfer of the low frequencies can take hours or even days [I123] . The vial could be

also in the proximity of the frequency source (homeopathic potency, imprinted water, or oscillator). The succussion of the vial or a brief application of the field of a strong permanent magnet allows the transfer of frequencies. The transfer of frequencies of body to a vial of 'clean' water is possible by a direct contact, say by holding the vial in hand. Succussion also helps the transfer.

Several questions relate to the dynamics of the magnetic flux sheet structures.

1. Do the flux structures exist already before imprinting or are they dynamical? Can one even speak about the growth of these structures from source to the imprinted system? The general model for quantum control and communications between magnetic and biological body predicts that magnetic body is dynamical and grows during the development of individual. Thus flux quanta could penetrate/diffuse/grow from the imprinted water to the interior of the glass seal. This means also the transfer of the magnetic transition frequencies.
2. High frequencies are reported to penetrate quicker than slow frequencies [I123]. If magnetic flux quanta penetrate to the imprinted system and homeostatic variations of the flux tube area keeping the flux constant are possible, the question transforms to a new form. Why thin magnetic flux tubes carrying strong magnetic fields and high frequencies penetrate quicker than the thick magnetic flux tubes carrying weak magnetic fields? Naive geometric intuition suggests an answer here. There are several possibilities: simple dimensional analytic argument $T \propto 1/f$ or equivalently $T \propto 1/f_c$. If the time of transfer is proportional to the p-adic time scale one would have $T \propto T(k) \propto 1/\sqrt{f_c}$ (this would mean a variation by factor of 10^6 in the range $10^{-3} - 10^9$ Hz).

There is also a list of question about the imprinting using arbitrary frequency source and frequency.

1. Does the magnetic body of the source represent the frequency of the source somehow? Is this magnetic body connected to the Earth's magnetic body? Is the presence of water really necessary? Are dark proton super-nuclei present also now and do they originate from the magnetic body of Earth? Is it really possible to imprint arbitrary frequencies?
2. The frequencies should be assignable to dark photons. Hence the question arises whether the emission of ordinary photons is accompanied by emission of dark photons represented by r -folded MEs. Are ordinary photons transformed with some rate to dark photons by the reversal of coherence phase transition. Is this phase transition de-coherence phase transition for phase conjugates of dark photons?
3. Do the magnetic flux quanta perhaps form closed flux tube structures connecting the source and imprinted water? This is actually suggested by the reported Aharonov-Bohm effect [I123], which would be due to the modification of vector potential along a closed magnetic flux circuit.

Erasing the frequency imprinting

According to [I123], the removal of Earth's magnetic field by surrounding the imprinted water by a metallic container removes the imprinting provides very strong support for the fundamental role of Earth's magnetic field. This however forces to consider critically the idea about r -folded dark magnetic flux quanta since the removal of also the r -fold dark variants of its flux quanta. This is frustrating but one must humbly accept the fact that the model for dark matter at space-time level is far from being final, and it is rather easy to end up to the garden of endlessly branching paths.

Also heating is reported lead to both appearance and disappearance of imprinted frequencies [I123]. The thermal instability conforms with the assumption that dark matter with large value of Planck constant and ordinary matter can be in thermal equilibrium: in the original framework it was assumed that larger space-time sheets are at so low temperatures that cyclotron energies are above thermal threshold.

The effect of the heating could have several explanations.

1. The simplest implication of heating is that cyclotron energies in question remain below thermal threshold and cannot anymore affect the behavior of the bio-matter. Heating can induce de-coherence phase transition of photons to ordinary ones so that the Bose-Einstein condensates of photons crucial for the effectiveness of homeopathic potency are lost temporarily. This

could be tested by heating the homeopathic potency and finding whether its effect disappears. The re-appearance of imprinted frequencies seems more difficult to understand, at least if they correspond to cyclotron energies below thermal threshold.

2. Heating could also affect magnetic flux quanta, say decompose $r = 2^{k_d}$ -folded flux quanta to 2 flux quanta at level $k_d - 1$ for which cyclotron photons have sub-thermal energies. Heating can induce split join along boundaries bonds between space-time sheets of ordinary matter and magnetic flux quanta.

According to [I123] it is also possible to hide imprinted frequencies by succussing the vial on one side of an oscillator output coil. My guess for "hide" is that the imprinted frequencies are not lost permanently and can be re-established. If the Bose-Einstein condensates of dark photons are lost temporarily but the dark protonic super-nuclei or water molecule clusters responsible for the mimicry remain intact, the frequencies would be indeed "hidden".

The effect of dilution to the imprinted frequencies

The effect of dilution can alter the imprinted frequency [I123] .

1. First example

In the first example $f = 1$ Hz was imprinted by succussion. Then the solution was diluted serially by a dilution factor $D \equiv 1/p = 10$. $f = 1$ Hz remained but after a succussion it disappeared and was replaced by 10 Hz. More generally, the imprinted frequency does not follow in a continuous manner the dilution factor but changes in a stepwise manner. The fact that cyclotron frequencies of DNA sequences are around 1 Hz whereas 10 Hz corresponds to alpha band containing the cyclotron frequencies of most bosonic ions [K26] might have some significance in this special case.

One can imagine two different explanations for the replacement of 1 Hz frequency with 10 Hz frequency.

1. The protonic super-nuclear (closet string like structures) having 1 Hz as cyclotron frequency would contain 300 dark protons. It could happen that these strings are unstable against the decay to super-nuclei with 30 dark protons expected to be present since frequencies in alpha band are certainly present at magnetic flux tubes of Earth. The analog of induced emission due to presence of 10 Hz dark photons would increase the rate for the decay process induced by succussion.
2. Frequency imprinting could increase the area of some flux quanta of Earth's magnetic field by a factor of 10 and thus lower the value of the magnetic field and cyclotron frequency from 10 Hz to 1 Hz so that ions in alpha band could be responsible for the frequency imprinting. The increase of the thickness by factor 10 could involve the p-adic scaling up of the thickness of the flux sheet by a factor 8 ($k = 169 \rightarrow 175$ or $k = 151 \rightarrow 157$) followed by a continuous increase of the thickness by a factor 5/4. Succussion could bring the magnetic flux return to the ordinary stable state corresponding to ~ 10 Hz cyclotron frequency for bosonic ions. For this option the effectiveness of homeopathic potency is not lost unlike for option 1).

2. Second example

In the second example 1 Hz is stable for a dilution factor $D = 1.4$ but for a dilution factor 1.5 it changes to 1.5 Hz.

1. The instability of $A = 300$ super-nuclei against decay to $A = 200$ perhaps mimicking some important ion (actually Gold ion Au^+ for $B_E = .5$ Gauss) could be in question. In this case the homeopathic efficiency of the potency is lost.
2. 1.5 is so near to $\sqrt{2} \simeq 1.414$ that one cannot avoid the question whether some kind of 2-adic effects are involved. The transition could reduce the thickness of the flux sheet by a factor $1/\sqrt{2}$, say in $k = 169 \rightarrow 168$ or $k = 151 \rightarrow 150$ p-adic transition. The efficiency of the homeopathic potency would not be lost. The stable magnetic field strengths for flux quanta would be piecewise constant functions of D reduced by a $1/\sqrt{2}$ -factor at $D/D_0 = \sqrt{2}^n$: this for sufficiently small

values of D . If the energy of the magnetic flux tube is invariant in the scaling then also its length varies as $L \propto D$ for small enough values of D . Similar plateau effects suggesting underlying 2-adicity [K54] have been found to be associated with the intensity of sensation as a function of stimulus [J61]. If the intensity of sensation is coded to ELF frequency this effect could perhaps be understood.

3. Other strange findings

Also other strange findings are reported in [I123]: for instance, no frequency at all was imprinted for the dilution factors in the range 13-19 when starting from an imprinted frequency of 1 Hz. If these findings represent reality, the rate for the formation of the mimicking structures depends on the density of existing representatives and this range of dilution factors would represent kind of a transition zone between two kinds of situations allowing stable imprinting.

The rate for the formation of mimicking structures is enhanced by the presence of Bose-Einstein condensates of photons (the analog of induced emission). Destructive interference effects for dark photons from Bose-Einstein condensates of disjoint flux quanta could however reduce this effect. For sufficiently large values of D the destructive interference effects of photons from different flux quanta would not be significant. For small values of D the flux quanta could fuse to form single structure guaranteeing the absence of destructive interference effects. There could however exist a transition region in which destructive interference are important and reduce the rate for the formation of mimicking structures: perhaps this region corresponds to D in the range 13-19.

Biological Aharonov-Bohm type effects

Even the vector potential of a vanishing magnetic field can affect the state of living matter and water. An example is provided by a ferrite toroidal coil containing its magnetic field inside the toroid [I123]. This can be understood as follows.

Suppose that there exist closed flux tubes or more general flux quanta connecting the frequency source and the vial containing the imprinted water. The non-vanishing vector potential of the ferrite toroid in the exterior of the toroidal coil affects the vector potential along these flux tubes and thus also the wave functions of the super-conducting ionic BE condensates at the closed flux tubes. The condition for this is that the closed magnetic flux tubes traversing from the source of frequencies to the vial of the clean water are linked with the toroidal coil so that magnetic flux through the surface bounded by the closed magnetic flux tube equals to the magnetic flux carried by the coil.

The vector potential A appearing in the quantization conditions for the magnetic flux

$$\oint (p - eA) dl = n \times 2\pi$$

for a linked loop is affected by the toroidal magnetic field since the loop integral is changed by the toroidal magnetic flux. This means that the momentum p of the super-conducting ion changes for this kind of magnetic flux loops going from the frequency source to the clean water. Thus ionic supra-currents change so that the ionic concentrations and homeostasis at the atomic space-time sheets are affected in case of living matter. Both the source and vial of clean water are 'magnetically entangled' in this kind of situation. An interesting question is what effects this kind of a toroid placed between two living organisms could induce. Note that for two toroidal coils with opposite current directions these effects should cancel out.

Does a critical dilution factor exist?

The dilution ratios used correspond to powers of 10: $p = 1/10^k$, $k = 1, 2, 3, \dots$. This is a mere convenient convention. There should however exist some critical dilution ratio p below which the rate for the formation mimicking molecules, be they water molecule clusters stealing the magnetic bodies of molecule or protonic super nuclei, is too low.

Similar critical ratios are encountered in the percolation of liquid to a porous substance: when the volume fraction of the wetted pores is overcritical the entire material gets wet. The strong mixing of the water could be seen as a manner to optimize the potentiation. It could also enhance the rate of dropping of protons to the magnetic flux quanta.

1. For instance, suppose that diluted potency generates at each step of the process dark super-nuclei (dark protonic strings with mass number A and charge Z) mimicking the already existing super-nuclei mimicking the original molecules. If the presence of the already existing super-nuclei enhances the rate of this process as it does in induced emission so that Bose-Einstein condensation is the end step of the generation of the super-nuclei, a lower bound for the dilution factor emerges.
2. In the case of water molecule clusters stealing magnetic bodies, the critical dilution ratio would have much simpler interpretation since the rate for the loss of magnetic bodies is proportional the density of actual molecules. If so then the long sequence of dilutions would not have considerable effect. Situation could change if the magnetic bodies can replicate. This kind of replication must take place in cell division but whether it can happen under much more primitive conditions is unclear.

7.3.6 A possible realization of water memory

The Benveniste's discovery of water memory [I68, I69] initiated quite dramatic sequence of events. The original experiment involved the homeopathic treatment of water by human antigene. This meant dilution of the water solution of antigene so that the concentration of antigene became extremely low. In accordance with homeopathic teachings human basophils reacted on this solution.

The discovery was published in *Nature* and due to the strong polemic raised by the publication of the article, it was decided to test the experimental arrangement. The experimental results were reproduced under the original conditions. Then it was discovered that experimenters knew which bottles contained the treated water. The modified experiment in which experimenters did not possess this information failed to reproduce the results and the conclusion was regarded as obvious and Benveniste lost his laboratory among other things. Obviously any model of the effect taking it as a real effect rather than an astonishingly simplistic attempt of top scientists to cheat should explain also this finding.

The model based on the notion of field body and general mechanism of long term memory allows to explain both the memory of water and why it failed under the conditions described.

1. Also molecules have magnetic field bodies acting as intentional agents controlling the molecules. Nano-motors do not only look co-operating living creatures but are such. The field body of the molecule contains besides the static magnetic and electric parts also dynamical parts characterized by frequencies and temporal patterns of fields. To be precise, one must speak both field and relative field bodies characterizing interactions of molecules. Right brain sings-left brain talks metaphor might generalize to all scales meaning that representations based on both frequencies and temporal pulse with single frequency could be utilized.
2. The effects of complex bio-molecule to other bio-molecules (say antigene on basofil) in water could be characterized to some degree by the temporal patterns associated with the dynamical part of its field body and bio-molecules could recognize each other via these patterns. This would mean that symbolic level in interactions would be present already in the interactions of bio-molecules. Cyclotron frequencies are most natural candidates for the frequency signatures and the fact that frequencies in 10 kHz range are involved supports this view.
3. The original idea was that water molecule clusters are able to mimic the bio-molecules themselves -say their vibrational and rotational spectra could coincide with those of molecules in reasonable approximation. A more natural idea is that they can mimic their field bodies. Homeopathy could rely on extremely simple effect: water molecule clusters would steal the magnetic bodies of the molecules used to manufacture the homeopathic remedy. The shaking of the bottle containing the solution would enhance the probability for bio-molecule to lose its magnetic body in this manner. For instance, water could produce fake copies of say antigenes recognized by basophils and reacting accordingly if the reaction is based on interaction with the magnetic body of the antigene.
4. The basic objection against this picture is that it does not explain why the repeated dilution works. Rather, it seems that dilution of molecules reduces also the density of mimicking pseudo-molecules. Even more, the potency of the homeopathic remedy is claimed to increase as the the

dilution factor increases. Also alcohol is used instead of water so that also alcohol must allow homeopathic mechanism. (I am grateful for Ulla Matfolk for questions which made me to realize these objections).

- (a) The only way out seems to be that the magnetic bodies or water molecule clusters having these magnetic bodies can replicate. The shaking of the remedy could provide the needed metabolic energy so that the population of magnetic bodies grows to a limiting density determined by the metabolic energy feed. In principle it would be possible to infect unlimited amount of water by these pseudo-molecules. When in bottle the population would be in dormant state but in the body of the patient it would wake up and form a population of molecular actors and stimulate the immune system to develop immune response to the real molecule.
 - (b) The potency of the homeopathic remedy is claimed to increase with the increased dilution factor. This would suggest that the continued dilution and shaking also increases the density of pseudo molecules, perhaps by feeding to the system metabolic energy or by some other mechanism.
 - (c) Also magnetic bodies must replicate in cell replication and their role as intentional agents controlling bio-matter requires that this replication serves as a template for biochemical replication. One can indeed interpret the images about cell replication in terms of replication of dipole type magnetic field. This process is very simple and could have preceded biological replication. The question is therefore whether water is actually a living system in presence of a proper metabolic energy feed. Also the water's ability near critical point for freezing to form nice patterns correlating with sound stimuli might be due to the presence of the molecular actors.
 - (d) This picture fits nicely with the vision that evolution of water in this kind of life form might have happened separately and that pre-biotic chemical life forms have formed symbiosis with living water [K31]. In the model of DNA as topological quantum computer [K28] the asymptotic self organization patterns of water flow in the vicinity of lipid layers indeed define quantum computer programs by inducing the braiding of the magnetic flux tubes connecting DNA nucleotides to lipids so that this symbiosis would have brought in new kind of information processing tool.
5. The magnetic body of the molecule could mimic the vibrational and rotational spectra using harmonics of cyclotron frequencies. Cyclotron transitions could produce dark photons, whose ordinary counterparts resulting in de-coherence would have large energies due to the large value of \hbar and could thus induce vibrational and rotational transitions. This would provide a mechanism by which molecular magnetic body could control the molecule. Note that also the antigens possibly dropped to the larger space-time sheets could produce the effect on basophils.
 6. There is a considerable experimental support for the Benveniste's discovery that bio-molecules in water environment are represented by frequency patterns, and several laboratories are replicating the experiments of Benveniste as I learned from the lecture of Yolene Thomas in the 7:th European SSE Meeting held in Rörös [J43]. The scale of the frequencies involved is around 10 kHz and as such does not correspond to any natural molecular frequencies. Cyclotron frequencies associated with electrons or dark ions accompanying these macromolecules would be a natural identification if one accepts the notion of molecular magnetic body. For ions the magnetic fields involved would have a magnitude of order .03 Tesla if 10 kHz corresponds to scaled up alpha band. Also Josephson frequencies would be involved if one believes that EEG has fractally scaled up variants in molecular length scales.

Consider now the argument explaining the failure to replicate the experiments of Benveniste.

1. The magnetic bodies of water molecules need metabolic energy for communications with their "biological body" using the fractally scaled analog of EEG. There is no obvious source for this energy in water. The model for protein folding and DNA as topological quantum computer assumes that magnetic flux tubes connecting subject person and target of directed attention serve as correlates for directed attention at the molecular level [K28, K4]. This should be true

also in macroscopic scales so that the experimentalist and the bottle containing the treated water should be connected by magnetic flux tubes. If experimenter has directed his attention to the bottle of water, the resulting magnetic flux tubes could allow a transfer of metabolic energy as a radiation along massless extremals parallel to the flux tubes and defining TGD counterparts of Alfvén waves. Experimenter's strong motivation to replicate experiments would help to realize the transfer of the metabolic energy. Experimenters not knowing, which bottles were treated did not have these flux tube bridges to the bottles, and were not able to provide the needed metabolic energy, and the magnetic bodies of antigens failed to generate the cyclotron radiation making them visible to the basophil.

2. If this interpretation is correct, then Benveniste's experiment would demonstrate besides water memory also psychokinesis and direct action of desires of experimenters on physics at microscopic level. Furthermore, the mere fact that we know something about some object or direct attention to it would mean a concrete interaction of our magnetic body with the object. The so called phenomenon of psi track [J69] provides additional support for this conclusion.

7.3.7 Could virtual DNAs allow a controlled development of the genome?

The fundamental question in the evolution biology is the question about the interaction between genome (G), phenotype (P), and environment (E).

1. The standard dogma is that the information transfer from G to P is unidirectional and that environment acts on G by inducing random mutations of G , from which E selects the lucky survivors as those with the best ability to reproduce. Lamarckism [I14, I88, I70] represents a deviation from standard dogma by assuming direct information transfer from E to G .
2. Genetic expression is controlled by environment, at least by silencing [I14], which is like selecting only few books to be read from a big library. Cell differentiation represents basic example of selective gene expression. DNA methylation and transposition are accepted to reflect information transfer from E to G , perhaps via P . These modifications are believed to be short lasting and not transferred to the offspring since it is difficult to imagine a mechanism transferring the mutations to the germ cells. There is however also evidence that epigenetic information transfer takes place [I111]: this transfer would be selective expression of genes of germ cells rather than that of modified genes.
3. There are findings challenging the dogmas of static genome and random mutations. The cells of the immune system remodel their genes coding for antibodies capable of recognizing large variety of antigens. There is quite recent finding [I66] revealing major genetic differences between blood and tissue cells. There are also mutations due to jumping genes - mobile elements of DNA known as LINE-1 elements usually regarded as junk DNA whose portion from genome increases as one climbs up along the evolutionary ladder. In mice jumping genes are limited to brain and germ cells: this is easy to understand since in organs like heart and lungs this kind of mutations would be fatal. Second recent discovery is that there is a high diversity of human brain cells believed to be due to the jumping genes [I44]. That brain cells would be producing with a high rate junk DNA is not an idea which would make me shout 'Eureka!'
4. The question remains whether the $G \rightarrow P - E$ actually could complete to a closed loop $G \rightarrow P - E - G$ so that genome could directly respond to the changing physical environment and could transfer the successful response to the next generation [I88].

Could genome be developed like computer hardware?

In TGD framework the sequence $G \rightarrow P - E$ is replaced with a closed loop $G - P - M - E$ to which E is attached at P by bidirectional arrow (organisms do also modify their environment actively). Magnetic body thus controls genome and receives information from cell membrane (P). The hierarchy of genomes (super-genome, hyper-genome,...) corresponding to the different levels of dark matter hierarchy allows this loop to be realized in different scales rather only at the level of single cell.

The question is whether the magnetic body of organism or higher level magnetic bodies could modify genomes, super-genomes, and hyper-genomes directly, perhaps by generating mutations of

the genome in a short time scale; by monitoring how genetically modified organism survives in the environment; and -if the outcome of the experiment is successful - replacing the corresponding portion of DNA with the modified DNA both in ordinary germ cells. One can even ask whether the abstract model of the external environment provided by the internal chemical milieu might be mimicked by water magnetic bodies of water molecule clusters and provide a virtual world testing ground for a search of favorable mutations.

In DNA as a tqc vision essentially the development of a new computer hardware would be in question, and should take place in a controlled manner and involve an experimentation before going to the market rather than by random modifications taking place in computer CPUs. Second basic aspect of DNA as tqc paradigm is that water and bio-molecules live in symbiosis in the sense that self organization patterns of the cellular water flow define the tqc programs. The following first guess for how the development of computer hardware might be achieved is just a first guess but might have something to do with reality.

1. What would be needed is a mechanism generating rapidly modifications of DNA. The mutations should be carried out using a kind of virtual DNA mimicking all the essential aspects of the symbolic dynamics associated with DNA. The magnetic bodies of DNA consisting of flux tubes connecting the nucleotides of DNA strands to cell membrane satisfy these conditions since A,T,G,C is coded to exotic light quarks u, d and anti-quarks \bar{u}, \bar{d} at the ends of flux tubes [K28]. DNA nucleotides could be replaced with clusters of water molecules but also other options can be imagined. Note that it does not matter when one speaks of mimicry of RNA or DNA molecules.
2. If the proposed model of the phantom DNA and homeopathy has something to do with reality, this kind of virtual DNA exists and is generated in phantom DNA effect as magnetic bodies of DNA, including of course the magnetic flux tubes connecting the nucleotides to the cell membrane or conjugate strand of DNA.
3. The crucial additional assumption would be that also the reversal of phantom DNA effect is possible and corresponds to the analog of DNA replication in which nucleotides attach to the virtual conjugate nucleotides of the virtual DNA strand or RNA strand in turn transformed to DNA strand by reverse transcription. The hypothesis would have rather strong implications for the genetic engineering since homeopathic remedies of genetically engineered DNA sequences could be transferred to cell nuclei just by drinking them.
4. Phantom DNA sequences could form populations and - as far as their properties as a hardware of topological quantum computer are involved - evolve under selection pressures of the virtual world defined by the nuclear, cellular and extracellular water. A competition of components of tqc hardware developed by the higher level magnetic body to realize optimally tqc programs needed for survival would be in question. The simplest mutation of phantom DNA would replace the quark pairs at the ends of the (wormhole-) magnetic flux tube with a new one and could occur in very short time scale. Also basic editing operations like cutting and pasting would be possible for these competing phantom DNA sequences. The winners in the competition would be transformed to actual DNA sequences by utilizing the reverse phantom DNA (or RNA -) effect and be inserted to genome. The genetic machinery performing cutting, gluing, and pasting of real DNA in a controlled manner exists. What is needed is the machinery monitoring who is the winner and making the decision to initiate the modification of the real DNA.
5. The transfer of the mutations to germ cells could be achieved by allowing the population of the virtual DNA sequences to infect the water inside germ cells. The genetic program inducing the modification of DNA by using the winner of the tqc hardware competition should run automatically.
6. One open question is whether the nuclear, cellular or perhaps also extracellular water should represent the physical environment and - if answer is affirmative - how it achieves this. As a matter of fact, considerable fraction of water inside cells is in gel phase and it might be that the intercellular water, which naturally defines a symbolic representation of environment, is where the virtual evolution takes place. Internal chemical milieu certainly reflects in an abstract

manner the physical environment and the ability of the water molecule clusters to mimic bio-molecules would make the representation of the chemical environment possible. Also sudden changes of external milieu would be rapidly coded to the changes in internal milieu which might help to achieve genetic re-organization. The craziest dream is water based simulation of both genes, proteins, and molecules representing external world running at dark space-time sheets.

Dark nuclear strings as analogs of DNA-, RNA- and amino-acid sequences and baryonic realization of genetic code?

The minimal option is that virtual DNA sequences have flux tube connections to the lipids of the cell membrane so that their quality as hardware of *tqc* can be tested but that there is no virtual variant of transcription and translation machinery. One can however ask whether also virtual amino-acids could be present and whether this could provide deeper insights to the genetic code.

1. Water molecule clusters are not the only candidates for the representatives of linear molecules. An alternative candidate for the virtual variants of linear bio-molecules are dark nuclei consisting of strings of scaled up dark variants of neutral baryons bound together by color bonds having the size scale of atom, which I have introduced in the model of cold fusion and plasma electrolysis both taking place in water environment [L7] , [L7] . Colored flux tubes defining braidings would generalize this picture by allowing transversal color magnetic flux tube connections between these strings.
2. This seems to work! The states of dark nucleons formed from three quarks can be naturally grouped to multiplets in one-one correspondence with 64 DNAs, 64 RNAs, and 20 aminoacids and there is natural mapping of DNA and RNA type states to aminoacid type states such that the numbers of DNAs/RNAs mapped to given aminoacid are same as for the vertebrate genetic code.

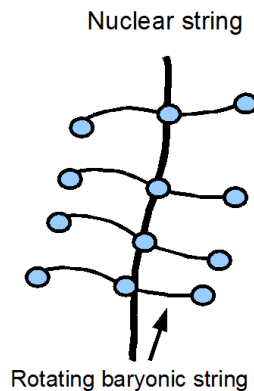


Figure 7.1: Illustration of a possible vision about dark nucleus as a nuclear string consisting of rotating baryonic strings.

The basic idea is simple. Since baryons consist of 3 quarks just as DNA codons consist of three nucleotides, one might ask whether codons could correspond to baryons obtained as open strings with quarks connected by two color flux tubes. This representation would be based on entanglement rather than letter sequences. The question is therefore whether the dark baryons constructed as string of 3 quarks using color flux tubes could realize 64 codons and whether 20 aminoacids could be identified as equivalence classes of some equivalence relation between 64 fundamental codons in a natural manner.

The following model indeed reproduces the genetic code directly from a model of dark neutral baryons as strings of 3 quarks connected by color flux tubes.

1. Dark nuclear baryons are considered as a fundamental realization of DNA codons and constructed as open strings of 3 dark quarks connected by two colored flux tubes, which can be

also charged. The baryonic strings cannot combine to form a strictly linear structure since strict rotational invariance would not allow the quark strings to have angular momentum with respect to the quantization axis defined by the nuclear string. The independent rotation of quark strings and breaking of rotational symmetry from $SO(3)$ to $SO(2)$ induced by the direction of the nuclear string is essential for the model.

- (a) Baryonic strings could form a helical nuclear string (stability might require this) locally parallel to DNA, RNA, or aminoacid) helix with rotations acting either along the axis of the DNA or along the local axis of DNA along helix. The rotation of a flux tube portion around an axis parallel to the local axis along DNA helix requires that magnetic flux tube has a kink in this portion. An interesting question is whether this kink has correlate at the level of DNA too. Notice that color bonds appear in two scales corresponding to these two strings. The model of DNA as topological quantum computer [K28] allows a modification in which dark nuclear string of this kind is parallel to DNA and each codon has a flux tube connection to the lipid of cell membrane or possibly to some other bio-molecule.
 - (b) The analogs of DNA -, RNA -, and of amino-acid sequences could also correspond to sequences of dark baryons in which baryons would be 3-quark strings in the plane transversal to the dark nuclear string and expected to rotate by stringy boundary conditions. In this case all dark baryons would be free to rotate. Thus one would have nuclear string consisting of short baryonic strings not connected along their ends (see Fig. 7.3.7).
2. The new element as compared to the standard quark model is that between both dark quarks and dark baryons can be charged carrying charge $0, \pm 1$. This is assumed also in nuclear string model and there is empirical support for the existence of exotic nuclei containing charged color bonds between nuclei.
 3. The net charge of the dark baryons in question is assumed to vanish to minimize Coulomb repulsion:

$$\sum_q Q_{em}(q) = - \sum_{flux\ tubes} Q_{em}(flux\ tube) . \quad (7.3.1)$$

This kind of selection is natural taking into account the breaking of isospin symmetry. In the recent case the breaking cannot however be as large as for ordinary baryons (implying large mass difference between Δ and nucleon states).

4. One can classify the states of the open 3-quark string by the total charges and spins associated with 3 quarks and to the two color bonds. Total em charges of quarks vary in the range $Z_B \in \{2, 1, 0, -1\}$ and total color bond charges in the range $Z_b \in \{2, 1, 0, -1, -2\}$. Only neutral states are allowed. Total quark spin projection varies in the range $J_B = 3/2, 1/2, -1/2, -3/2$ and the total flux tube spin projection in the range $J_b = 2, 1, -1, -2$. If one takes for a given total charge assumed to be vanishing one representative from each class (J_B, J_b) , one obtains $4 \times 5 = 20$ states which is the number of amino-acids. Thus genetic code might be realized at the level of baryons by mapping the neutral states with a given spin projection to single representative state with the same spin projection. The problem is to find whether one can identify the analogs of DNA, RNA and aminoacids as baryon like states.

1. States in the quark degrees of freedom

One must construct many-particle states both in quark and flux tube degrees of freedom. These states can be constructed as representations of rotation group $SU(2)$ and strong isospin group $SU(2)$ by using the standard tensor product rule $j_1 \times j_2 = j_1 + j_2 \oplus j_1 + j_2 - 1 \oplus \dots \oplus |j_1 - j_2|$ for the representation of $SU(2)$ and Fermi statistics and Bose-Einstein statistics are used to deduce correlations between total spin and total isospin (for instance, $J = I$ rule holds true in quark degrees of freedom). Charge neutrality is assumed and the breaking of rotational symmetry in the direction of nuclear string is assumed.

Consider first the states of dark baryons in quark degrees of freedom.

1. The tensor product $2 \otimes 2 \otimes 2$ is involved in both cases. Without any additional constraints this tensor product decomposes as $(3 \oplus 1) \otimes 2 = 4 \oplus 2 \oplus 2$: 8 states altogether. This is what one should have for DNA and RNA candidates. If one has only identical quarks uuu or ddd , Pauli exclusion rule allows only the 4-D spin $3/2$ representation corresponding to completely symmetric representation -just as in standard quark model. These 4 states correspond to a candidate for amino-acids. Thus RNA and DNA should correspond to states of type uud and ddu and aminoacids to states of type uuu or ddd . What this means physically will be considered later.
2. Due to spin-statistics constraint only the representations with $(J, I) = (3/2, 3/2)$ (Δ resonance) and the second $(J, I) = (1/2, 1/2)$ (proton and neutron) are realized as free baryons. Now of course a dark -possibly p-adically scaled up - variant of QCD is considered so that more general baryonic states are possible. By the way, the spin statistics problem which forced to introduce quark color strongly suggests that the construction of the codons as sequences of 3 nucleons - which one might also consider - is not a good idea.
3. Second nucleon like spin doublet - call it 2_{odd} - has wrong parity in the sense that it would require $L = 1$ ground state for two identical quarks (uu or dd pair). Dropping 2_{odd} and using only $4 \oplus 2$ for the rotation group would give degeneracies $(1, 2, 2, 1)$ and 6 states only. All the representations in $4 \oplus 2 \oplus 2_{odd}$ are needed to get 8 states with a given quark charge and one should transform the wrong parity doublet to positive parity doublet somehow. Since open string geometry breaks rotational symmetry to a subgroup $SO(2)$ of rotations acting along the direction of the string and since the boundary conditions on baryonic strings force their ends to rotate with light velocity, the attractive possibility is to add a baryonic stringy excitation with angular momentum projection $L_z = -1$ to the wrong parity doublet so that the parity comes out correctly. $L_z = -1$ orbital angular momentum for the relative motion of uu or dd quark pair in the open 3-quark string would be in question. The degeneracies for spin projection value $J_z = 3/2, \dots, -3/2$ are $(1, 2, 3, 2)$. Genetic code means spin projection mapping the states in $4 \oplus 2 \oplus 2_{odd}$ to 4.

2. States in the flux tube degrees of freedom

Consider next the states in flux tube degrees of freedom.

1. The situation is analogous to a construction of mesons from quarks and antiquarks and one obtains the analogs of π meson (pion) with spin 0 and ρ meson with spin 1 since spin statistics forces $J = I$ condition also now. States of a given charge for a flux tube correspond to the tensor product $2 \otimes 2 = 3 \oplus 1$ for the rotation group.
2. Without any further constraints the tensor product $3 \otimes 3 = 5 \oplus 3 \oplus 1$ for the flux tubes states gives $8+1$ states. By dropping the scalar state this gives 8 states required by DNA and RNA analogs. The degeneracies of the states for DNA/RNA type realization with a given spin projection for $5 \oplus 3$ are $(1, 2, 2, 2, 1)$. 8×8 states result altogether for both uud and udd for which color bonds have different charges. Also for ddd state with quark charge -1 one obtains $5 \oplus 3$ states giving 40 states altogether.
3. If the charges of the color bonds are identical as the are for uuu type states serving as candidates for the counterparts of aminoacids bosonic statistics allows only 5 states ($J = 2$ state). Hence 20 counterparts of aminoacids are obtained for uuu . Genetic code means the projection of the states of $5 \oplus 3$ to those of 5 with the same spin projection and same total charge.

3. Analogs of DNA, RNA, aminoacids, and of translation and transcription mechanisms

Consider next the identification of analogs of DNA, RNA and aminoacids and the baryonic realization of the genetic code, translation and transcription.

1. The analogs of DNA and RNA can be identified dark baryons with quark content uud , ddu with color bonds having different charges. There are 3 color bond pairs corresponding to charge pairs $(q_1, q_2) = (-1, 0), (-1, 1), (0, 1)$ (the order of charges does not matter). The condition that the

total charge of dark baryon vanishes allows for uud only the bond pair $(-1, 0)$ and for udd only the pair $(-1, 1)$. These thus only single neutral dark baryon of type uud resp. udd : these would be the analogous of DNA and RNA codons. Amino-acids would correspond to uuu states with identical color bonds with charges $(-1, -1)$, $(0, 0)$, or $(1, 1)$. uuu with color bond charges $(-1, -1)$ is the only neutral state. Hence only the analogs of DNA, RNA, and aminoacids are obtained, which is rather remarkable result.

2. The basic transcription and translation machinery could be realized as processes in which the analog of DNA can replicate, and can be transcribed to the analog of mRNA in turn translated to the analogs of amino-acids. In terms of flux tube connections the realization of genetic code, transcription, and translation, would mean that only dark baryons with same total quark spin and same total color bond spin can be connected by flux tubes. Charges are of course identical since they vanish.
3. Genetic code maps of $(4 \oplus 2 \oplus 2) \otimes (5 \oplus 3)$ to the states of 4×5 . The most natural map takes the states with a given spin to a state with the same spin so that the code is unique. This would give the degeneracies $D(k)$ as products of numbers $D_B \in \{1, 2, 3, 2\}$ and $D_b \in \{1, 2, 2, 2, 1\}$: $D = D_B \times D_b$. Only the observed degeneracies $D = 1, 2, 3, 4, 6$ are predicted. The numbers $N(k)$ of aminoacids coded by D codons would be

$$[N(1), N(2), N(3), N(4), N(6)] = [2, 7, 2, 6, 3] .$$

The correct numbers for vertebrate nuclear code are $(N(1), N(2), N(3), N(4), N(6)) = (2, 9, 1, 5, 3)$. Some kind of symmetry breaking must take place and should relate to the emergence of stopping codons. If one codon in second 3-plet becomes stopping codon, the 3-plet becomes doublet. If 2 codons in 4-plet become stopping codons it also becomes doublet and one obtains the correct result $(2, 9, 1, 5, 3)!$

4. Stopping codons would most naturally correspond to the codons, which involve the $L_z = -1$ relative rotational excitation of uu or dd type quark pair. For the 3-plet the two candidates for the stopping codon state are $|1/2, -1/2\rangle \otimes \{|2, k\rangle\}$, $k = 2, -2$. The total spins are $J_z = 3/2$ and $J_z = -7/2$. The three candidates for the 4-plet from which two states are thrown out are $|1/2, -3/2\rangle \otimes \{|2, k\rangle, |1, k\rangle\}$, $k = 1, 0, -1$. The total spins are now $J_z = -1/2, -3/2, -5/2$. One guess is that the states with smallest value of J_z are dropped which would mean that $J_z = -7/2$ states in 3-plet and $J_z = -5/2$ states 4-plet become stopping codons.
5. One can ask why just vertebrate code? Why not vertebrate mitochondrial code, which has unbroken $A-G$ and $T-C$ symmetries with respect to the third nucleotide. And is it possible to understand the rarely occurring variants of the genetic code in this framework? One explanation is that the baryonic realization is the fundamental one and biochemical realization has gradually evolved from non-faithful realization to a faithful one as kind of emulation of dark nuclear physics. Also the role of tRNA in the realization of the code is crucial and could explain the fact that the code can be context sensitive for some codons.

4. Understanding the symmetries of the code

Quantum entanglement between quarks and color flux tubes would be essential for the baryonic realization of the genetic code whereas chemical realization could be said to be classical. Quantal aspect means that one cannot decompose to codon to letters anymore. This raises questions concerning the symmetries of the code.

1. What is the counterpart for the conjugation $ZYZ \rightarrow X_c Y_c Z_c$ for the codons?
2. The conjugation of the second nucleotide Y having chemical interpretation in terms of hydrophobia-hydrophilily dichotomy in biology. In DNA as tqc model it corresponds to matter-antimatter conjugation for quarks associated with flux tubes connecting DNA nucleotides to the lipids of the cell membrane. What is the interpretation in now?

3. The A-G, T-C symmetries with respect to the third nucleotide Z allow an interpretation as weak isospin symmetry in DNA as tqc model. Can one identify counterpart of this symmetry when the decomposition into individual nucleotides does not make sense?

Natural candidates for the building blocks of the analogs of these symmetries are the change of the sign of the spin direction for quarks and for flux tubes.

1. For quarks the spin projections are always non-vanishing so that the map has no fixed points. For flux tube spin the states of spin $S_z = 0$ are fixed points. The change of the sign of quark spin projection must therefore be present for both $XYZ \rightarrow X_c Y_c Z_c$ and $Y \rightarrow Y_c$ but also something else might be needed. Note that without the symmetry breaking $(1, 3, 3, 1) \rightarrow (1, 2, 3, 2)$ the code table would be symmetric in the permutation of 2 first and 2 last columns of the code table induced by both full conjugation and conjugation of Y .
2. The analogs of the approximate $A - G$ and $T - C$ symmetries cannot involve the change of spin direction in neither quark nor flux tube sector. These symmetries act inside the A-G and T-C sub-2-columns of the 4-columns defining the rows of the code table. Hence this symmetry must permute the states of same spin inside 5 and 3 for flux tubes and 4 and 2 for quarks but leave 2_{odd} invariant. This guarantees that for the two non-degenerate codons coding for only single amino-acid and one of the codons inside triplet the action is trivial. Hence the baryonic analog of the approximate $A - G$ and $T - C$ symmetry would be exact symmetry and be due to the basic definition of the genetic code as a mapping states of same flux tube spin and quark spin to single representative state. The existence of full 4-columns coding for the same aminoacid would be due to the fact that states with same quark spin inside $(2, 3, 2)$ code for the same amino-acid.
3. A detailed comparison of the code table with the code table in spin representation should allow to fix their correspondence uniquely apart from permutations of n-plets and thus also the representation of the conjugations. What is clear that Y conjugation must involve the change of quark spin direction whereas Z conjugation which maps typically 2-plets to each other must involve the permutation of states with same J_z for the flux tubes. It is not quite clear what X conjugation correspond to.

5. Some comments about the physics behind the code

Consider next some particle physicist's objections against this picture.

1. The realization of the code requires the dark scaled variants of spin 3/2 baryons known as Δ resonance and the analogs (and only the analogs) of spin 1 mesons known as ρ mesons. The lifetime of these states is very short in ordinary hadron physics. Now one has a scaled up variant of hadron physics: possibly in both dark and p-adic senses with latter allowing arbitrarily small overall mass scales. Hence the lifetimes of states can be scaled up.
2. Both the absolute and relative mass differences between Δ and N resp. ρ and π due to color magnetic hyper-fine splitting are large in ordinary hadron physics and this makes the decays of Δ and ρ possible kinematically. This is due to color magnetic spin-spin splitting proportional to the color coupling strength $\alpha_s \sim .1$, which is large. In the recent case α_s could be considerably smaller - say of the same order of magnitude as fine structure constant $1/137$ - so that the mass splittings could be so small as to make decays impossible. The masses of different states should not differ much: eV scales is suggestive.

The color magnetic spin interaction energy give rise to hyperfine splitting of quark in perturbative QCD is of form $E_c \propto \hbar g B / m$, where m is mass parameter which is of the order of baryon mass. Magnetic flux scales as \hbar by flux quantization and if flux tube thickness scales as \hbar^2 , one has $B \propto 1/\hbar$. Mass splittings would not depend on \hbar , which does not make sense. Mass splitting becomes small for large \hbar if the area of flux quantum scales as \hbar^{2+n} , $n > 0$ so that color magnetic hyper-fine splitting scales as $1/\hbar^n$ from flux conservation. The magnetic energy for a flux tube of length L scaling as \hbar and thickness $S \propto \hbar^{2+n}$ has order of magnitude $g^2 B^2 L S$ and does not depend on \hbar for $n = 1$. Maybe this could provide first principle explanation for the desired scaling.

The size scale of DNA would suggest that single DNA triplet corresponds to 3 Angstrom length scale. Suppose this corresponds to the size of dark nucleon. If this size scales as $\sqrt{\hbar}$ as p-adic mass calculations suggest, one obtains a rough estimate $\hbar/\hbar_0 = 2^{38}$. The proton- Δ mass difference due to hyper-fine splitting would be scaled down to about $2^{-38} \times 300 \text{ MeV} \sim 10^{-9} \text{ eV}$, which is completely negligible in the metabolic energy scale .5 eV. If the size of dark nucleon scales as \hbar the mass difference is about 12 eV which corresponds to the energy scale for the ionization energy of hydrogen. Even this might be acceptable.

3. Dark hadrons could have lower mass scale than the ordinary ones if scaled up variants of quarks in p-adic sense are in question. Note that the model for cold fusion that inspired the idea about genetic code requires that dark nuclear strings have the same mass scale as ordinary baryons. In any case, the most general option inspired by the vision about hierarchy of conscious entities extended to a hierarchy of life forms is that several dark and p-adic scaled up variants of baryons realizing genetic code are possible.
4. The heaviest objection relates to the addition of $L_z = -1$ excitation to $S_z = |1/2, \pm 1/2\rangle_{\text{odd}}$ states which transforms the degeneracies of the quark spin states from (1, 3, 3, 1) to (1, 2, 3, 2). The only reasonable answer is that the breaking of the full rotation symmetry reduces $SO(3)$ to $SO(2)$. Also the fact that the states of massless particles are labeled by the representation of $SO(2)$ might be of some relevance. The deeper level explanation in TGD framework might be as follows. The generalized imbedding space is constructed by gluing almost copies of the 8-D imbedding space with different Planck constants together along a 4-D subspace like pages of book along a common back. The construction involves symmetry breaking in both rotational and color degrees of freedom to Cartan sub-group and the interpretation is as a geometric representation for the selection of the quantization axis. Quantum TGD is indeed meant to be a geometrization of the entire quantum physics as a physics of the classical spinor fields in the "world of classical worlds" so that also the choice of measurement axis must have a geometric description.

The conclusion is that genetic code can be understood as a map of stringy baryonic states induced by the projection of all states with same spin projection to a representative state with the same spin projection. Genetic code would be realized at the level of dark nuclear physics and biochemical representation would be only one particular higher level representation of the code. A hierarchy of dark baryon realizations corresponding to p-adic and dark matter hierarchies can be considered. Translation and transcription machinery would be realized by flux tubes connecting only states with same quark spin and flux tube spin. Charge neutrality is essential for having only the analogs of DNA, RNA and aminoacids and would guarantee the em stability of the states.

Crying and screaming cells and magnetic bodies expressing their emotions

By using nanotechnological methods James Gimzewski [J8], his student Andrew Pelling and collaborators discovered that the cell walls of bacterium *Saccharomyces cerevisiae* perform periodic motion with amplitude about 3 nm in the frequency range .8-1.6 kHz (one octave) [I76]. Or more concretely, bacteria produce sounds audible to humans with average frequency of 1 kHz in a range of one octave. The frequency has strong temperature dependence, which suggests a metabolic mechanism. From the temperature dependence one deduces the activation energy to be 58 kJ/mol, which is consistent with the cell's metabolism involving molecular motors such as kinesin, dynein, and myosin. The magnitude of the forces observed (10 nN) suggests concerted nanomechanical activity is operative in the cell.

From less formal popular articles [I89] one can learn that it is difficult to avoid the impression that intelligent communication is in question. Dying cells produce a characteristic screaming sound. One can also distinguish between normal cells and cancer cells on basis of the sound they produce as well as between mammalian and bacterial cells.

What might be the explanation of these findings in TGD framework?

1. It is known that the region of frequencies audible to human ear is from about 20 Hz to 2×10^4 Hz. This is more or less same as the range of frequency range of sferics, the em noise in atmosphere [F3]. This suggests a strong coupling between electromagnetic oscillations and sound as also the fact that biological structures are piezo-electrets transforming em oscillations to sounds and vice versa.

2. The activation energy per mole corresponds to .6 eV per molecule which is at the upper range for the variation range the energy associated with the fundamental metabolic energy quantum identified as the change of zero point kinetic as proton is transferred from atomic space-time sheet to much larger space-time sheet or vice versa. That metabolic energy is needed to produce the sounds supports the view that the sounds are produced intentionally.
3. If one takes seriously the notion of magnetic body as intentional agent controlling biological body, one is led to ask which must sound a totally crazy question in reductionistic ears: could magnetic body express its emotions in terms of frequencies of cyclotron transitions transformed to sound via genetic expression using piezo electric mechanism? Could it be that the photons involved are dark photons with large value of Planck constant so that their energy is above thermal energy. Could one propose a materialistic scientist to consider anything more irritating than singing and crying magnetic bodies!
4. Suppose that the homeopathic mechanism is based on replication of pseudomolecules with same magnetic body as that of solvent molecules and that neutral dark nuclear strings realize analogs of DNA, RNA, and aminoacids and realizing genetic code exactly in its vertebrate nuclear form and appearing also in the TGD based model of cold fusion and biological transmutations. If so, then homeopathic mechanism (recognition of molecules) could involve also the transformation of cyclotron radiation to sound at the level of "biological bodies" of molecules.
5. If this picture makes sense then also our speech as a self expression of the magnetic body might involve genetic code mapping sequences of DNA codons to temporal patterns of cyclotron radiation in turn transformed to speech by above mechanism. This would require a realization of genetic code at level of dark matter: could it be that dark nuclear code could define universal quantum level realization of language? The findings of Peter Gariaev and others and structural resemblance of intronic portion of genome with language and their report that DNA sequences are coded to temporal patterns of the rotation angle of the polarization of laser light (in turn inducing genetic expression).

7.4 Further experimental findings related to water memory

In this section I discuss further experimental findings giving support for both TGD based view about water memory and TGD based vision about living cell.

7.4.1 Genes and water memory

After long time I had opportunity to read a beautiful experimental article about experimental biology. Yolene Thomas, who worked with Benveniste, kindly sent the article to me. The freely loadable article is *Electromagnetic Signals Are Produced by Aqueous Nanostructures Derived from Bacterial DNA Sequences* by Luc Montagnier, Jamal Aissa, Stephane Ferris, Jean-Luc Montagnier, and Claude Lavall'e published in the journal *Interdiscip. Sci. Comput. Life Sci.* (2009) [I98].

Basic findings at cell level

I try to list the essential points of the article. Apologies for biologists: I am not a specialist.

1. Certain pathogenic micro-organisms are objects of the study. The bacteria *Mycoplasma Pirum* and *E. Choli* belong to the targets of the study. The motivating observation was that some procedures aimed at sterilizing biological fluids can yield under some conditions the infectious micro-organism which was present before the filtration and absent immediately after it. For instance, one filtrates a culture of human lymphocytes infected by *M. Pirum*, which has infected human lymphocytes to make it sterile. The filters used have 100 nm and 20 nm porosities. *M. Pirum* has size of 300 nm so that apparently sterile fluids results. However if this fluid is incubated with a mycoplasma negative culture of human lymphocytes, mycoplasma re-appears within 2 or 3 weeks! This sounds mysterious. Same happens as 20 nm filtration is applied to a minor infective fraction of HIV, whose viral particles have size in the range 100-120 nm.

2. These findings motivated a study of the filtrates and it was discovered that they have a capacity to produce low frequency electromagnetic waves with frequencies in good approximation coming as the first three harmonics of kHz frequency, which by the way plays also a central role in neural synchrony. What sounds mysterious is that the effect appeared after appropriate dilutions with water: positive dilution fraction varied between 10^{-7} and 10^{-12} . The uninfected eukaryotic cells used as controls did not show the emission. These signals appeared for both *M. Pirum* and *E. Choli* but for *M. Pirum* a filtration using 20 nm filter canceled the effect. Hence it seems that the nano-structures in question have size between 20 and 100 nm in this case.

A resonance phenomenon depending on excitation by the electromagnetic waves is suggested as an underlying mechanism. Stochastic resonance familiar to physicists suggests itself and also I have discussed it while developing ideas about quantum brain [K65]. The proposed explanation for the necessity of the dilution could be kind of self-inhibition. Maybe a gel like phase which does not emit radiation is present in sufficiently low dilution but is destroyed in high dilutions after which emission begins. Note that the gel phase would not be present in healthy tissue. Also a destructive interference of radiation emitted by several sources can be imagined.

3. Also a cross talk between dilutions was discovered. The experiment involved two tubes. Donor tube was at a low dilution of *E. Choli* and "silent" (and carrying gel like phase if the above conjecture is right). Receiver tube was in high dilution (dilution fraction 10^{-9}) and "loud". Both tubes were placed in mu-metal box for 24 hours at room temperature. Both tubes were silent after this. After a further dilution made for the receiver tube it became loud again. This could be understood in terms of the formation of gel like phase in which the radiation does not take place. The effect disappeared when one interposed a sheath of mu-metal between the tubes. Emission of similar signals was observed for many other bacterial species, all pathogenic. The transfer occurred only between identical bacterial species which suggests that the signals and possibly also frequencies are characteristic for the species and possibly code for DNA sequences characterizing the species.
4. A further surprising finding was that the signal appeared in dilution which was always the same irrespective of what was the original dilution.

Experimentation at gene level

The next step in experimentation was performed at gene level.

1. The killing of bacteria did not cancel the emission in appropriate dilutions unless the genetic material was destroyed. It turned out that the genetic material extracted from the bacteria filtered and diluted with water produced also an emission for sufficiently high dilutions.
2. The filtration step was essential for the emission also now. The filtration for 100 nm did not retain DNA which was indeed present in the filtrate. That effect occurred suggests that filtration destroyed a gel like structure inhibiting the effect. When 20 nm filtration was used the effect disappeared which suggests that the size of the structure was in the range 20-100 nm.
3. After the treatment by DNase enzyme inducing splitting of DNA to pieces the emission was absent. The treatment of DNA solution by restriction enzyme acting on many sites of DNA did not suppress the emission suggesting that the emission is linked with rather short sequences or with rare sequences.
4. The fact that pathogenic bacteria produce the emission but not "good" bacteria suggests that effect is caused by some specific gene. It was found that single gene - adhesin responsible for the adhesion of mycoplasma to human cells- was responsible for the effect. When the cloned gene was attached to two plasmids and the *E. Choli* DNA was transformed with the either plasmid, the emission was produced.

Some consequences

The findings could have rather interesting consequences.

1. The refinement of the analysis could make possible diagnostics of various diseases and suggests bacterial origin of diseases like Alzheimer disease, Parkinson disease, Multiple Sclerosis and Rheumatoid Arthritis since the emission signal could serve as a signature of the gene causing the disease. The signal can be detected also from RNA viruses such as HIV, influenza virus A, and Hepatitis C virus.
2. Emission could also play key role in the mechanism of adhesion to human cells making possible the infection perhaps acting as a kind of password.

The results are rather impressive. Some strongly conditioned skeptic might have already stopped reading after encountering the word "dilution" and associating it with a word which no skeptic scientist in his right mind should not say aloud: "homeopathy"! By reading carefully what I wrote above, it is easy to discover that the experimenters unashamedly manufactured a homeopathic remedy out of the filtrate! And the motivating finding was that although filtrate should not have contained the bacteria, they (according to authors), or at least the effects caused by them, appeared within weeks to it! This is of course impossible in the word of skeptic.

The next reaction of the skeptic is of course that this is fraud or the experimenters are miserable crackpots. Amusingly, one of the miserable crackpots is Nobelist Luc Montagnier, whose research group discovered AIDS virus.

How TGD could explain the findings?

Let us leave the raging skeptics for a moment and sketch possible explanations in TGD framework.

1. Skeptic would argue that the filtration allowed a small portion of infected cells to leak through the filter. Many-sheeted space-time suggests a science fictive variant of this explanation. During filtration part of the infected cells is "dropped" to large space-time sheets and diffused back to the original space-time sheets during the next week. This would explain why the micro-organisms were regenerated within few weeks. Same mechanism could work for ordinary molecules and explain homeopathy. This can be tested: look whether the molecules return back to the the diluted solution in the case of a homeopathic remedy.
2. If no cells remain in the filtrate, something really miraculous looking events are required to make possible the regeneration of the effects serving as the presence of cells. This even in the case that DNA fragments remain in the filtrate.
 - (a) The minimum option is that the presence of these structures contained only the relevant information about the infecting bacteria and this information coded in terms of frequencies was enough to induce the signatures of the infection as a kind of molecular conditioning. Experimentalists can probably immediately answer whether this can be the case.
 - (b) The most radical option is that the infecting bacteria were actually regenerated as experimenters claim! The information about their DNA was in some form present and was transcribed to DNA and/or RNA, which in turn transformed to proteins. Maybe the small fragment of DNA (adhesin) and this information should have been enough to regenerate the DNA of the bacterium and bacterium itself. A test for this hypothesis is whether the mere nanoparticles left from the DNA preparation to the filtrate can induce the regeneration of infecting molecules.

The notion of magnetic body carrying dark matter quantum controlling living matter forms the basic element of TGD inspired model of quantum biology and suggests a more concrete model. The discovery of nanotubes connecting cells with distance up to 300 μ [I92] provides experimental support for the notion .

1. If the matter at given layer of the onion-like structure formed by magnetic bodies has large \hbar , one can argue that the layer corresponds to a higher evolutionary level than ordinary matter with longer time scale of memory and planned action. Hence it would not be surprising if the magnetic bodies were able to replicate and use ordinary molecules as kind of sensory receptors and motor organs. Perhaps the replication of magnetic bodies preceded the replication at DNA level and genetic code is realized already at this more fundamental level somehow. Perhaps the replication of magnetic bodies induces the replication of DNA as I have suggested.

2. The magnetic body of DNA could make DNA a topological quantum computer [K28]. DNA itself would represent the hardware and magnetic bodies would carry the evolving quantum computer programs realized in terms of braidings of magnetic flux tubes. The natural communication and control tool would be cyclotron radiation besides Josephson radiation associated with cell membranes acting as Josephson junctions. Cyclotron frequencies are indeed the only natural frequencies that one can assign to molecules in kHz range. There would be an entire fractal hierarchy of analogs of EEG making possible the communication with and control by magnetic bodies.
3. The values of Planck constant would define a hierarchy of magnetic bodies which corresponds to evolutionary hierarchy and the emergence of a new level would mean jump in evolution. Gel like phases could serve as a correlate for the presence of the magnetic body. The phase transitions changing the value of Planck constant and scale up or down the size of the magnetic flux tubes. They are proposed to serve as a basic control mechanism making possible to understand the properties and the dynamics of the gel phases and how biomolecules can find each other in the thick molecular soup via a phase transition reducing the length of flux tubes connecting the biomolecules in question and thus forcing them to the vicinity of each other.

Consider now how this model could explain the findings.

1. Minimal option is that the the flux tubes correspond to "larger space-time sheets" and the infected cells managed to flow into the filtrate along magnetic flux tubes from the filter. This kind of transfer of DNA might be made possible by the recently discovered nanotubes already mentioned.
2. Maybe the radiation resulted as dark photons invisible for ordinary instruments transformed to ordinary photons as the gel phase assignable with the dark matter at magnetic flux tube network associated with the infected cells and corresponding DNA was destroyed in the filtration.

This is not the only possible guess. A phase conjugate cyclotron radiation with a large value of Planck constant could also allow for the nanostructures in dilute solute to gain metabolic energy by sending negative energy quanta to a system able to receive them. Indeed the presence of ambient radiation was necessary for the emission. Maybe that for sufficiently dilute solute this mechanism allows to the nanostructures to get metabolic energy from the ambient radiation whereas for the gel phase the metabolic needs are not so demanding. In the similar manner bacteria form colonies when metabolically deprived. This sucking of energy might be also part of the mechanism of disease.

3. What could be the magnetic field inducing the kHz radiation as a synchrotron radiation?
 - (a) For instance, kHz frequency and its harmonics could correspond to the cyclotron frequencies of proton in magnetic field which field strength slightly above that for Earth's magnetic field (750 Hz frequency corresponds to field strength of B_E , where $B_E = .5$ Gauss, the nominal strength of Earth's magnetic field). A possible problem is that the thickness of the flux tubes would be about cell size for Earth's magnetic field from flux quantization and even larger for dark matter with a large value of Planck constant. Of course, the flux tubes could make themselves thinner temporarily and leak through the pores.
 - (b) If the flux tube is assumed to have thickness of order 20-100 nm, the magnetic field for ordinary value of \hbar would be of order .1 Tesla from flux quantization and in the case of DNA the cyclotron frequencies would not depend much on the length of DNA fragment since the it carries a constant charge density. Magnetic field of order .2 Tesla would give cyclotron frequency of order kHz from the fact that the field strength of .2 Gauss gives frequency of about .1 Hz. This correspond to a magnetic field with flux tube thickness ~ 125 nm, which happens to be the upper limit for the porosity. Dark magnetic flux tubes with large \hbar are however thicker and the leakage might involve a temporary phase transition to a phase with ordinary value of \hbar reducing the thickness of the flux tube. Perhaps some genes (adhesin) plus corresponding magnetic bodies representing DNA in terms of cyclotron frequencies depending slightly on precise weight of the DNA sequence and thus coding it correspond to the frequency of cyclotron radiation are the sought for nano-structures.

4. While developing a model for homeopathy based on dark matter I ended up with the idea that dark matter consisting of nuclear strings of neutrons and protons with a large value of \hbar and having thus a zoomed up size of nucleon could be involved. The really amazing finding was that nucleons as three quark systems allow to realize vertebrate code in terms of states formed from entangled quarks [L7], [L7] described also in this chapter! One cannot decompose codons to letters as in the case of the ordinary genetic code but codons are analogous to symbols representing entire words in Chinese. The counterparts of DNA, RNA, and aminoacids emerge and genetic code has a concrete meaning as a map between quantum states.

Without any exaggeration this connection between dark hadronic physics and biology has been one of the greatest surprises of my professional life. It suggests that dark matter in macroscopic quantum phase realizes genetic code at the level of nuclear physics and biology only provides one particular (or probably very many as I have proposed) representations of it. If one takes this seriously one can imagine that genetic information is represented by these dark nuclear strings of nanoscopic size and that there exists a mechanism translating the dark nuclei to ordinary DNA and RNA sequences and thus to biological matter. This would explain the claimed regeneration of the infected cells.

5. Genetic code at dark matter level would have far reaching implications. For instance, living matter - or rather, the magnetic bodies controlling it - could purposefully perform genetic engineering. This forces me to spit out another really dirty word, "Lamarckism"! We have of course learned that mutations are random. The basic objection against Lamarckism is that there is no known mechanism which would transfer the mutations to germ cells. In the homeopathic Universe of TGD the mutations could be however performed first for the dark nucleon sequences. After this these sequences would diffuse to germ cells just like homeopathic remedies do, and after this are translated to DNA or RNA and attach to DNA.

7.4.2 Water electric as protocell

Ulla Matfolk sent to me some interesting material at the web page of Dr. Mae-Wan Ho which provides further insights into the model of cell. The articles are "Water electric" [D27] and "Making Fuel from Water" [D25]. The articles summarize an experimental discovery which could be called Pollack-Zheng effect [D39, D19]. Both articles relate closely to what might be called the holy grail of artificial photosynthesis. The unreasonable effectiveness of photosynthesis in the sense that the waste of energy during the process is extremely small, makes artificial photosynthesis an excellent candidate for the final solution of energy problems as far energy sources and minimization of wastes are considered. In the following I comment only the first paper in detail from TGD viewpoint.

How photosynthesis manages to be so effective is one of the mysteries of biology. TGD based view about metabolic energy involves two ideas.

1. TGD predicts a hierarchy of metabolic energy quanta [K8, K38]. The basic quanta come as $E(k) = 2^k E_0$, where k is positive or negative integer and $E_0 \simeq .5$ eV holds true. For instance, 2 eV metabolic energy quantum corresponding to red light corresponds to $k = 3$. This is actually oversimplification since there is a cascade of quanta $E(k, n) = (1 - 2^{-n}) E(k)$ converging to $E(k)$ for each p-adic length scale. These energies correspond to energies liberated when electron or proton drops to a larger space-time sheet at the limit when second space-time becomes very large and the particle starts from rest and remains to rest: this is second idealization as also the particle in a box geometry. The idea is that these universal metabolic energy quanta preceded the metabolism based on chemical storage of energy and that the primary step in photosynthesis is kicking of proton or electron to a smaller space-time sheet.
2. Second idea relies on the hierarchy of Planck constants.
 - (a) The rate of dissipation - that this the energy wasted per unit time - is inversely proportional to \hbar in the first naive guess and means that macroscopically quantum coherent dark matter dissipates very little. Could photon kick charged dark particles to smaller space-time sheet where they dissipate very little? Or could photosynthesis capture ordinary or dark photons of sunlight to some layer of the onion like structure formed by the magnetic body of the

organism, where it kicks particles to smaller space-time sheets. This light could correspond to bio-photons liberated as the biological body of the organism dies.

- (b) Could this storage of photons have preceded chemical storage of energy in living matter? And could this energy reserve explain some rather mysterious findings about the ability of some people to survive without ordinary metabolic energy feed (usually saints and this kind of people telling that light is enough for them to survive;-). Also animals are capable to these metabolic miracles [I120] : see the article "Researchers Seek to Demystify the Metabolic Magic of Sled Dogs" in Science. Of course, the storage of energy to that of dark matter or dark photons confined to the net defined by magnetic flux tubes could be the eventual manner to avoid energy waste and associated entropy growth inducing environmental problems. Hierarchy of Planck constants would allow the storage in arbitrary long length scales for given energy of photon so that even a community of organisms could have collective metabolic energy resources: maybe synergy has something to do with this.

The first article summarizing the Pollack-Zheng effect gives quantitative support for this picture. I have formatted the text as comments to the summary represented in the article of Mae-Wan Ho [D27]

Exclusion zones

The article summarizes the sequence of events initiated by the discovery of Gerald Pollack and his student Jian-ming Zheng [D39, D19] . As a matter fact, the fascinating findings described in detail by Gerald Pollack in his book were absolutely crucial for the recent TGD based view about quantum biology in which dark matter plays key role.

1. Pollack and his student discovered that suspensions of colloids and dissolved substances are excluded from a region extending some hundreds of micrometres from the surfaces of hydrophilic gels. An exclusion zone (EZ) of this magnitude conflicts the belief that interfacial water forming at liquid-solid, or liquid-air interfaces can be no more than a few layers of molecules thick. What's observed is a million layers or more! 'Exclusion' means that the water suspension of micro-spheres moved away from the surface of gel with constant velocity and behaving like single structural unit.

Comment: The sizes of cells vary up to hundreds of micrometers and cells are by definition structures which are isolated from the environment. Maybe EZs represent protocells or their predecessors. Pollack and coauthors have indeed proposed that their finding might relate to the origin of life [D19] . That the surface was that of gel might be important. In TGD based model of living matter gels have magnetic bodies and their presence might relate to the formation of the thick water layer in non-standard phase.

2. Similar exclusion zones were found next to any hydrophilic surface including surfaces coated with a monolayer of hydrophilic molecules, and around ion exchange resin beads. Electric charge appears to be important, as EZ failed to form around charge-exhausted resin beads. Although EZ can form in pure water, it is enhanced and stabilized by low concentrations of buffer (2 to 10 mM at pH 7).

Comment: Hydrophily could correspond to the formation of magnetic flux tubes connecting the hydrophilic surface to water molecules as assumed in the model of protein folding and biocatalysis [K4] .

3. The EZ phase is very different from the bulk water. An unusually ordered crystalline phase where the molecules are less free to move is suggestive. The UV and visible absorption spectrum gave a single absorption peak at $\lambda \simeq 270$ nm in the UV region completely absent in the bulk phase. The infrared emission record showed that the EZ radiates very little compared with bulk water, as would be expected on account of the reduced mobility of water molecules. The magnetic resonance imaging mapping similarly gave a transverse relaxation time (T2) of 25.4 + 1 ms, which is shorter than the 27.1 + 0.4 ms recorded for the bulk water phase, again indicative of restricted motion.

Comment: The reduced radiation might mean that part of photons are dark and bound inside magnetic flux tubes defining a structure responsible for the formation of gel like phases inside cell and perhaps also inside EZ. The interpretation as bio-photons is suggestive. This phase of water could be predecessor of the water in cell interior since in the crystalline phase long bio polymers like DNA and aminoacid sequences would be stable against hydration.

4. EZ had a different electrical potential from the bulk phase, by as much as 100–200 mV, depending on the hydrophilic surface. With a negatively charged surface such as polyacrylic acid or Nafion (widely used as a proton exchange membrane), the potential is negative compared with the bulk water away from the EZ. Simultaneously, the hydrogen ion (proton, H^+) concentration is high just outside the EZ, decreasing in a gradient away from it. This indicates that the formation of the EZ is accompanied by a separation of positive and negative electrical charges, which led to the build up of electrical potential between the EZ and the bulk water. In effect, the water has become an electrical battery, and can provide electricity through an external circuit.

Comment: Cell membrane is also a battery and the potential is around 50–80 mV to be compared with 100–200 mV, and the size scale of cell varies from 5 micrometer to hundreds of micrometers so that EZs could be involved with the formation of cell and cell membranes. The kicking of electrons or protons to smaller space-time sheet could be the mechanism inducing electric potential at a given space-time sheet. The formation of battery would mean that water could some day used to store very effectively the energy of solar radiation.

A connection with photosynthesis

Separating H^+ from e^- (electron) is the first step of photosynthesis in green plants which provides energy for most of the biosphere. In this case the energy comes from solar radiation. The separation of charges requires energy also in the case of EZ and the question is where this energy comes from in the case of EZ.

1. A clue came after having inadvertently left the experimental chamber with the EZ on the microscope overnight. Next morning, the EZ had shrunk considerably. But after turning on the microscope lamp, it began to immediately grow again, restoring itself within minutes to its former size. The energy for EZ formation comes from light, as in photosynthesis, but it can use the low energy part of the solar spectrum that photosynthesis cannot.

Comment: Could one consider the possibility that photosynthesis involves unknown step and this step is just the kicking of electrons or protons to a smaller space-time sheet. This step would also induce the separation of charges and the generation of electric potential.

2. Although the entire spectrum of visible light appeared effective in making the EZ grow, the most effective part is in the infrared region, peaking at $\lambda \simeq 3100$ nm. A 10 minute exposure at that wavelength expanded the width of an EZ 3.7 times, and after an hour of exposure, the expansion was more than 6 times. After the light was turned off, the EZ remained constant for about 30 minutes before beginning to shrink, reaching halfway to its baseline level in about 15 minutes.

Comment: $\lambda = 3100$ nm corresponds to .4 eV. The nominal value of the fundamental metabolic energy quantum is around $E_0 = .5$ eV and one has $E(k=0, n=3) = 0.4375$ eV for this value of E_0 . Perhaps the photons indeed kick electrons or protons to a smaller space-time sheet.

- (a) In the case of protons the smaller space-time sheet would correspond to atomic space-time sheets characterized by $p \simeq 2^{137}$: the larger one would correspond to $k = 141$.
- (b) For electrons the size of the smaller space-time sheet would be by a factor $m_p/m_e = 940/.5 = 1880 \simeq 2^{11}$ larger and would correspond to $k = 137 + 11 = 148$. This is one half of the thickness of the lipid layer of cell membrane. The larger space-time sheet would correspond to cell membrane thickness $L(151) = 10$ nm and perhaps the dark space-time sheet serving as a template for the formation of the cell membrane! If $E = .4$ eV corresponds to electron, then proton would correspond to $E(0, 3) = .44$ eV giving for the metabolic energy quantum the value $E_0(p) = 0.5029$ eV in the case of proton and $E_0(e) = 0.4616$ eV in the case of electron.

- When the UV and visible range was tested, a peak in the degree of EZ expansion was detected at $\lambda = 270$ nm in the UV region, corresponding to the characteristic absorption peak of EZ that was identified before. However, as the optical power used in the UV and visible region was 600 times that in the IR, the most profound effect was identified in the IR region, particularly at 3 100 nm.

Comment: $\lambda = 270$ nm corresponds to the energy 4.5926 eV. $E=4$ eV is the nearest metabolic energy quantum. This energy does not correspond directly to any metabolic energy quantum assignable to .4 eV or .43 eV. One must be however cautious with conclusions since the model is very rough.

- The mechanism of EZ formation is still unknown. But the two wavelengths that expand the EZ most effectively may offer some hint. The UV wavelength 270 nm is close to the 250 nm ($\simeq 5$ eV) required to ionize water under standard state conditions and taking into account the hydration of the resulting ions. The 3 100 nm peak, on the other hand is close to the OH stretch of the ring hexamer identified as the most abundant species in infrared predissociation spectroscopy of large water clusters, and also in neon matrices by infrared spectroscopy. These results suggest that photoexcitation of ring hexamers and photoionisation followed by ejection of protons play synergistic roles in the assembly of the EZ phase. Pollack and colleagues believe that the infrared radiation, though normally insufficient to break OH bonds, can nevertheless work via resonance induced dissociation of large hydrogen-bonded networks.

Comment: Ring hexamers bring in mind the crucial role of aromatic cycles in TGD inspired model of DNA as topological quantum computer which leads also to a model of $ADP \leftrightarrow ATP$ transition involving reconnection of magnetic flux tubes and having also information theoretic interpretation as a change of the topology of the braid structure defining topological quantum computer program [K28] . Magnetic flux tubes carrying dark electrons begin from these and can end up to other bio-molecules or water. Just a guess: could they end on ring hexamers?

Summary

The findings suggest additional details to the TGD based view about living matter.

- The kicking of electrons or protons or both of them to a larger space-time sheet would be the first step in photosynthesis as I indeed suggested for years ago. The energy of 3100 nm photons indeed corresponds to that for the fundamental metabolic energy quantum. I have also proposed this process to be a fundamental step also in bio-catalysis: the temporary dropping of electron or proton of the catalyst molecule could provide the energy helping the reacting molecules to overcome the potential wall preventing the reaction from running. This metabolic coin could be returned to catalyst with high enough probability or the photons exchanged could be virtual.
- The findings suggest also a mechanism for how solar radiation generates proto cells or their predecessors. The resulting phases of water have size extending to those for largest cells and the water could involve a gel like phase in which magnetic flux tubes containing dark matter could play a key role and eventually lead to quantum computer like behavior [K28] . The kicking of electrons (or protons) to smaller space-time sheet would induce ionization at given space-time sheet so that electric potential difference would result. The magnitude of the potential difference is of a correct order of magnitude. Cell membrane scale is present as a p-adic length scale for the space-time sheet of electrons before the kicking to the smaller space-time sheet and these space-time sheets could act as templates for the formation of cell membrane.
- Interestingly, TGD based model of high T_c super conductivity predicts that both cell membrane length scale and size scale of cell are involved with the super-conductivity [K13] . Cell membrane acts as a Josephson junction in TGD based model of cell membrane, nerve pulse, and EEG.

7.4.3 A model for chiral selection

Chiral selection of bio-molecules is one of the basic mysteries of biology and it is interesting to see whether the existing bits of data combined with vision about quantum TGD could help to build a coherent picture about the situation. Let us first try to identify the most important pieces of the puzzle.

1. Chiral selection requires parity breaking in the scale of biomolecules. Standard model predicts parity breaking interactions but the effects are extremely small above intermediate boson length scale which is by a factor 10^{-7} shorter than atomic length scale. The proposed solution of the problem is that dark variants of intermediate gauge bosons are in question so that the Compton lengths of intermediate gauge bosons are scaled up by a factor $r = \hbar/\hbar_0$. Below the dark Compton length weak gauge bosons would be effectively massless and above it possess ordinary masses. Large parity breaking effects induced by dark intermediate gauge bosons would be possible.
2. For instance, for $r = 2^{44}$ for which EEG photons have energies just above thermal threshold at room temperature, the effective p-adic length scale would correspond to $L(k)$, $k = 89 + 44 = 133$ of about .2 Angstrom. This scale in turn would scale up to $L(133 + 44 = 177)$. Secondary p-adic length scale assignable to $k = 89$ which is important in zero energy ontology would correspond to $k = 2 \times 89 = 178$ which corresponds to about $L(178) \simeq 100 \mu\text{m}$, the length scale assignable to large cells and the thickness of water layers in the experiment of Pollack.
3. Parity breaking interaction is associated with spin and the interaction energy of form $ks \cdot E_Z$, where s is the spin of particle and E_Z is Z^0 electric field. Classical induced gauge fields are very strongly correlated in TGD since they are expressible in terms of four CP_2 coordinates and their gradients. Hence classical electromagnetic field E is in the generic case accompanied by classical Z^0 field $E_Z = aE$. This means that if there is classical electromagnetic field and charge density at the dark space-time sheet, large parity breaking effect is possible at the level of spin. The induced Z^0 electric field could force the spins to become parallel and in this manner induce also magnetization.

The crucial finding about which I learned three years ago is that L glutamate is more stable than R glutamate in water and that heavy water does not induce this effect [I106]. This suggests a connection with Pollack-Zheng effect [D39]. Heavy water nuclei have vanishing spin whereas hydrogen nuclei have spin $1/2$ so that H_2 in water molecules can be in spin singlet or triplet states (para and ortho configurations). Could the nuclear spin of water molecules somehow induce parity breaking and the magnetic interaction distinguishing between these molecules?

1. Suppose that bio-molecules in question have magnetic moment and water carries magnetic field, most naturally at dark magnetic flux tubes. The parity breaking interaction energy $-p \cdot E$ with dark electric field remains invariant under reflection and rotation of π changing the orientation of the mirror image of the molecule with respect to electric field. The interaction energy with magnetic field however changes its sign since magnetic moment is not affected by the reflection but changes direction under rotation. The angular momentum of the molecule responsible for the magnetic moment can of course change sign but since the transformation involves acts on angular momenta only, it is not a symmetry of entire system. Indeed, if there is interaction between angular momentum degrees of freedom and geometric degrees of freedom the magnetic interaction energy for the mirror image is different. Suppose that the breaking of reflection symmetry induced by the chirality of the molecule induces internal electric field E_{int} . The parity breaking interaction energy $ks \cdot E_{int}$ would indeed break the symmetry in the transformation changing the directions of angular momenta and spins.
2. It deserves to be emphasize that the parity breaking of the molecule itself would induce the symmetry breaking if molecule possesses dark magnetic body. One can actually imagine a cascade of parity breakings proceeding from shorter to longer length scales in this manner.
3. The mechanism creating electric field could be the charging of water, perhaps by the Pollack-Zheng mechanism and having in TGD framework an interpretation as a basic mechanism storing the energy of sunlight to metabolic energy (kicking of electrons and/or protons to a smaller space-time sheet so that oppositely charge space-time sheets emerge as a consequence). A direct connection with metabolism would be admittedly a highly satisfactory feature of the mechanism.
4. Parity breaking energy $ks \cdot E$ for say dark protons assignable to hydrogen nuclei of bio-molecules in the internal electric field of the molecule or dark protons of water molecules in the electric field induced by Pollack-Zheng effect [D39] does not change sign under the reflection of the molecule

so that spin polarization independent of chirality could result from both water molecules in crystal like phase and for bio-molecules possessing dark protons (and dark hydrogen atoms). This could in turn serve as a seed for magnetization essential for the existence of dark magnetic flux tubes.

If water is replaced with heavy water there is no difference between L and R. What distinction H and D could explain this difference?

1. The basic difference between water and heavy water nuclei is that for water nucleus is just proton having spin $1/2$ so that H_2 in water molecule can be in spin triplet and singlet states. Fractions of the two states are $3/4$ and $1/4$ in the absence of external magnetic field.
2. On the other hand, in attosecond time scale (corresponding length scale is 3 Angstroms) water is known to behave effectively as $H_{1.5}O$. A possible explanation is that $1/4$ th of H nuclei/atoms are effectively dark having large Planck constant. The dark protons cannot correspond to H_2 in spin singlet state since the interaction energy $ks \cdot E$ would be small in this case. Dark spin triplet states of H_2 could however induce parity breaking in water and make crystal like water phase both electret and magnet. If the spin $s_z = 1$ with negative interaction energy with E becomes dark then $1/4$ of hydrogen atoms would be dark and $H_{1.5}O$ formula would hold true. For D_2O this mechanism would not work.
3. The model for homeopathy led to the idea that dark nuclei consisting of scale up variants of nucleons possibly having size of order atomic length scale could be crucial for understanding living matter. The states of nucleons correspond naturally to those DNA, RNA, and amino acids and vertebrate genetic code emerges naturally with DNA code word replaced with 3 quark state with entanglement between the quarks representing the information. Could it be that dark protons of water combine to form dark nuclei providing a fundamental representation of the genetic code and could the spin of protons induce electro-weak chiral symmetry breaking. Also now this mechanism fails for D_2O .

7.4.4 Burning water and photosynthesis

For a physicist liberated from the blind belief in reductionism, biology transforms to a single gigantic anomaly about which recent day physics cannot say much. During years I have constructed several models for these anomalies helping to develop a more detailed view about how the new physics predicted by quantum TGD could allow to understand biology and consciousness.

The basic problem is of course the absence of systematic experimentation so that it is possible to imagine many new physics scenarios. For this reason the article series of Mae-Wan Ho [D27, D25, D23, D26] in ISIS was a very pleasant surprise, and already now has helped considerably in the attempts to develop the ideas further.

The first article "Water electric" [D27] told about the formation of exclusion zones around hydrophilic surfaces, typically gels in the experiments considered [D39]. The zones were in potential of about 100 meV with respect to surroundings (same order of magnitude as membrane potential) and had thickness ranging to hundreds of micrometers (the size of a large cell): the standard physics would suggest only few molecular layers instead of millions. Sunlight induced the effect. This finding allowed to develop TGD based vision about how proto cells emerged and also the model for chiral selection in living matter by combining the finding with the anomalies of water about which I had learned earlier.

The article "Can water burn?" [D23] tells about the discovery of John Kanzius - a retired broadcast engineer and inventor. Kanzius found that water literally burns if subjected to a radio frequency radiation at frequency of 13.56 MHz [D2]. The mystery is of course how so low frequency can induce burning. The article "The body does burn water" [D26] notices that plant cells burn water routinely in photosynthesis and that also animal cells burn water but the purpose is now to generate hydrogen peroxide which kills bacteria (some readers might recall from childhood how hydrogen peroxide was used to sterilize wounds!). Hence the understanding of how water burns is very relevant for the understanding of photosynthesis and even workings of the immune system.

Living matter burns water routinely

Photosynthesis burns water by decomposing water to hydrogen and oxygen and liberating oxygen. Oxygen from CO_2 in atmosphere combines with the oxygen of H_2O to form O_2 molecules whereas H from H_2O combines with carbon to form hydrocarbons serving as energy sources for animals which in turn produce CO_2 . This process is fundamental for aerobic life. There is also a simpler variant of photosynthesis in which oxygen is not produced and applied by an-aerobic life forms. The article "Living with Oxygen" by Mae-Wan Ho gives a nice overall view about the role of oxygen [D24]. As a matter fact, also animals burn water but they do this to produce hydrogen peroxide H_2O_2 which kills very effectively bacteria.

Burning of water has been studied as a potential solution for how to utilize the solar energy to produce hydrogen serving as a natural fuel [D25]. The reaction $O_2 + H_2 \rightarrow 2H_2O$ occurs spontaneously and liberates energy of about 1.23 eV. The reverse process $2H_2 \rightarrow H_2O_2 + H_2$ in the presence of sunlight means burning of water, and could provide the manner to store solar energy. The basic reaction $2H_2O + 4h\nu \leftrightarrow H_2O_2 + H_2$ stores the energy of four photons. What really happens in this process is far from being completely understood. Quite generally, the mechanisms making possible extreme efficiency of bio-catalysis remain poorly understood. Here new physics might be involved. I have discussed models for photosynthesis and $ADP \leftrightarrow ATP$ process involved with the utilization of the biochemical energy already earlier [K38].

How water could burn in TGD Universe?

The new results could help to develop a more detailed model about what happens in photosynthesis. The simplest TGD inspired sketch for what might happen in the burning of water goes as follows.

1. Assume that 1/4 of water molecules are partially dark (in sense of nonstandard value of Planck constant) or at least at larger space-time sheets in atto-second scale [D10, D9, D13, D35]. This would explain the $H_{1.5}O$ formula explaining the results of neutron diffraction and electron scattering.
2. The question is what this exotic fraction of water precisely is. The models for water electret, exclusion zones and chiral selection lead to concrete ideas about this. Electrons assignable to the H atoms of (partially) dark H_2O reside at space-time sheet $k_e = 151$ (this p-adic length scale corresponds to 10 nm, the thickness of cell membrane). At least the hydrogen atom for this fraction of water molecules is exotic and findings from neutron and electron scattering suggest that both proton and electron are at non-standard space-time sheets but not necessarily at the same space-time sheet. The model for the burning requires that electron and proton are at different space-time sheets in the initial situation.
3. Suppose all four electrons are kicked to the space-time sheet of protons of the exotic hydrogen atoms labeled by k_p . This requires the energy $E_\gamma = (1 - 2^{-n})E_0(k_p)$ (the formula involves idealizations). At this space-time sheet protons and electrons are assumed to combine spontaneously to form two H_2 atoms. Oxygen atoms in turn are assumed to combine spontaneously to form O_2 .
4. For $k_f = 148$ and $n = 3$ minimum energy needed would be $4E_\gamma = 4 \times .4 = 1.6$ eV. For $k_p = 149$ (thickness of lipid layer) and $n = 2$ one would have $4E_\gamma = 4 \times .3462 = 1.385$ eV whereas $H_2O_2 + H_2 \rightarrow 2H_2O$ liberates energy 1.23 eV. Therefore the model in which electrons are at cell membrane space-time sheet and protons at the space-time sheet assignable to single lipid layer of cell membrane suggests itself. This would also mean that the basic length scales of cell are already present in the structure of water. Notice that there is no need to assume that Planck constant differs from its standard value.

There is no need to add, that the model is an unashamed oversimplification of the reality. It might however catch the core mechanism of photosynthesis.

Burning of salt water induced by RF radiation

Engineer John Kanzius has made a strange discovery [D2] : salt water in the test tube radiated by radiowaves at harmonics of a frequency $f=13.56$ MHz burns. Temperatures about 1500 K, which correspond to .15 eV energy have been reported. One can irradiate also hand but nothing happens. The original discovery of Kanzius was the finding that radio waves could be used to cure cancer by destroying the cancer cells. The proposal is that this effect might provide new energy source by liberating chemical energy in an exceptionally effective manner. The power is about 200 W so that the power used could explain the effect if it is absorbed in resonance like manner by salt water.

Mae-Wan Ho's article "Can water Burn?" [D23] provides new information about burning salt water [D2] , in particular reports that the experiments have been replicated. The water is irradiated using polarized radio frequency light at frequency 13.56 MHz. The energy of radio frequency quantum is $E_{rf} = .561 \times 10^{-7}$ eV and provides only a minor fraction $E_{rf}/E = .436 \times 10^{-7}$ of the needed energy which is $E = 1.23$ eV for single $2H_2O \rightarrow H_2O_2 + H_2$ event. The structure of water has been found to change, in particular something happens to O-H bonds. The Raman spectrum of the water has changed in the energy range [0.37, 0.43] eV. Recall that the range of metabolic energy quanta $E(k, n) = (1 - 2^{-n})E_0(k)$ varies for electron in the range [.35, .46] eV in the model for the formation of exclusion zone induced by light. Therefore the photons assigned to changes in Raman spectrum might be associated with the transfer of electrons between space-time sheets.

The energies of photons involved are very small, multiples of 5.6×10^{-8} eV and their effect should be very small since it is difficult to imagine what resonant molecular transition could cause the effect. This leads to the question whether the radio wave beam could contain a considerable fraction of dark photons for which Planck constant is larger so that the energy of photons is much larger. The underlying mechanism would be phase transition of dark photons with large Planck constant to ordinary photons with shorter wavelength coupling resonantly to some molecular degrees of freedom and inducing the heating. Microwave oven of course comes in mind immediately.

As I made this proposal, I did not realize the connection with photosynthesis and actual burning of water. The recent experimental findings suggest that dark radio frequency photons transform to photons inducing splitting of water as in photosynthesis so that that one should have $r = \hbar/\hbar_0 = E_{rf}/4E$. One could say that large number of radio wave photons combine to form a single bundle of photons forming a structure analogous to what mathematician calls covering space. In the burning event the dark photon would transform to ordinary photon with the same energy. This process would thus transform low energy photons to high energy protons with the ratio $r = \hbar/\hbar_0$.

Therefore the mechanism for the burning of water in the experiment of Kanzius could be a simple modification of the mechanism behind burning of water in photosynthesis.

1. Some fraction of dark radio frequency photons are dark or are transformed to dark photons in water and have energies around the energy needed to kick electrons to smaller space-time sheets .4 eV. After this they are transformed to ordinary photons and induce the above process. Their in-elastic scattering from molecules (that is Raman scattering) explains the observation of Raman scattered photons. For a fixed value of \hbar the process would occur in resonant manner since only few metabolic quanta are allowed.
2. How dark radio frequency photons could be present or could be produced in water? Cyclotron radiation assignable to say electrons in magnetic field comes in mind. If the cyclotron radiation is associated with electrons it requires a magnetic field of 4.8 Gauss the cyclotron frequency is 13.56 MHz. This is roughly ten times the nominal value $B_E = .5$ Gauss of the Earth's magnetic field and 24 times the value of dark magnetic field $B_d = .4B_E = .2$ Gauss needed to explain the effects of ELF em fields on vertebrate brain. Maybe dark matter at flux tubes of Earth's magnetic field with Planck constant equal to $\hbar/\hbar_0 = \frac{1}{4} \frac{E}{E_{rf}}$ transforms radio frequency photons to dark photons or induces resonantly the generation of cyclotron photons, which in turn leak out from magnetic flux tubes and form ordinary photons inducing the burning of water. $E_\gamma = .4$ eV would give $\hbar/\hbar_0 = 1.063 \times 2^{21}$ and $E_\gamma = .36$ eV would give $\hbar/\hbar_0 = .920 \times 2^{21}$.
3. Magnetic fields of magnitude .2 Gauss are in central role in TGD based model of living matter and there are excellent reasons to expect that this mechanism could be involved also with processes involved with living matter. There is indeed evidence for this. The experiments of Gariaev demonstrated that the irradiation of DNA with 2 eV laser photons (which correspond

to one particular metabolic energy quantum) induced generation of radio wave photons having unexpected effects on living matter (enhanced metabolic activity) [I75] , and that even a realization of genetic code in terms of the time variation of polarization direction could be involved. TGD based model [K11, K84] identifies radio-wave photons as dark photons with same energy as possessed by incoming visible photons so that a transformation of ordinary photons to dark photons would have been in question. The model assumed hierarchy of values of magnetic fields in accordance with the idea about onion like structure of the magnetic body.

There are several questions to be answered.

1. Is there some trivial explanation for why salt must be present or is new physics involved also here. What comes in mind are Cooper pairs dark Na^+ ions (or their exotic counterparts which are bosons) carrying Josephson currents through the cell membrane in the model of the cell membrane as a Josephson junction which is almost vacuum extremal of Kähler action. In the experimental arrangement leading to the generation of exclusion zones the pH of water was important control factor, and it might be that the presence of salt has an analogous role to that of protons.
2. Does this effect occur also for solutions of other molecules and other solutes than water? This can be tested since the rotational spectra are readily calculable from data which can be found at net.
3. Are the radio wave photons dark or does water - which is very special kind of liquid - induce the transformation of ordinary radio wave photons to dark photons by fusing $r = \hbar/\hbar_0$ radio wave massless extremals (MEs) to single ME. Does this transformation occur for all frequencies? This kind of transformation might play a key role in transforming ordinary EEG photons to dark photons and partially explain the special role of water in living systems.
4. Why the radiation does not induce spontaneous combustion of living matter which contains salt. And why cancer cells seem to burn: is salt concentration higher inside them? As a matter fact, there are reports about [D6] . One might hope that there is a mechanism inhibiting this since otherwise military would be soon developing new horror weapons unless it is doing this already now. Is it that most of salt is ionized to Na^+ and Cl^- ions so that spontaneous combustion can be avoided? And how this relates to the sensation of spontaneous burning [D5] - a very painful sensation that some part of body is burning?
5. Is the energy heating solely due to rotational excitations? It might be that also a "dropping" of ions to larger space-time sheets is induced by the process and liberates zero point kinetic energy. The dropping of proton from $k=137$ ($k=139$) atomic space-time sheet liberates about .5 eV (0.125 eV). The measured temperature corresponds to the energy .15 eV. This dropping is an essential element of remote metabolism and provides universal metabolic energy quanta. It is also involved with TGD based models of "free energy" phenomena. No perpetuum mobile is predicted since there must be a mechanism driving the dropped ions back to the original space-time sheets.

Recall that one of the empirical motivations for the hierarchy of Planck constants came from the observed quantum like effects of ELF em fields at EEG frequencies on vertebrate brain and also from the correlation of EEG with brain function and contents of consciousness difficult to understand since the energies of EEG photons are ridiculously small and should be masked by thermal noise.

Free radicals, expanding Earth, water memory, and Cambrian revolution

The title is intentionally chosen to involve notions which one would expect to have absolutely nothing in common. The purpose is to show that this expectation might be wrong. Consider first the free radical theory [I17] . The theory states that free radical produced in mitochondria are responsible for the ageing since they are highly reactive and cause damage for the DNA. One can however wonder what is the mechanism causing the generation of the free radicals.

A TGD based justification for the free radical theory came as unexpected application of the quantum model for how metabolic batteries are loaded in many-sheeted space-time. The kicking of electrons

to smaller space-time sheet loads metabolic batteries in TGD Universe. The dropping of electrons back liberates metabolic energy. These processes occur all the time in $ADP \leftrightarrow ATP$ "Karma's" cycle. The quantitative model for the burning of water producing hydrogen peroxide and hydrogen (this process could provide a mechanism of storing solar energy by a mechanism analogous to photosynthesis) as already discussed.

Burning water, photo synthesis, and water memory

The burning of water, photons synthesis and water memory are closely interrelated phenomena in TGD Universe. Recall first what was observed in the experiments carried out by the group led by Luc Montagnie.

1. What was done was filtration of human cells infected by bacteria in sterilization purpose to eliminate the infected cells. Human cells were added to the filtrate. Rather magically, the infection returned to the filtrate within few weeks. Something having size of order of nanoscale leaked through. It was also found that when the filtrate was diluted by water to produce an analog of homeopathic remedy, it produced at multiples of kHz if the dilution factor was in the range $10^{-7} - 10^{-12}$.
2. The second discovery was that if you have two bottles containing a solute of nanostructures such that for the first one dilution factor is small and for the second in the critical range so that it radiates at kHz frequencies. What was found that in the final situation neither radiates but only if the dilutions correspond to the same bacterial species! I proposed two interpretations. The first one was that the nanoscale systems in the highly diluted system are starving and gain metabolic energy by sending negative energy photons to the low dilution system and this makes them possible to replicate and achieve higher dilution after which the process stops.
3. One of the most fascinating possibilities suggested by the discovery is that the nanoscale structures identified as certain gene of the bacteria plus possibly something else (the magnetic body of gene in TGD context) might have been able to regenerate the bacteria themselves! This would require a non-chemical representation of genetic code and its translation to DNA or RNA. For about year ago I indeed discovered a realization of genetic code in terms of dark nuclei with states of nucleons representing the code words [L7] , [L7] .

These findings allow a more detailed interpretation of the findings of the experiments of the group of Luc Montagnie.

1. The mysterious burning of water induced by radiowaves in GHz range and interpreted in terms of a decomposition of water molecules to hydrogen peroxide and hydrogen: $2H_2 \rightarrow H_2O_2 + H_2$ is closely related to the splitting of water to hydrogen and oxygen occurs also in photosynthesis. The interpretation was that radiowaves are resonantly transformed to dark photons with same frequency but with very large value of Planck constant and hence of energy followed by a transformation to ordinary IR photons with much higher frequency but same energy around .4 eV. The finding that Raman scattering (non-elastic scattering of photons on molecules) around this energy occurs in the burning water supports this view. The natural guess is that also in the recent case something similar occurs.
2. This kind of frequency scaling is one of the basic mechanisms of water memory as I learned for the first time from the lecture of Cyril Smith in CASYS conference many years ago. One of the basic findings was that there is an unknown mechanism transforming low frequencies to high ones and vice versa. The low frequencies are scaled up by a factor which has a preferred value $r \simeq 2 \times 10^{11}$ interpreted in TGD framework as the ratio of the dark matter Planck constant to the ordinary one. I christened this correlation as a scaling law of homeopathy.
3. It is interesting to apply the law to kHz frequency. In this case the law would give frequency $f = 2 \times 10^{14} > \text{Hz}$. The corresponding energy is .826 eV, which is essentially twice the energy quantum associated with burning water and thus has interpretation as a p-adically scaled up frequency (by one octave). Interestingly, Mae-Wan Ho states in [D24] that *"to use water as electron-donor, and hence to produce oxygen, requires the creation of the chlorophyll-a in cyanobacteria*

and green plants that can be boosted to a higher electrochemical potential of $0.82 V$. Hence .83 eV is very near to a metabolically interesting energy.

4. This finding supports the view that kHz radiation produced by nano-structures corresponds to dark phase conjugate photons with energy equal to a metabolic energy quantum. The interpretation would be that the unidentified nanoscale systems in the highly diluted system are starving and get metabolic energy by sending negative energy quanta in the hope that there are metabolic energy reservoirs around able to absorb them. If biophotons are Bose Einstein condensates of dark cyclotron photons at the flux tubes of magnetic body acting like population reversed lasers, they could serve as metabolic energy reservoir as suggested in on basis of the discovery described by Mae-Wan Ho in [D27] .
5. A continual fight for metabolic resources is raging everywhere in Nature, presumably also at the monocellular level. It would not be surprising if harmful bacteria would try to steal the metabolic energy of other organisms stored (say) as biophotons by sending phase conjugate light to the biophoton resources of multicellular organisms. Nor it would be surprising if living organisms would have developed manners to prevent this. The fine tuning of the metabolic frequencies so that only the members of the same species can share the energy could guarantee this. Also password like protocols might have developed and either or both of them might be involved.

In the two-bottle experiments the nanoscale systems in the highly diluted system would gain metabolic energy by sending negative energy photons received by the low dilution system. The gain of metabolic energy would make possible for the nanosystems to replicate and achieve higher dilution after which the process would stop as was indeed observed. That this took place only for the bacteria of same species supports the interpretation that frequency tuning or password mechanism was involved. This metabolic mechanism (quantum credit card as I have called it) could be a completely general mechanism energy sharing mechanism for cells of the same multicellular organism and perhaps even same species in TGD Universe.

7.5 DNA waves and water

The article "DNA waves and water" by L. Montagnier, J. Aissa, E. Del Giudice, C. Lavalée, A. Tedeschi, and G. Vitiello [I71] has created quite a furor even before its publication. The article was preceded by article [I98] , whose results led to my own proposal about the existence of new kind of representation of DNA in water [L16] and the recent article indeed suggests the existence of a new kind nano-scale representation of DNA besides electromagnetic representation of the code, which was also suggested for years ago by the group of Peter Gariaev [I74] and also in TGD framework [K35] . New Scientist reacted by an article "Scorn over claim of teleported DNA" [I37] , whose title is completely misleading (nothing new in popular science journalism dominated by sensationalism): authors make no claim about quantum teleportation.

Already "DNA waves and water" is enough to induce a deep growl from the throat of a hard-nosed skeptic, and the words "homeopathy" and "water memory" are the signals, which transform even civilized skeptic to a raging blood hound. Water memory at gene level is indeed what the article is about. What makes the situation so problematic is that Montagnier is HIV Nobelist so that it is not so easy to dismiss the work as has been done routinely for all work related to water memory since the days of Benveniste and before.

The story began when Benveniste found evidence for water memory [I68, I69] . Water solution of biomolecules was diluted so that there was no trace about the molecules. What Benveniste and collaborators claimed was that the treated water is however somehow able to represent the biologically relevant properties of molecules so that its action on some biomolecules can be the same as that of the original molecules. This could obviously explain the claimed effects of homeopathy.

Benveniste got a label of fraudster in a scientific investigation led by the magician James Randi (true, this is what the standards of skeptic science sadly often are!). The work of Benveniste has been however continued behind the scenes and it has been for a long time to possible to reproduce the effects of biologically active molecules by using only the low frequency electromagnetic spectrum of these molecules which suggest that biological signalling relies on low frequency em radiation [I69] . Skeptics have simply dismissed all this research.

That genes have electromagnetic representation have been also claimed by Peter Gariaev and his collaborators for long time ago in terms of the notion of wave DNA [I74] (references contain also other articles of Gariaev and collaborators). I have proposed TGD inspired models for wave DNA related effects [K84, K1] . The latter article has been written in collaboration with Peter Gariaev. Also biophotons [I64] and the effects of ELF em fields on vertebrate brain [J27] relate very closely to the story in TGD framework. Quite generally, the findings provide additional key data allowing to develop the vision about the central role of electromagnetism related macroscopic effects in living matter.

Also Huping Hu and Maoxin Wu [J64] have reported highly brain effects involving water and electromagnetic fields. Applying magnetic pulses to the brain when an anesthetic was placed in between caused the subject person to feel the effect of anesthetic. Also drinking water exposed to magnetic pulses, laser light or microwave radiation when an anesthetic was placed in between caused brain effects. The proposed interpretation was in terms of quantum entanglement. The explanation based on the mimicry of the anesthetic molecules by water does not exclude the presence of quantum entanglement.

In the following I will develop a more detailed model for the findings reported in [I98] using the new findings of Montagnier's team [I71] . The findings provide information allowing to develop much more detailed view about water memory and representations of genetic code in terms of water and related ideas about the role of dark matter (understood as a hierarchy of phases with large value of Planck constant) in biology.

7.5.1 The basic findings of Montagnier's group

The claim of Montagnier's team is that the radiation generated by DNA affects water in such a manner that it behaves as if it contained the actual DNA. A brief summary of experiment of Montagnier and collaborators is in order.

1. Two test tubes containing 100 bases long DNA fragments were studied. Both tubes were subjected to 7 Hz electromagnetic radiation. Earth's magnetic field was eliminated to prevent its possible interference (the cyclotron frequencies of Earth's magnetic field are in EEG range and one of the family secrets of biology and neuroscience since eventually is that cyclotron frequencies in magnetic fields have biological effects on vertebrate brain). The frequencies around 7 Hz correspond to cyclotron frequencies of some biologically important ions in the endogenous magnetic field of .2 Tesla explaining the findings. This field is 2/5 of the nominal value of the Earth's magnetic field.
2. What makes the situation so irritating for skeptics who have been laughing for decades for homeopathy and water memory is that the repeated dilution process used for the homeopathic remedies was applied to DNA in the recent case. The dilution containing no detectable amounts DNA (dilution factor was 10^{-12}) was placed in second test tube whereas the first test tube contained 100 bases long DNA in the original concentration.
3. After 16 to 18 hours both tubes were subjected to polymerase chain reaction (PCR), which builds DNA from its basic building bricks using DNA polymerase enzyme. What is so irritating that DNA was generated also in the test tube containing the highly diluted water. Water seems to be able to cheat the polymerase by mimicking the presence of the actual DNA serving in the usual situation as a template for building copies of DNA. One could also speak about the analog quantum teleportation.

In TGD inspired quantum biology the representations of genes in terms of temporal patterns of em radiation are in central role. TGD leads to a concrete model for water memory in terms of the magnetic body of biomolecule whose cyclotron frequency pattern codes for the biological effects of the molecule. Water memory means that water can build magnetic bodies mimicking those of biomolecules or perhaps steal them in the process of dilution which involves the shaking of the solution.

TGD suggest also another representation of the genetic code in terms of dark nucleons [L7] , [L7] , which could be highly relevant for the realization of water memory in terms of a dark portion of water for which there exist empirical evidence [K27] . This dark portion would also explain the numerous anomalies of water. It became as a total surprise that the states of dark nucleons correspond in natural

manner to DNA, RNA, tRNA, and aminoacids. DNA would define only one particular representation of the genetic code, which in the primary form would be realized at elementary particle level and that there could exist many representations of DNA. Also the model for DNA as topological quantum computer [K28] proposes a non-standard representation of the code.

The existence of a multitude of representations of the code would not be too surprising when one realizes that the information processing performed by computers involves endless variety of different representations of various codes. The problem is about attitudes: the dogma that biology is nothing but chemistry is what is being challenged and we love dogmas because they liberate us from the burden of using our own brains.

7.5.2 Questions

Montagnier's work gives support for water memory in terms of representations of some molecules in terms of water molecules or some nano-structures present in water treated in the same manner as the homeopathic remedies are made. What is really amazing is that the representations seem also to realize genetic code. The experimental arrangement stimulates several questions which I try to answer in the framework of TGD inspired model of biology.

1. The presence of 7 Hz magnetically induced oscillation seems to be necessary for the presence of the effect. What is the role of this radiation whose frequency is not far from the lowest Schumann resonance frequency with nominal value of 7.83 Hz. Recall that this frequency is in the lowest approximation determined by the radius of Earth of alone. The wave length of 7 Hz photons is slightly larger than the circumference of Earth. Could it be that a temporal pattern associated with a single period of 7 Hz oscillation could code for DNA codons. The energies involved are of course ridiculously small as compared to the thermal energy at room temperature and quantal effects are excluded in standard quantum theory.
2. How water could represent some biologically relevant aspects of molecules? For what kind of molecules this representation does exist? What are the roles of mechanical agitation and dilution in the generation of water memory? Does the 7 Hz frequency near the lowest Schumann resonance frequency relate to this somehow?
3. How water and electromagnetic radiation could represent genetic code?

7.5.3 TGD inspired answers to the questions

In the following TGD inspired answers to the questions posed in the introduction are discussed. The answers are of course very tentative and involve a lot of speculative new and non-tested physics predicted by TGD.

Some key ideas of TGD inspired quantum biology

TGD helps to imagine possible answers to these questions. The identification of dark matter as a hierarchy of phases with large Planck constant [K29, K27] and the notion of magnetic body [L16] - both deriving naturally from basic quantum TGD- are the key notions.

1. The basic vision is that magnetic body communicates with biological body and controls it by using a generalized variant of EEG consisting of fractal hierarchy of dark photons corresponding to a hierarchy of values of Planck constant [K26] with large Planck constant implying that even ELF photons can have thermal energies above thermal energy. This is the essential element in the model for the effects of ELF frequencies on vertebrate brain. The transformation of dark photon to a bunch of ELF photons or single high energy photon would be basic mechanisms transforming dark photons to ordinary ones. Biophotons would be dark photons transformed to single dark photon. EEG would represent outcome consisting of a bunch of ELF photons.
2. TGD suggests that dark DNA, RNA,... and even dark aminoacids could have a key role in biological evolution providing kind of virtual world realization of biomolecules. This would make possible a controlled evolution analogous to the research and development carried out in industry. This is in conflict with the vision of standard biology according to which the planning

of travel phone would be a process in which one throws some random collection of electronic components to a hat and looks whether a travel phone emerges from the hat after sufficiently long waiting period.

Biological R&D would require that transcription and translation process have dark counterparts. Also the transcription of dark DNA to ordinary DNA and vice versa and even more general processes should be possible. If the water containing ordinary DNA contains its dark variant able by its darkness to leak through the filters used in the experimental situation studied by Montagnier and collaborators, the dark DNA could be able to cheat the polymerase protein so that it interprets dark DNA as a genuine DNA template and starts to generate ordinary DNA. If the magnetic flux tubes coding for DNA are all that is relevant for this, this mechanism would not depend whether the ends of flux tubes contain real or dark DNA.

3. The dark magnetic flux tubes connecting bio-molecules make it possible for them to recognize and find each other in the dense soup of biomolecules. The reduction of Planck constant for the flux tube brings the bio-molecules near to each other so that catalytic reaction becomes possible. The reconnection process for flux tubes is also in an essential role and involved with ADP-ATP process and would provide elegant realization of codes.
4. In this framework evolutionary leaps can be seen as a quantum leap in which a new level of dark matter hierarchy with Planck constant larger than those of already existing levels emerges. Another basic implication is the existence of coherent gene expressions in various length scales leading to the notion of hypergenome and collective gene expression.

Representations for the genetic code in TGD

TGD suggest several non-standard representations of the genetic code.

1. Temporal patterns of electromagnetic radiation with some carrier frequency is one possibility. Gariaev's work suggests that temporal patterns of polarization directions of radiation could code for DNA sequences with each nucleotide corresponding to a definite change of polarization direction [K84] . This would mean a hierarchy of realizations of the code corresponding to different frequency scales with period of radiation defining the duration of the code word.
2. The TGD inspired model for DNA as topological quantum computer [K28] suggests a realization of codons in terms of u , and d quarks and their antiquarks at the ends of magnetic flux tubes connecting DNA nucleotides to lipids of nuclear or cellular membranes. TGD indeed predicts the possibility of several fractally scaled up copies of hadron physics with different mass scales and also dark variants of ordinary hadron physics with the Compton lengths of quarks scaled up while keeping mass scales the same. Entire fractal hierarchy of representations corresponding to carrier frequencies of dark photons could be realized.
3. One of the most amazing predictions of TGD comes from the model of dark nucleons [L7] , [L7] . The states of dark nucleons are in 1-1 correspondence with DNA, RNA, tRNA, and amino acids and vertebrate genetic code is realized naturally as dark nuclear strings analogous to ordinary nuclei which are also nuclear strings in TGD based model of nuclei. The representation could be based on triplets of magnetic flux tubes with quarks at ends correlating with the genetic code words defined by the states of dark nuclei just like the representation of DNA in DNA as tqc model. A natural guess would be that the size scale of dark nucleon is same as the size scale of single DNA triplet.

What is the role of 7 Hz radiation?

7 Hz is near the frequency of the lowest Schumann resonance representing collective oscillation of the Earth's magnetic field and one can wonder about its role in the experiment of Montagnier and collaborators.

1. 7 Hz need not provide a representation for genetic code although it could do so. A possible role is as the provider of bio-rhythm and as a possible source of energy in the case that dark photons with energy above thermal energy are in question. TGD inspired theory of consciousness predicts

what I call self hierarchy and one can speak about gene expression at the level of organism and even population. Schumann resonance would naturally couple with living matter and couple the magnetic bodies of living systems to the magnetic body of Earth- magnetic Mother Gaia one might say. Flux tubes within flux tubes would be simplest representation for the coupling making possible frequency modulation and also amplitude modulation. Frequency modulation is especially interesting and the song of whales provides a possible concrete example of underlying frequency modulation. The model for hologram generating properties of DNA suggests that the dark photons assignable to 7 Hz radiation pump energy to build up hologrammic representations of DNA.

2. Cyclotron resonances for ions in the Earth's magnetic field are in 1-100 Hz range and it has been known from seventies that electromagnetic fields in this frequency range have effects of vertebrate brain. These effects look very quantal and correspond to cyclotron frequencies which is $.2 \text{ Gauss} \cdot 2/5$ of the nominal value of the Earth's magnetic field. Also the authors of the article suggest that cyclotron resonances of ions are involved and in TGD inspired model for living body in terms of magnetic bodies cyclotron resonances are in a key role. Cyclotron frequencies could provide a coupling of biologically important ions to Schumann resonance if the flux tubes involved can vary their thickness so that the strength of magnetic field varies by flux conservation.
3. VLF frequencies above kHz seem to take this role in water memory. The wave lengths and corresponding layers of magnetic bodies are still enormous as compared to that of DNA.

How water could represent molecules?

The TGD inspired model for how water could represent at least some aspects of at least some molecules is based on earlier ideas plus some ideas inspired by the findings of Montagnier's group and by the role of ordered water and hydrogen bonds in the self-organization of biomolecules.

1. The basic idea is that the magnetic body of the molecules represents biologically relevant aspects of molecule in the sense that the cyclotron radiations generated by the magnetic body is responsible for biological control and also receives signals from part of organism in some length and time scales. The mechanical agitation of water involves in the process generating water memories implies that the magnetic bodies of some molecules just drop to water. This is enough for the mimicry of the biomolecules by water.
2. Water interacts strongly with polar (hydrophilic) molecules so that the polarity of the molecules in question is expected to be very relevant for the process. Polar molecules are covered by a hydrogen bonded layer of ordered water molecules analogous to ice covering. This molecular ice freezes various biomolecules to standard configuration and the feed of energy freezes the ice cover so that processes like protein folding and formation of their aggregates which is central element in the reaction of living matter to external perturbations becomes possible. The natural idea is that the polar molecules having hydrogen bonds with water layer dictate to high degree the structure of the magnetic body.
3. The mechanical agitation of water could feed the energy needed to induce the splitting of the hydrogen bonds of a polar molecule so that the ice coating to which the magnetic body of the molecule would drop out. The process would be similar to the reaction of biomolecule to external influence. This magnetic body would represent the molecule in terms of cyclotron frequencies and behave as a real molecule as far as the effects caused by cyclotron frequencies are considered. Basically a symbolic representation of the biomolecule would be in question.

This mechanism is obviously very general and the prediction is that water remembers the presence of molecules with polar regions and do not distinguish between molecules with different non-polar regions. These non-polar regions are hydrophobic and tend to be shielded from water. Protein folding is one example of this shielding.

How the magnetic bodies could represent genetic code?

The intriguing finding that about 1/4 of hydrogen atoms of water behave effectively like dark matter in attosecond time scale was one of the first findings motivating the development of ideas about dark matter as large \hbar phases and is also of crucial importance for the model of water memory. The TGD based explanation is that dark hydrogen atoms correspond to dark protons with Compton size of order atom size at least. The varying fraction of this phase would explain the large number of anomalies related to the thermodynamics of water.

The proposal is that the splitting of hydrogen bond transforms the hydrogen or at least the proton of hydrogen to a dark nucleon. The states of dark nucleons would correspond to multiplets assignable to DNA, RNA, tRNA code words, and aminoacids. If the state of dark nucleon corresponds to quarks assignable to the ends of the three magnetic flux tubes, one has a representation of the genetic code in terms of dark nuclear string consisting of protons glued to form dark nuclear string (TGD indeed leads to a model of nuclei as nucleon sequences connected by color magnetic bonds [K21]).

How transcription and translation type processes could be realized for dark DNA and how dark DNA and DNA could transform to each other?

Reconnection of magnetic flux tubes allows to imagine a very simple model for how DNA is coded to dark DNA and vice versa. As a matter fact, the process applies to very general class of processes defining a pairing of biomolecules. All that is needed is that the quark pair at the ends of the flux tube to some degree dictates which molecules can form. One can actually imagine a generalization of the genetic code applying to much more general molecules than molecules involved with the genetic code if this mechanism involves dark nucleons at the ends of the magnetic flux tubes involves.

1. Assume that the nucleotides of dark DNA and conjugate molecules are connected by flux tubes having quark and antiquark at their ends that u, d and their antiquarks correspond in one-one manner to DNA nucleotides so that coding results. Suppose that similar coding takes place for dark DNA in the sense that dark DNA code work is connected by three flux tubes to its conjugate for corresponding dark aminoacid. Assume that both dark and ordinary DNA nucleotides can be connected to their conjugates by relatively long flux tubes (large \hbar) and that they can be also accompanied by short-circuited flux loops. Assume again that genetic code mapping codons to quarks is realized. Similar short circuited closed flux loops could be possible for aminoacids and RNA.
2. Assume that a reconnection for long flux tube connecting nucleotides and their conjugates and for nucleotide flux loop is possible if corresponding quarks are same so that the assignment realizes genetic code. For instance, a reconnection in the middle of flux tubes connecting dark DNA and its conjugate would generate an ordinary DNA sequence. If this sequence binds to DNA strand and if the reverse of the reconnection process occurs after that, dark DNA sequence becomes coded ordinary DNA sequence. Obviously much more general processes of this kind are possible and are relatively independent of what is at the ends of the flux tubes so that genetic coded would permeate whole biology and determined selection rules of reaction involving all kinds of polar molecules.

What is the role of dilution and agitation?

I have already discussed these questions. The following discussion involves new ideas inspired by the findings of Montagnier's group.

The role of dilutions in the generation of water memories looks like a mystery and provides strongest weapon for a simple-minded skeptic and one can make only guesses in this respect. The situation does not distinguish between DNA and other molecules which water is able to represent. All these molecules could correspond to dark molecules resulting when the hydrogen bonds connecting polar molecule to its water coating split if above ideas are on a right track. Consider now the questions.

1. Is the dilution necessary in order that the magnetic flux tubes of the molecular magnetic expected to have size of order 100 nm in the solution do not overlap? This would mean that the density of dark DNA in the experiments of Montagnier would be rather low in the experimental situation, maybe something like 1 DNA sequence per volume of cell nucleus. Can so low density explain

the effects of polymerase in the experiment of Montagnier's team? Could the critical dilution be the dilution above which the 7 Hz radiation is able to serve as a metabolic resource?

2. Could it be that the density of dark molecules is actually much higher than the dilution would suggest? This would require replication of dark molecules, which is indeed quite conceivable if dark molecules define a life form preceding ordinary DNA. The mechanical agitation could provide the metabolic energy for the dark molecules. Dark molecules could also be part of time in lethargic state and wake up only when energy is feeded and replicate just as biomolecules are ice-covered and wake up only when external perturbation feeds energy and induces self-organization. But why would be critical dilution required? Why the density of ordinary molecules must be so small? This is difficult to understand.
3. Is it the number of dilutions and agitations which matters rather than the density of the ordinary molecules in the final situation? Could the sequence of dilutions induce an evolutionary process analogous to a sequence of environmental catastrophes posing evolutionary pressures (population density for dark molecules is reduced by a factor of ten) and leading to rapid evolution of dark DNA variant able to replicate and survive? Could each mechanical agitation induce quantum phase transitions increasing the value of Planck constant for the flux tubes inducing evolutionary leaps and increasing the size scale of the corresponding magnetic body? Could the associated feed of metabolic energy also induce a replication of the dark molecules so that one would have a population with a density much higher than that of the ordinary molecules in the final situation? Whether the number of agitation-dilution processes matters instead of final density of molecules could be tested by using different initial values for the density.
4. Cyclotron radiation of dark photons from the magnetic body of dark DNA transforming to ordinary VLF photons serves as a signature for its presence. In the abstract of [I97] Montagnier group reports following.
 "Electromagnetic signals of low frequency have been shown to be durably produced in aqueous dilutions of the Human Immunodeficiency Virus DNA. In vivo, HIV DNA signals are detected only in patients previously treated by antiretroviral therapy and having no detectable viral RNA copies in their blood. We suggest that the treatment of AIDS patients pushes the virus towards a new mode of replication implying only DNA, thus forming a reservoir insensitive to retroviral inhibitors. Implications for new approaches aimed at eradicating HIV infection are discussed."
 "New mode of replication" would correspond in TGD framework to replication of magnetic bodies of RNA or DNA representing genes as dark nucleon sequences and would allow HIV RNA or RNA to survive despite the treatment.

The idea about rapid micro-evolution taking place in human time scale for the magnetic bodies is as radical as it is fascinating but is in principle testable. I have considered alternative explanations but they are not so simple as this one. I do not of course believe that attitudes in biological sciences would be mature for testing this kind of ideas. Big changes in the world view are painful and take place slowly and existing theoretical hegemony is the worst obstacle in the progress.

7.6 Field codes associated with homeopathy and a model for the magnetic body

Homeopathy involves also more complex aspects than mere entrainment and imprinting. Benveniste represents evidence for codes based on the modulations of the carrier frequency [I68, I69]. This kind of code brings in mind the magnetic pulse patterns inducing altered states of consciousness [J84]. Cyril Smith claims that the imprinted frequency can be an arithmetic function (sum or product) of the imprinting pair of frequencies [I123].

These claims of course look highly implausible in the reductionistic framework. The presence of magnetic bodies acting as intelligent intentional agents changes the situation in TGD Universe. Dark plasma oscillations patterns induced by state function reduction of charge entanglement by W MEs define an ideal representation for the code words inducing motor actions, and one ends up to a more detailed vision about how magnetic body receives and experiences sensory input from the biological body and controls it using codes with code words expressed as plasma oscillation patterns transformed to ionic waves. The model for Priore's machine [I54, I107] allows to test these ideas.

7.6.1 Plasmoids as primitive life forms associated with magnetic bodies

In TGD framework plasmoids can be regarded as primitive life forms associated with rotating magnetic flux quanta, and it has been demonstrated that plasmoids seem to possess the basic characteristics of a living system [I103]. The plasma in question is dark plasma. BE condensates of ions defining dark plasmas represent more advanced life forms of this kind. Dark plasma oscillations define ideal representations for field patterns inducing ionic (say Ca^{++}) waves (by many-sheeted Faraday's law) in turn inducing generalized motor activities.

The possibility of charged entanglement induced by W MEs and generating Bose-Einstein condensates of exotic ions brings in a genuinely new element to the model of plasmoids discussed earlier as predecessors of biological life [K31]. The notion has been already applied in the model of nerve pulse [K62]. One can speak about non-Abelian holograms at the level of dark matter with W bosons taking key role in the realization of motor actions and neutral bosons playing similar role in the realization or sensory and memory representations.

Plasmoids as rotating magnetic systems

If plasmoids rotate they generate em charge by the effect known already by Faraday but not explained satisfactorily by Maxwell's electrodynamics. In TGD framework vacuum charge density induces radial electric field inducing radial Ohmic current which is not divergenceless and hence charges the rotating magnet. Cell, DNA, and other sub-systems in living matter are usually negatively charged and the underlying reason could be the presence of rotating plasmoids around which biochemical life forms have evolved.

Also Searl device [A18], [H11] discussed in [K83] is a rotating magnetic system. In this case the charging of the system implies an effective loss of weight in Earth's electric field. Searl device is known to develop cylindrical magnetic walls [A18]. According to TGD based model of Searl device [K83], the rotating magnetic walls represent a simple example of a magnetic body containing dark matter. The energy and angular momentum transfer from the magnetic flux walls generated by the rotation to the rotating system is assumed to explain the accelerated rotation of the system.

Dark plasma waves

Dark plasma waves have synchronously oscillating spatial patterns. Charge densities correspond to the order parameters of BE condensates of bosonic ions so that the introduction of the ion densities is not an idealization as in the non-quantum situation.

The dispersion relation of dark plasma oscillations in the lowest order approximation reads as

$$f_p = \sqrt{e^2 n / m} ,$$

where n and m are the number density and mass of plasma waves. In the case of dark plasma waves n corresponds to the density defined by the order parameter of the Bose-Einstein condensate of ordinary or exotic ions. The dispersion relation does not depend on wave vector at all so that the plasma wave recurs to the same pattern again and again and therefore provide ideal representations of mental images.

Since the notion of ionic density is not an idealization in case of dark plasma waves, it seems sensible to assign energy quantum to the dark plasma waves. Since plasma frequency is purely classical quantity the plasma energy $E_p = \hbar(k) f_p$ would scale as $\hbar(k)$ and an increasing hierarchy of plasma wave energies is predicted. These energies could define the metabolic energy quanta in the case of plasmoid life forms. These quanta can decay to $k_d = 0$ low energy quanta as they are used.

Plasma wave patterns could provide a realization for the control commands inducing motor activities and the energy of the plasma wave could be sucked from metabolic energy sources by time mirror mechanism and dissipated in the realization of motor action as the plasma wave decomposes into r plasma waves at the lowest level of the hierarchy.

Quite large energies are involved at higher levels of dark matter hierarchy and the question arises whether there exist suitable sources of metabolic energy. The dropping of electrons from $k = 137$ atomic space-time sheets could provide metabolic energy quantum $E(137) \simeq 1$ keV. The dropping of electron from $k = 131$ space-time sheet would liberate energy $E(131) \simeq 64$ keV. The requirement that plasma wave energies correspond to zero point kinetic energies forces quantization of the densities of

ions for Bose-Einstein condensates. Also the cyclotron transition energies of electrons or their Cooper pairs can provide the metabolic energy quanta. Note that metabolic efficiency requires quantization of the densities of Bose-Einstein condensates.

A further source of metabolic energy could be dark microwave photons generated by quartz crystals in the rock. Callahan has found that rocks consisting mainly of quartz SiO_2 serve as a source of bio-photons and that paramagnetic soil implying strong Schumann resonance amplitudes is favorable for the well-being of plants [I42]. Bio-photons could be produced as de-coherence products of dark microwave photons. Interestingly, SiO_2^- ion has cyclotron frequency 10 Hz for the nominal value $B_E = .5$ Gauss of the Earth's magnetic field equal to the fundamental bio-rhythm and the p-adic frequency $f(2, 127)$ associated with the memetic code.

It is possible to assign definite time scales to various plasma densities in magnetosphere possibly relevant to consciousness and this in principle makes it possible to build a more detailed view about quantal magnetosphere.

Dark plasma wave patterns as a tool of bio-control

Dark plasma wave patterns correspond to small deviations of charge densities from the non-equilibrium charge density by exotic ionization. Charge entanglement by W MEs with the magnetic body is an ideal mechanism for the generation of these deviations.

W ME generates oscillatory entanglement with coefficients which depend on space-time coordinates. In the state function reduction one of the outcomes is a state in which Bose-Einstein condensates in both systems carry exotic nuclear em and weak charges.

The reduction occurs for entire Bose-Einstein condensates of bosonic ions at biological body. The stronger the W field, the higher the probability that exotically charged BE condensate results. Ionic BE condensates define the pixels of the motor map as well as sensory map and the size of coherence region determines the pixel size. Similar mechanism works at the level of sensory input to the magnetic body.

Dark plasma waves induce ordinary ionic waves such as Ca^{++} waves as asymptotic self-organization patterns which would naturally correspond to generalized motor actions. Plasma wave patterns generate also cyclotron radiation the interaction of which with Josephson junctions induce a sensory representation for these patterns so that the control loop closes. Digital spatial and temporal modulation of the plasma wave patterns makes possible field codes for motor activities induced by ionic waves. Obviously the coding of plasma wave patterns to motor actions would be very robust.

7.6.2 Field representations of information using codes

As already mentioned, the work of Benveniste [I68, I69], Gariaev [I75], and Persinger [J84] provides evidence for the existence of field codes and for the view that water can learn associations [I39]. The basic distinction as compared to the genetic code is that field codes could be context dependent conventions somewhat like natural languages since magnetic body brings in conscious intelligence and flexibility. Therefore the earlier vision about memetic code [K35] assuming strict duration of the memetic codons could be un-necessarily restrictive.

Information theoretic aspects

Code words are names for biological functions which can be very complex.

1. Associative learning of the code

Flexibility is the basic property of the field codes. The codes can be therefore context dependent and characterize individual organism rather than being biological invariants. Personal code might well be necessary in order to guarantee that biological body cannot be "possessed" by outsiders. The higher the level of dark matter hierarchy, the higher this flexibility is expected to be (natural language in contrast to primitive signals which are rather universal). The work of [I68] [I68, I69] and the report of Smith about context specified 7-bit code for frequency importing [I123] provide support for the associative learning in water.

Flexibility implies that an associative learning of the code is required. There are two diametrically opposite manners to understand what the establishment of the code could mean.

1. The definitely higher IQ and quantum flexibility of the magnetic body suggests that magnetic body learns by searching the patterns inducing the desired responses of the biological body.
2. Magnetic body could also teach, or rather modify, the biological body to respond in a desired manner to plasma wave patterns. This mode of learning requires plasticity and might be important at the level of brain: associative regions of the cortex of higher primates are indeed known to be highly plastic so that changes of connectivity could make possible this kind of learning. The learning requires feedback circuit. An input signal representing the motor action is dark plasma wave pattern. There is also a motor input modifying the response function of the biological body using already learned code. The feedback is essentially the output allowing to decide about next motor input modifying the response function. Automatic associative learning results if the control loop is made automatic. A fascinating possibility is that this kind of modification could occur at the level of genes as a kind of genetic self engineering.

Quite generally, spin glass degeneracy and classical non-determinism are prerequisites for learning at various levels of dark matter hierarchy. In neuroscience rewards and punishments represented by neurotransmitters and various information molecules are believed to drive the learning.

2. *The information content of code is maximized*

Negentropy Maximization Principle [K46] is expected to pose constraints on the possible codes but it is difficult to imagine deduction of these constraints directly from NMP. The number theoretic model reproducing the genetic code as well as its variants [K22] suggests much more direct approach.

Number theoretical variants of Shannon entropy allow interpretation as positive information measures. The information content of the code should be maximized by assigning to it somehow a statistical ensemble or a set of statistical ensembles. In the model of genetic code the 64 codons labelled by integers in the range $0, \dots, 63$ and the corresponding aminoacids are labelled by the 18 primes $p < 64$ and integers $0, 1$ which correspond to DNAs labelled by $0, 1$. Hence the task reduces to finding an assignment $n \rightarrow p(n)$. The prime associated with a given integer from the maximization of negentropy for the entire code. Dynamics is thermodynamics for the partitions of n to a sum of r integers, $r = 1, \dots, n$. Quantum criticality suggests that the Hamiltonian $H(r)$ (or rather, Boltzmann weights) can be engineered freely. The negentropy $N(n)$ is maximum over p-adic negentropies $N_p(n)$ (formally Shannon entropies) fixing the prime $p(n)$.

This principle generalizes to an arbitrary code provided one can label the codewords using integers n and their images by primes $p(n)$. In the model of the genetic code n codons code for $0, 1$ and primes $p < n$, whose number $N(n)$ behaves for large values of n like $N(n) \simeq n/\log(n)$. This is obviously a highly non-trivial prediction about the code. The model as such does not tell anything about how the plasma oscillation patterns are labelled by integers.

The patterns to which codons are mapped should be effectively digital just as in the case of a computer graphics. Dark matter Bose-Einstein condensates react as single particles and serve as natural digits and the number of codons is finite. BE condensate patterns induce patterns of ionic waves (such as Ca^{++} waves), and if it is only the asymptotic self-organization pattern which matters, the degeneracy of the code follows naturally.

3. *How the meaning emerges?*

Information without meaning is not information. The model based on magnetic body and biological body allows to understand how the meaning of the symbolic signals used in the communications emerges. The biological self-organization process induced by the signal acting as a control signal give rise to a mental image at the level of biological body (symbolic mental image at the level of brain and sensory mental images at the level of sensory organs) shared by the magnetic body via entanglement. This mental image would give the meaning for the signal.

How magnetic body perceives?

In order to speak about perception as something more than a completely automatic process, it is necessary to assume that the perceiver is an intentional agent receiving sensory input and able to perform motor actions. Magnetic bodies at higher levels of dark matter hierarchy would be a natural identification for the recognizer.

1. *The general model for motor action and sensory communications*

The general model for motor actions and communications of sensory input to the magnetic body relies crucially on magnetic flux quanta connecting system to its magnetic body and Josephson junctions serving the role of sensory receptors. This model was first developed for cell with cell/nuclear membrane serving as Josephson junction and DNA double strand as a basic instrument of motor action allowing to realize motor commands via gene expression. An essential assumption is the presence of quantum critical high T_c super-conductivity, or actually two kinds of super-conductivities possible in some finite temperature range for which a good guess is 36-37 °C [K26]. The model assigns to the cell membrane and its scaled up variants a hierarchy of Josephson junctions and generalized EEGs. $k_d = 47$ corresponds to the 5 Hz frequency of EEG.

This model allows to develop a model of sensory perception using the patterns of Josephson radiation. The model of Comorosan effect [I59] suggests that even molecules could be carriers of supra currents and that the structures formed by enzymes and substrate molecules contain Josephson junctions. Hence the model might apply even when the perceiving system is the magnetic body of bio-molecule, say that of a molecular motor. In the case of DNA double strand the identification of the candidates for Josephson junctions is obvious.

Josephson junction codes information about all kinds of radiation to the pattern of Josephson radiation. In particular, the dark cyclotron radiation generated by the cyclotron transitions of the cyclotron BE condensates at the magnetic bodies creates a voltage perturbation and thus affects Josephson current in the Josephson junctions assignable with the recognizing system and the resulting Josephson radiation received by the magnetic body contains information about the cyclotron radiation emitted by the target.

2. *How magnetic body perceives the sensory input from the biological body?*

An important question is how the magnetic body generates the cyclotron radiation to which the biologically important molecules respond. In the vicinity of Earth (say below ionosphere) this radiation could be generated by the ions themselves but at high enough heights it is basically protons and electrons which are present in significant amounts.

An elegant resolution of the problem would be provided by the model of frequency imprinting and entrainment. Exotically ionized super-nuclei formed by protonic strings dropped to magnetic flux sheets are able to mimic ordinary ions. These super-nuclei could also act as receiving antennas and can serve as kind of amplifiers in the recognizing system. Time mirror mechanism would also allow to amplify phase conjugate signal using population reversed cyclotron laser.

3. *Sensory input from biological body as a somatosensory map at magnetic body*

The basic recognition process is related to the recognition of the patterns of Josephson radiation consisting of frequencies $f_{n,\pm} = nf_c \pm f_J$. Somehow these patterns must define what might be called somatosensory maps at the level of magnetic body.

The previous work with frequency coding of positions of objects of perceptive field using varying cyclotron frequencies [K65] suggests that the magnetic field at the magnetic flux quanta is slowly varying so that the input at frequency $f_{n,\pm} = nf_c \pm f_J$ generates resonant cyclotron transitions at a position of the magnetic flux quantum determined by the condition $\hat{f}_c = f_{n,\pm}$.

This would map the sensory input to a geometric pattern along magnetic body defined by the varying intensity of induced cyclotron transitions and magnetic body would experience the input from the biological as a kind of bodily sensation. It is quite possible that same sensory input is mapped to several positions at the magnetic body.

The harmonics of "alpha" band would correspond to $\hat{f}_c = nf_c$ and would correspond to motor areas of the magnetic body disjoint from sensory areas. "Beta" and "theta" bands would correspond to $nf_c + f_J$ and $nf_c - f_J$ and receive sensory input. This allows two options.

1. The magnetic flux could vary in discrete manner so that $\hat{f}_c = nf_c$ would corresponds to magnetic flux $n\hbar(k)$: in this case the harmonics of alpha band would correspond to disjoint flux quanta within which magnetic field varies in a relatively narrow range. In this case EEG bands would have precise geometric correlates.
2. If the magnetic flux has minimal value of $\hbar(k)$, the area of the magnetic flux quantum would vary as $S(n) \propto 1/\sqrt{n}$ by flux quantization. There would be a cutoff in n since the field strength

cannot be too high.

If the magnetic field strength decreases as a function of distance from Earth as one might expect, beta and gamma bands would be nearer to the biological body than theta and delta bands for both options. This conforms with the fact that the EEG activity above alpha band is typically associated with rapid reactions and the time delay due to the sensory communications should be minimal. The magnetic body can extend below the Earth's surface where the field strength increases.

The role of brain would be to construct symbolic representations by abstracting only the essential features of the sensory input so that also pattern completion would become possible. Magnetic body itself would accept the sensory input from brain and body as such.

Dark plasma wave patterns as motor commands

Since dark plasma waves recur again and again to the same pattern they are ideal for the field representation of codewords representing biological activities. Dark plasma oscillations can induce various ionic waves such as Ca^{++} and Mg^{++} waves since plasma wave modifies the scalar potential at dark space-time sheets and thus also at ordinary space-time sheets by Faraday law in many-sheeted space-time. Plasma wave pattern generates also a pattern of cyclotron radiation in the magnetic field and its presence is detected at the magnetic body via sensory system so that a motor-sensory feedback loop results.

Dark plasma wave patterns would define self-organizing "motor mental images" assignable to the biological body and perhaps also with motor areas of magnetic bodies since the motor control of magnetic bodies from higher levels is also expected to be present. These self-organization patterns would represent control commands realized in terms of frequencies and spatial field patterns assignable to W MEs. Digitalization would be implied by the size of the coherent region of the BE condensate making collective quantum phase transition to a state involving plasma oscillation with a probability proportional the intensity of W field inside coherence region.

The realization of motor action involves W MEs. Exotic W bosons behave as massless particles below the weak length scale but above this scale they possess a mass obtained by p-adically scaling down the mass ~ 80 GeV of the ordinary $k = 89$ W boson. This suggests that a large metabolic energy of order W boson mass is needed to generate W ME and that this energy transformed to the energy of plasma oscillation as charge entanglement is reduced and produces exotic ionization. This metabolic energy could be provided by the dropping of an electron from atomic or sub-atomic space-time sheet to a larger space-time sheet.

7.6.3 Priore's machine as a test bench for the model

Theoretician encounters often inventions which work but seem to defy all attempts to understand them. Even more, it seems a complete mystery how the inventor has ended up with his device, unless one accepts the idea that the inventor was working under the guidance of some higher level conscious entities. Priore's machine demonstrated to heal cancer certainly belongs to this category. Although the biological effects of the Priore's device are described in high detail, the construction of the machine, which is very complicated, is described in a very sketchy manner [I107]. This makes it difficult to see what is essential and what is not. In the following the model for bio-control is taken as a guideline in attempts to understand why Priore's machine works.

Three approaches to the cure of cancer

One can approach the cure of cancer from at least three different directions.

1. *Cure the cancer cells*

The general vision about biological evolution as emergence of higher levels of dark matter hierarchy suggests that some higher levels in the hierarchy of magnetic bodies are lacking in the case of cancer cell population so that cells become lonely individuals having replication as the sole purpose of life. Dysfunction at the level of super-genes looks a plausible reason for the asocial behavior. Magnetic flux sheets corresponding to some super genes could be lacking so that "social" control from some magnetic bodies in the hierarchy would fail. A possible cure of cancer would be healing of the cancer

cells by super-gene therapy: something probably not possible for a long time even if the concept made sense.

The basic problem could be the absence of a magnetic body responsible for the quantum bio-control at some levels of the p-adic and dark matter hierarchies. The cure would be the restoration of this magnetic body by using external magnetic fields. The control of this magnetic body by higher level magnetic bodies should be mimicked by inducing periodic modulations of the magnetic field strength with frequencies which correspond to important bio-rhythms. The functioning of Priore's machine supports this interpretation.

2. *Help immune system in its task*

The presence of cancer cells is not a fatal problem if immune system is intact. The simplest reason for the failure of the immune system to eliminate cancer cells would be that it does not possess metabolic resources or that it lacks "soldiers" doing the dirty jobs, or messengers mediating commands to the battle field. Perhaps the restricted metabolic energy resources do not allow to generate plasmoids realizing the control commands from higher levels of the immune system as plasma wave patterns. In this case a possible cure would be the introduction of metabolic energy from outside and generation of additional plasmoids. Priore's machine seems to stimulate the immune system somehow and there is no detectable direct effect on the replication of the cancer cells. Thus this strategy could be realized by Priore's machine to some extent.

3. *Could cancer be cured by editing the geometric past?*

The earlier attempt to understand the functioning of Priore's machine was based on the idea that cancer cells realize some biological program ("replicate", more or less) plus the hypothesis that control commands correspond to holograms and the reversals of these commands to phase conjugates of the holograms. This allows to imagine the possibility of curing cancer by using the phase conjugate of the command "replicate".

This does not however work. The simple reason is that the general model for the realization of intentions implies that *all* motor actions are realized in terms of phase conjugate MEs, in particular negative energy W MEs inducing charge entanglement. The phase conjugate of the motor command would thus represent communication of sensory information rather than negation of the motor command. This duality between passive and active aspects of consciousness seems rather deep and has remained without sufficient attention hitherto.

One can however consider the possibility of sending the motor command "do not replicate" to a sufficiently distant geometric past or a command for an immune system to eliminate the replicators more effectively than it does in the recent geometric past. This would be essentially editing of geometric past affecting also the geometric now and could induce rather dramatic quantum jumps in which the state of patent would suddenly change. Highest levels of dark matter hierarchy consistent with the duration of the human life cycle should be involved which suggests that this kind of healing is based on spiritual practices indeed claimed to induce miraculous healings. Indeed, in the case of Priore's machine the time scales involved are so fast that there is no reason to believe that it could send motor commands to the immune system of the distant geometric past.

Description of the device

Consider first the main points related to the structure and function of the device.

1. *Plasma is present*

Priore's machine is a tube containing rotating plasma. Ions of Ne and Argon gas are used. No information about how complete the ionization is given although the field used is enough to ionize $n = 3$ electrons in the case of Argon. The estimate for the pressure is given but temperature is not reported so that it is not possible to make reliable estimates about the density of the plasma.

The voltage $V = .43$ kV voltage generates the plasma in the tube. Argon and Neon are reported to be used as plasma gases. For Argon ionization energy is $E_1 \sim 18^2 \times 13.6$ eV = 4.405 keV. The ionization of $n = 3$ electrons with energy $E_3 = E_1/9$ is possible by the electrons accelerated in the voltage and gaining thus maximal energy of .49 keV if dissipative effects can be neglected. 8-fold ionization is possible for Ar since the energies of $n = 3$ electrons are nearly degenerate. For Ne the potential ionizing electrons at $n = 2$ shell would differ by a factor $(3 \times 10/2 \times 18)^2 = 25/36 \simeq .7$ from

that for Ar. Also Hg plasma is mentioned [I54] : the tube is reported to be 2 mmHg vacuum: my interpretation is that it contains 2 millimoles of Hg that is 1.2×10^{21} Hg atoms per tube volume. For Hg the ionization energy of $n = 6$ electrons would be about 5 times higher than for Ar so that 5 times higher voltage would be needed.

2. Cyclotron frequencies of Ar and Ne ions are equal to the cyclotron frequency of Ca ion

The observation which puts bells ringing is that Ar^{++} and Ne^+ have same cyclotron frequency as Ne^+ as Ca^{++} . The radiation at the cyclotron frequency of Ca^{++} is known to have effects on living matter [J33] , and TGD based model for these effects led to the model for the hierarchy of generalized EEGs associated with the dark matter hierarchy [K26] .

3. Plasma is rotating

A rotating deflector to which ions arrive induces a rotation of the plasma in the direction of the axis of the cylindrical cavity. Rotation frequency f is reported to be below 100 rpm ($f \leq 1.7$ Hz). Rotation makes the plasmoids charged by an effect known already by Faraday. Also Searl device is a rotating magnetic system and its charge explains the reported effective loss of weight as being due to the interaction with the Earth's radial electric field. Searl device is also known to develop cylindrical magnetic walls [A18] , [H11] . According to the TGD based model of the Searl device the rotating magnetic walls represent a simple example of a magnetic body containing dark matter. In this case the dropping of electrons from atomic space-time sheet to a larger space-time sheet provides the energy for the accelerated rotation and for the formation of magnetic walls. Also transfer of angular momentum to magnetic walls is in principle possible.

The rotation of the plasma with the magnetic flux lines frozen to the plasma could create a similar situation, and the rotating magnetic walls could receive metabolic energy from the dropping of electrons and provide it for the immune system whose stimulation seems to be involved with the healing. Also the magnetic field in the region of target would rotate so that plasmoids containing biologically important dark ions could be generated also here.

4. Magnetic field of order kGauss is present

Magnetic field of order kGauss is present also in the target. 620 Gauss and 1240 Gauss are the typical field values used. It would be nice to understand why the strength of the magnetic field used is what it is. The ratio of the magnetic field $B_1 = 612$ Gauss to the dark magnetic field $B_d = .2$ Gauss playing key role in the TGD based model of living matter is $B_1/B_d = 2^{11+1/2}$ with 5 per cent accuracy, which suggests that p-adically scaled up version of this magnetic field corresponding to the p-adic length scale $k = 169 - 23 = 146 = 2 \times 73$ could be in question.

The external magnetic field is modulated between some limits with the period of heart beat in the optimal situation. Hence the values of magnetic fields at which biological effects occur could differ from the nominal values. For $B_{end} = .2$ Gauss the cyclotron energies of all biologically important ions are above thermal threshold if the magnetic flux quanta correspond to $k_d \geq 43$ levels of dark matter hierarchy. For 62 Gauss magnetic field this holds true for $k_d \geq 33$ and for 1240 Gauss for $k_d \geq 32$. For kHz frequency the lower bound is $k_d \geq 22$.

5. Modulated microwave radiation is present

Microwave radiation with frequency $f_1 = 9.4$ GHz modulated by a frequency $f_2 = 17$ MHz in a typical experiment is also present. The wavelengths used are in range 3 cm–80 cm corresponding to the range 10 GHz–.38 GHz. The optimal microwave frequency depends on the organ irradiated. Microwave radiation is crucially important and there are reasons to believe that its frequency can vary only in a narrow range. The intensity of the microwave radiation correlates strongly with healing effects. The presence of the modulation is necessary to achieve the healing effect. Several modulation patterns are used which suggests that control commands based on field code are involved.

6. Also highly energetic charged particles are involved

The system involves very high voltages generating highly energetic electrons and ions [I107] . These voltages are much higher than the ionization voltage for Ne and Ar or even Hg. Hence the highly energetic electrons and X rays could be essential also for the primary function of the Priore's machine. Highly energetic electrons and ions could give their energy for dark microwave photons. High energy X rays with energies $E \simeq 300$ keV would transform to dark microwave photons which in turn would

be transformed to plasma oscillations. The patent of Priore mentions that a typical voltage $V = 300$ kV is present in the device [I107] so that electrons accelerated in this voltage could indeed provide the X rays transforming to dark microwave photons to dark plasma oscillations.

A proposal for the mechanism of healing

The model for the hierarchy of EEGs discussed in [K26] is a good starting point in the attempts to understand that role of the modulated microwave photons and external magnetic field. In this model Josephson radiation has energies in visible and UV range for the typical values of the resting potential. Frequency modulation of Josephson radiation is used to code information and frequency modulated Josephson radiation is also responsible for both the representation of sensory data at the magnetic body and motor control by magnetic body. Since the amplitude modulated microwave radiation is responsible for the healing effects the natural proposal is that it is transformed to dark photons with frequencies in the same range as Josephson radiation associated with the cell membrane.

1. Microwave photons have frequency $f = 9.4$ GHz. The corresponding photon energy is below the thermal threshold. The condition that the energy of the dark photons with this energy is the energy E_J of Josephson photon reads as

$$\frac{E_J}{eV} = .41 \times \frac{f}{10^{14} \text{ Hz}} \times r \quad . \quad (7.6.1)$$

For $r = 2^{16}$ one obtains $E = 2.66$ eV.

2. For electron the cyclotron frequency for $B_{end} = .2$ Gauss is $c_c(e) = 6 \times 10^5$ Hz. For $B = 620$ Gauss $= 3100B_{end}$ and for $r = 2^{16}$ the energy of cyclotron energy quantum is

$$\frac{E_c}{eV} = r \times \frac{B}{B_{end}} \times .41 \times \frac{f_c(e)}{10^{14} \text{ Hz}} = .49 \text{ eV} \quad . \quad (7.6.2)$$

This is the energy of metabolic energy quantum.

This observations would suggest that the mechanism involves both control signal and transfer of metabolic energy.

1. The amplitude modulated microwave photons transform to Josephson radiation coupling to some biologically important ion at cell membrane and transmit information in accordance with the finding that the modulation pattern is important.
2. The cyclotron photons associated with electrons at the magnetic flux tubes of the external magnetic field generate cyclotron radiation serving as a source of metabolic energy.

For the mechanism to work it is essential to have a desired value of Planck constant once the value of the magnetic field is fixed. This fixes the ration of the microwave photon energy and electron's cyclotron energy so that one has $f/B = \text{constant}$. $k_d = 16$ is the value in the case considered. The proposal is consistent with Mersenne hypothesis: the value of k_d corresponds to the pair $k = 151$ and $k = 167$ of Mersenne primes assignable corresponding to the size scale of 10 nm (cell membrane) and 250 nm (size of cell nucleus).

7.6.4 Fields and genes

Fields and genes could relate in several manners. Field patterns could code for genes in the sense that W MEs would induce the Mg^{++} waves activating genes. Coding of genes by plasma wave patterns would be a higher level code in which genes take the role of amino-acids and plasma wave patterns that of genes. Genes could be also expressed as field patterns: introns are good candidates in this respect. There are claims that field patterns can induce genetic modifications: perhaps there are genes coding for genetic self engineering operations.

Coding of genes by plasma wave patterns

According to the dark matter inspired vision, magnetic bodies act as intentional agents inducing processes like DNA transcription and translation. The model for the findings of Gariaev [I75] led to the proposal that the radio wave spectrum emitted by DNA subject to irradiation by laser light could be a superposition of copies of EEG like spectra corresponding to various p-adic length scales. The spectrum suggests that cyclotron frequencies of Mg^{++} ions are present (25 Hz for ordinary EEG). Mg^{++} ions are indeed known to be important for the functioning of DNA. Therefore magnetic bodies could excite Mg^{++} waves use dark plasma oscillations induced by W MEs as control commands to excite Mg^{++} waves leading to the activation of various processes like translation and transcription. Perhaps even topological quantum computation like processes could occur [K91]. Each gene could be sensitive to a particular subset of Mg^{++} wave patterns and thus to a particular subset kind of W field patterns. The frequency assignable to W ME in turn correlating directly with its distance from magnetic body could be automatically select the correct group of genes.

In principle the coding of genes by plasma oscillation patterns could be context sensitive and perhaps the genome contains a subset of genes which are purely personal so that foreign magnetic bodies cannot activate them. Also the portions of hyper genes in given organism could be activated by plasma oscillation patterns characteristic for this organism. Language could correspond directly to this kind of oscillation patterns perhaps activating intronic portions of the genome to express itself in some un-orthodox manner, say processes involving RNA, field patterns, or topological quantum computation [K91].

At lower levels field codes are expected to be rather hard-wired just like computer languages or primitive languages consisting of signals. The codons of the memetic code could be realized as sequences of 21 DNA triplets at the intron level [K35] and corresponding plasma oscillation patterns might correspond directly to linguistic expressions.

If field codes are learned, the question arises whether also genetic code is learned in the same manner. Variations of the genetic code and the slight context dependency of some variants of the genetic code [K22] support the view that genetic code is probably also learned at very early stages of biological evolution. The deviations from universality would suggest that the maximization of the total information of the code occurs only locally in the space of all codes.

Is electromagnetic information represented using genetic code?

The TGD based model of the genetic code as a single code in a hierarchy of codes results from a model for abstraction process as a repeated formation of Boolean statements about Boolean statements [K35]. This process starts from two statements (0 and 1) and gives at the first step $2^2 - 1 = 3$ statements if one statement (represented set-theoretically by empty set) is thrown away. At the next steps one obtains by a similar procedure $2^3 - 1 = 7$, $2^7 - 1 = 127$, $2^{127} - 1$, etc. statements: the numbers of statements are obviously given by Mersenne numbers. The number of the mutually consistent statements is 1, 2, 4, 64, ... at various levels of the hierarchy and the interpretation of DNA and its conjugate as representations of mutually consistent statements and their negations suggests itself as being associated with the level $M_7 = 127$. There are good reasons to assume that these codes are realized in many manners in living matter and can represent all kinds of information.

Smith gives in his article support for the existence of seven bit electric code emerging already at the level of frequency imprints in water making possible arithmetic operations for the external frequencies imprinted to water [I123]. The seven bit character of the code brings in mind the hierarchy of genetic codes predicted by TGD [K35] and encourages the conjecture that the sequences of 7 vacuum current pulses with single pulse representing either zero or one should provide an electromagnetic realization of the genetic code and its conjugate each consisting of 64 different pulse sequences and that a sequence and its Boolean conjugate represent command and its time reversal.

In his talk about water memory effects related to homeopathy Cyril Smith reported in CASYS2001 [I123] evidence for a context dependent 7-bit coding of binary arithmetic operations (addition, subtraction, multiplication and division) of two source frequencies, call them f_1 and f_2 , giving as a result the imprinted frequency $f(f_1, f_2)$. The experimental arrangement involves two frequency sources (f_1 and f_2) contained by beakers, a pulse generator and the 'receiver'. The arithmetic operation determining the frequency imprinted into water as a function $f(f_1, f_2)$ of f_1 and f_2 is coded by a pair of pulse sequences consisting of 7 pulses with 1 and 0 represented by the polarity of the electrical pulse.

1. For instance, when the beakers and receiver are (in this order) along East-West axis (Earth's magnetic field is important!) and connected serially to the pulse generator, the pulse sequence 1001001 1111111 codes for addition. When the receiver is replaced between the beakers connected to the pulse generator in a parallel manner, multiplication results.
2. When the beakers are in East-West direction and coupled serially to the pulse generator, 1000001 1111111 codes for subtraction. When the beakers are along North-South axis, the same sequence codes for division. f_1/f_2 or f_2/f_1 results depending on the order of the frequency sources connected in a serial manner to the pulse generator.
3. When the latter sequence 1111111 is replaced by 0000000, the imprint is in the 'opposite phase' (biologically depressive instead of being stimulatory). Thus the latter sequence might tell whether genetic code or its conjugate is used and thus whether the imprinted frequency represents command or its time reversal realized as a reference wave giving rise to a hologram.

What one can conclude about the general structure of the code on basis of these experimental evidence?

1. The result of the arithmetic operation is context dependent and thus not coded completely by the binary sequence. As a consequence, single bit can code for the binary operation in question and 3+3 bits can be used to code for additional operations acting on each of the two arguments.
2. The structure of the code word should reflect the structure of the binary arithmetic operation, which is quite generally of form $(f_1, f_2) \rightarrow X f_1 O Y f_2$, where O denotes $+$, $-$, \times or $/$ and X and Y are operations acting on the arguments f_1 and f_2 .
 - i) The requirement that the time reversal of the bit sequence also codes for a binary operation fixes the general structure of the codeword to be $X O Y$ where X and Y have same length and O is thus in the middle of the codeword.
 - ii) The context dependence of the operation implies that O can be represented by a single bit. $O = o_1$ in the middle of the codeword is indeed invariant under the time reversal. $O = 1$ signifies addition or multiplication whereas $O = 0$ signifies subtraction or division.
 - iii) The 3-bit sequences $X = x_1 x_2 x_3$ and $Y = y_1 y_2 y_3$ should code for the possible operations performed for the arguments. Note that the number of bits is same as that for the codewords at the level $M_3 = 7$ below $M_7 = 127$. For commutative operations like $+$ and \times the time reversal of the codeword obtained by changing the order of the bits in the command should yield the same end result. This is the case if the time reversal $Y = X_T$ of X obtained by reversing the order of bits in X has the same effect on f_2 as X has on f_1 . $X = 100$ and $Y = 001$ appearing in the operations are indeed mirror images and have interpretation as identity operations. Besides identity operation 7 additional operations for the arguments are predicted to be possible (this brings in mind octonion units). Clearly, the pairs (X, Y) of operations correspond to 64 DNA code words and the arithmetical operation itself corresponds to the 7:th bit in the middle of the codeword.
 - iv) The proposed structure of the codeword is consistent with the data reported in [I123]. In particular, the symmetry of the sequence 1000001 coding for a division with respect to the reversal of the bits is compensated by the asymmetry induced by the exchange of the beakers. In the case of subtraction the change of the order of beakers should change the sign of the imprinted frequency: does this mean that the effect of resulting frequency is changed to its time reversal?

Of course, one can pose several critical questions relating to the experimental arrangement. Has it been tested how the situation changes when the direction of the linear arrangement is not East-West or North-East? Does the outcome of the operation change continuously in this kind of operation? In how wide a range of frequencies the coding of the arithmetic operations has been verified? However, the mere demonstration that

1. the structure of the pulse sequences consisting of a pair of 7 pulses determines the imprinted frequency as function $f(f_1, f_2)$ of the source frequencies f_1 and f_2 and that

2. the effect of this frequency is changed from stimulatory to depressive by the binary conjugation of the binary sequence is consistent with the view that a realization of the genetic code by electromagnetic pulse sequences is in question and that reference wave and its phase conjugate induce opposite biological effects.

Is it possible to transfer genetic information using field patterns?

The work of Yu. Chen Kangeng gives evidence that the transfer of the genetic information by electromagnetic means is possible [J10] . According to [I52] , where the method is summarized, the successful transfer of the genetic information from a donor bio-system to an acceptor system was achieved via high-frequency electromagnetic fields feed repeatedly through the optically-active donor bio-system and then delivered over a long period of time to the receiving bio-system in its early developmental stages. The hybrids created through the irradiation of eggs and seeds with such "genetically loaded" fields are claimed to show very specific mixed characteristics that were transferred to the next generation without need for further irradiation.

It would seem that the donor genome or parts of it are imprinted to the electromagnetic field pattern in the process and that this field pattern is able to modify the target genome.

Nothing precludes the possibility that genes/supergenes/hyper genes at some level of dark matter hierarchy can also code for genetic self engineering since these activities are after all very similar to other genetically coded bio-chemical activities. The computer analogy would be programs writing programs. The engineering genes would be activated by W MEs inducing plasma oscillation patterns. The claimed effects could be understood if the interaction with genetically imprinted electromagnetic field pattern activates genes inducing genetic self engineering yielding the genetic modifications consistent with the pattern represented by the em radiation.

Magnetic body would receive information about the desired outcome as electromagnetic field patterns emitted by other organisms, most naturally members of the same species. If these modifications are successful, the magnetic body is exposed to this information for long enough time to react and activate W MEs inducing the genetic program inducing the genetic program leading to the suggested genetic modification.

Hyper-genes integrating groups of organisms to larger wholes would be naturally involved with the mechanism. This mechanism would guarantee a rapid propagation of successful genetic modifications to the entire population and would be much more effective than the slowly occurring selection of random mutations. The possibly existing genes responsible for the genetic self engineering could be also introns and express themselves by activating nuclear RNA and process like reverse transcription.

The mechanism could explain the findings of Sheldrake about learning at the level of species. The observed rather recent emergence of 223 new genes into human genome [I60, I87] could be understood as a genetic self engineering rather than genetic engineering by more advanced civilizations as suggested in [K23] (note however that the higher levels of dark matter hierarchy can be also regarded as "more advanced civilizations"). A further quite recent mystery discussed in [K35] is that corals seem to possess genes responsible for higher level psychological functions in mammals [I118] : it is very difficult to understand this as an outcome of selective pressures combined with random mutations. The proposed mechanism might explain these genes as a result of genetic engineering.

The basic ingredient of the coral backbone is calcium carbonate $CaCO_3$. Salt is in question so that also Ca^{++} and CO_3^{-} ions are present. Ca^{++} could obviously give rise to Calcium waves. CO_3^{-} has atomic weight $A = 60$ with cyclotron frequency 10 Hz for the nominal value of the Earth's magnetic field. This frequency defines the fundamental biological rhythm and characterizes also memetic code. It characterizes also effectively 2-dimensional waves closed inside the ionospheric cavity: for l^{th} harmonic the frequency is $f = \sqrt{l(l+1)}/2\pi R_E$, R_E Earth's radius, and $l = 1$ gives 10 Hz frequency. Could the transfer of the genetic information in the Earth's length scale with 126-bit memetic codons be realized as ripples 10 Hz waves make possible genetic self engineering of coral genome?

During the early developmental stages the genome might be plastic enough to allow genetic self engineering. The genetic modification during this period also the most rational option since this gives the best guarantee that the modifications are transferred to the offspring.

Could genes be expressed in terms of field patterns?

The previous considerations assume that genes are activated using field patterns. It is also possible to consider the possibility that genes are expressed in terms of field patterns. Introns which are chemically silent are excellent candidates in this respect and the notion of memetic code relies to the idea that intronic portions of genome consist of sequences of 21 DNA triplets defining memetic codons expressed electromagnetically. This would also fit nicely with the hypothesis that introns correspond to hyper genes. Note however that introns could also express themselves by activating processes involving nuclear RNA, in particular genetic self engineering. Even process like topological quantum computation can be assigned to introns.

7.6.5 Magnetic mirrors, remote viewing and remote healing

Magnetic mirrors formed by the magnetic flux tube-ME pairs occur in many different contexts in TGD inspired theory of consciousness. Magnetic mirrors of length of order light life appear in the model of long term memory (when I, that is my magnetic body, looks at sufficiently distant mirror I see the me of the geometric past). Magnetic mirrors are crucial for the model of the sensory canvas and there seems to be no sharp difference between different types of memory which suggests that there is an entire hierarchy of memories in various p-adic time scales.

Dark matter hierarchy provides a classification for the memories in terms of the level of the dark matter hierarchy [K26] , and it is possible to identify the time scale of sensory experience as a very short term memory with time of .1 seconds (in accordance with the findings of Libet), minute scale short term memory, a memory with a time scale of days, and what is usually regarded as long term memory in terms of the levels of the dark matter hierarchy.

Magnetic mirrors play a key role in the model of frequency imprinting and provide a general molecular recognition mechanism as well as model for how sensory percepts are communicated to the magnetic body and how magnetic body performs motor actions. Magnetic mirrors allow also a generalization of many-sheeted DNA so that magnetic mirrors represent genetic information in electromagnetic form.

The wide applicability of the magnetic mirror notion suggests in accordance with the fractality of consciousness that various functions associated with the magnetic mirrors are aspects of the same basic phenomenon. Magnetic mirrors would thus provide sensory canvases, long term memory mirrors and recognition mechanism at all length scales. Even many-sheeted DNA would possess sensory canvas and long term memories, perhaps an entire hierarchy of them. One can even consider the possibility that our long term memories are average over those associated with genes associated with various neurons!

Nothing in principle precludes the possibility that magnetic mirrors can also serve as bridges between different organisms: even the notion of organism must be generalized if the idea of multi-brained magnetic selves is taken seriously. The notions of super- and hyper genes give a concrete content for this generalization [K43, K26] . This could make possible effects similar to observed at DNA level (such as self assembly and translation of RNA to proteins). Why this kind of telepathic bridges are rarely realized in the post-modern society can be understood as a result price to be paid for the gradual individualization taken place during evolution from bacteria to bicamerality to modern consciousness: in the era of market economy it would not be wise to allow a direct access to your personal consciousness from outside.

A general model for remote viewing and healing

The last observation suggest also a general model for the phenomena like remote viewing and healing defying standard science explanations (see the article of Lian Sidorov [J93]). One healing method goes under name Qigong (see the article [J32]). Qigong is a general term for a large variety of traditional Chinese energy exercises and therapies. Qigong is generally considered as a self-training method or process through Qi (vital energy) and Yi (consciousness or intention) cultivation to achieve the optimal state of both body and mind. The traditional Chinese medicine postulates the existence of Qi, which could be regarded as a kind of subtle energy circulating around the physical body.

In TGD framework the energy associated with MEs and supra-currents flowing along magnetic circuitry would be a natural counterpart of Qi. Yi would in turn would translate to p-adic cognitive representations representing also intentions, perhaps p-adic variants of MEs. Internal Qigong refers

to self healing whereas external Qigong means directing Qi energy or intention to help others by opening Qi blockages or inducing the sick Qi to get out of body, or helping to achieve Qi balance. The physiological, chemical and electromagnetic effects of both internal and external Qigong have been studied ([J93] contains large number of related references). Also the effects of Qigong healing on cancer has been studied [J32] .

Skeptics tend to eliminate these effects from their consciousness simply by denying their reality or claiming that only placebo effects are in question. The deep irony is that placebo effect represents a basic example of this kind of effect. The basic psychological reason for this reactive attitude is very simple: only the understood phenomenon is an existing phenomenon. In TGD framework these phenomena can be indeed understood using a model generalizing the vision about endogenous bio-control so that the sender and receiver of the control signal can be different organisms. Thus independently whether the claimed effects are replicable not, this kind of effects are more or less predicted by TGD framework.

The general model for remote viewing and healing is roughly following.

1. Magnetic mirrors connecting the sender and receiver make possible a universal mechanism for the transfer of intent (Yi) and action (Qi). p-Adic MEs represent the transfer of a mere intent and real MEs represent a transfer of action. p-Adic ME can be transformed to real ME either by receiver or some higher level magnetic self.
2. The transfer of intent gives rise to a healing mechanism which can act both endo- and exogenously. ME-magnetic flux tube pairs characterized by their fundamental frequencies make possible bridges between healer and healee and allow a resonant interaction in which healer can initiate various control commands or 4-dimensional templates represented as holograms. Also smaller MEs can be send along these MEs serving as bridges (this is like throwing balls with light velocity!).
3. The ME-magnetic flux tube pair connecting healer and healee acts as a reference wave which can initiate an arbitrarily complex hologram representing biological program. Healer has the ability to generate and amplify the frequencies which induce holograms representing the control commands. In particular, healer can initiate complex biological programs without knowing anything about their functioning.
4. It is quite possible that also multi-brained and -bodied higher level magnetic selves actively participate in the process.

Dark matter hierarchy and remote mental interactions

The ideas inspired by dark matter hierarchy allow a concretization of these ideas.

1. Charge entanglement as basic mechanism of remote mental interactions

The sharing of mental images could quite universally involve charge entanglement by W MEs so that remote mental interactions, the basic mechanism of intentional action, and exotic weak interactions would be very closely related.

Negative W MEs become also a basic tool of intentional interaction and the active party could in principle use the body of the subject person to realize his intentions. Hypnosis could rely on this mechanism. This could occur also in the case of healing, and the generalized motor commands would include gene expression. The body of the healee would provide the metabolic energy in this case.

There is a mental disorder in which patient mimics with an amazing authenticity the gestures of persons which she does not know beforehand. The neuro-scientific explanation would probably relay on exceptionally active/abundant mirror neurons. One can imagine two alternative quantum explanations: either the motor areas of the patient quantum entangle with those of the object of mimicry or the magnetic body of the object entangles with the motor areas of patient, whose magneto-immune system fails for some reason.

If the code defined by the proposed map of plasma oscillation patterns mediated by W MEs to generalized motor actions (induced by ionic waves) is not universal, the healer must use only the universal part of the code, be able to learn the personal code of the healee, or act with the mediation of collective levels of self hierarchy able to utilize "multi-person" codes. The universality might fail only at the higher levels of dark matter hierarchy where organisms become individuals.

2. Time mirror mechanism as energy source

The heelee can suck metabolic energy from the healer by time mirror mechanism, that is by sending neutral negative energy MEs received by the healer or possible third party.

Remote mental interactions affecting non-biological targets would rely on same mechanisms, in particular charge entanglement by W MEs. For instance, capacitors with voltage near to a di-electric breakdown might be sensitive targets of remote mental interactions. The model of Priore's machine suggests that remote mental interactions could affect and even generate plasmoids in rotating plasma.

3. Hierarchy of time scales associate with remote mental interactions

It is possible to assign to the remote mental interactions a hierarchy of time and length scales and in time scales shorter than human life cycle there are seven levels involved. This brings in mind chakra hierarchy. Since magnetic bodies at levels $k_{em} \geq 4$ have astrophysical size scale, the distance between the biological bodies of the healer and heelee does not matter at these levels. The time scale remote viewing process would correspond to the time scale of entanglement identifiable as the time scale of the generalized EEG involved.

Comparison with data

The model of remote healing and vision proposed above seems to conform with the findings described in [J93] (the URL references of this article provide a comprehensive source of background data).

1. Coordinate healing and healing using adjunct

The basic observation [J24, J93] is that there are two classes of transfer of intent (including remote healing and vision as special cases).

1. The target is found by the remote healer or viewer being given a name, location, birthdate, etc. What is strange is that this information need not have any conscious meaning for healer. This can be understood if multi-brained magnetic selves are involved with the process so that it is enough that the information has meaning for some brain involved. The well-documented effects of prayer groups (see [J24] which gives various aspects of spiritual healing) could be understood if the higher level selves receiving information from all prayers are actively engaged in the process. Also a coherent amplification of the effect (the so called Maharishi effect in transcendental meditation proportional to the square of the number of participants) would be involved.
2. An adjunct (an object previously treated by the healer, such as water, cloth, a crystal, etc) is used by the heelee with or without the healers's knowledge. Adjunct could act as a relay station being connected to the healer and heelee by MEs containing same frequencies. Besides serving as relay station, the adjunct can also act as an antenna amplifying the healing frequencies. This would explain why water (LC water blobs), linear structures like lock of hair of heelee containing DNA, and crystals are effective adjuncts. This also explains why remote viewer can have vision about the viewed by touching some object belonging to the viewed.

2. The role of imagery

The role of imagery is known to be important. The abilities of the sender to transmit the intent seem to be better the more vivid is his/her ability to imagine the intent. This conforms with the hypothesis that the transfer of intent involves at basic level the generation of a p-adic space-time sheet transformed to real form at some stage and that the transformation to a real action occurs in the easiest manner if the p-adic pseudo constants involved are genuine constants as for real solutions of the field equations.

2. Two kinds of healing mechanisms seem to be involved

TGD view conforms with the fact that two kinds of healing mechanisms seem to be involved. Healer either uses his own energy to influence the heelee or uses 'universal energy'. In the first case healer herself would transform the p-adic intent into a real action. In the second case this transformation is carried out by the heelee or some third agent, possibly higher level self.

3. *Distance does not seem to matter*

The model explains also how healing effects can be achieved over distances of thousands of miles. The basic characteristic of MEs is that they allow a directed propagation of classical energy without attenuation (Maxwell's equations do not allow this kind of solutions). Thus, if magnetic mirrors serve as bridges between the sender and receiver of intent, the high precision communication of intent does not look mysterious.

Lian Sidoroff [J93] mentions the experiment performed by M. Sue Benford et al. (unpublished), where exposing half of a hair sample to a non-ionizing radiation produced radiographic film exposure underneath the other half of the sample, located many miles away. The explanation of this effect must be based on macroscopic entanglement. The basic idea is that the effect is analogous to spin measurement in Einstein-Rosen-Podolski experiment: that is, the measurement of the spin of an electron fixes the spin of the electron entangled with it. The simplest explanation that come in mind are following.

1. The exposure to the non-ionizing radiation reduced charge entanglement by dark W MEs between the two halves of the the sample and that the resulting exotically ionized state produced the radiation leading to the exposure of the film.
2. In another experiment of Sue Benford [I55] (to be discussed in the next section) the intentional action of the experimenter is reported to induce dots and tracks in the photographic emulsion. It is is not possible to exclude the possibility that the subconscious intentional action of the experimenter might have produced the exposure also in this experiment.

Variants of this experiment could provide a justification for the notion of macroscopic quantum entanglement. In particular, charge entanglement by W MEs could in principle be demonstrated by proving so simultaneous generation of opposite charges by state function reduction that it cannot be explained in terms of em currents flowing with sub-luminal velocity.

4. *Supra currents in astrophysical length scales as an alternative for charge entanglement*

A competing explanation for genuinely nonlocal generation of charge is charge transfer by supra currents along magnetic flux quanta. One could test also the hypothesis of super-conductivity in macroscopic length scale by using variant of this kind of experiment. For instance, a variant of this test is based in the addition isotopes of selected ions to other half of the sample and finding whether the fraction of ion isotopes increases in the second half of the sample located, say, at the second side of the globe. That supra-currents could flow in these length scales is in consistency with the magnetic sensory canvas model.

The model for auroras as an astrophysical quantum phenomenon discussed in [K13, K14] relies on the assumption that the magnetic flux tubes of both earth's and solar magnetic fields are super-conductors (solar wind would thus flow as supra currents). A topological model for the crucial reconnection phenomenon of the magnetic field lines of earth's and solar magnetic fields results. Recombination is accompanied by the leakage of the supra currents to nonconducting space-time sheets through join along boundaries bonds: this mechanism is a good candidate for a universal mechanism leading to breakdown of super-conductivity and is presumably involved with a wide class of atmospheric phenomena like lightnings, ball lightnings, tornadoes, etc.. The model allows to identify the mechanism generating the electric fields responsible for the acceleration of ions eventually giving rise to auroras via collisions with the ions of the ionosphere.

What is fascinating that the sounds claimed to be heard during auroras but not measured by micro-phones might represent genuine extrasensory percepts resulting from the perturbations of the magnetic auditory canvas caused by the auroras. The breakdown of the super conductivity might even correlate with the loss of consciousness reported to sometimes occur during perceiving auroras. This picture encourages to think that weather phenomena, in particular thunder storms, relate to our consciousness also in extrasensory manner.

5. *The effects of healers to the em frequency spectrum of water*

There is evidence that healers can affect the em frequency spectrum of water. In [J93] examples of these effects are listed: the Raman spectra of water can be influenced from a distance up to 1900 km; the polarization angle of He-Ne laser can be affected by so called waiqi method; the IR spectrum (hydrogen bonds) of sterile water changes in the proximity of therapeutic touch practitioners.

Experiments do not support the hypothesis that the time of exposure correlates with the intensity of the effect. On the other hand, the treatment time of adjuncts is known to be an important factor in the distant healing. Also the UV spectrum of the water treated by healers differs from that for control samples.

It is not difficult to understand these effects in terms of W entanglement inducing an exotic ionization of dark Bose-Einstein condensates in turn inducing electric fields at the level of ordinary matter (recall the many-sheeted version of Faraday's law). Atoms with exotically ionized nuclei behave effectively like isotopes and have thus slightly different energy levels than their ordinary counterparts. This could serve as a test for the presence of exotic ions. Same applies to exotically ionized molecules.

The effects at UV frequencies could involve MEs with lengths shorter than 10^{-7} meters are involved and produced in de-coherence of dark photons to ordinary photons. Micro-tubules in UV length scale range are natural candidates for being accompanied by $k_d = 0$ UV MEs (for instance, the receptors in retina contain micro-tubuli in UV wave length range). The cell membrane could contain an array of MEs of length $L(151) = 10$ nm parallel to lipids whereas genes should involve also MEs with lengths corresponding to the wave lengths of visible light [I74].

Especially interesting wave lengths for bio-photons in IR-UV range are the p-adic length scales $L(151) = 10$ nm, $L(157) = 80$ nm, $L(163) = 640$ nm, and $L(167) = 2.52 \mu\text{m}$ which all correspond to Gaussian Mersenne primes (Mersenne primes are in a preferred role in elementary particle physics: all charged leptons, nuclei, hadrons and intermediate gauge bosons correspond to ordinary or Gaussian Mersennes). That these primes span all p-adic length scales between cell membrane thickness and cell length scale could be the number theoretic correlate for the miracle of life. Needless to emphasize, the finding that these frequencies are biologically special frequencies would give an enormous boost for TGD approach.

According to the original model the transfer of intent could involve sending of MEs with short lengths, say in UV or IR range: this would be like throwing a ball to a tunnel. The model based on de-coherence of dark MEs does not seem to require this. Be as it may, these MEs would move inside larger MEs forming the bridge between sender and receiver. $L(163) = .640 \mu\text{m}$, which is in the lower end of the visible portion of photon spectrum ($.4 - .7 \mu\text{m}$) and thus corresponds to red light, equals with .6 per cent precision with the wave length $\lambda = 644 \mu\text{m}$ associated with photosynthesis by chlorophyll b) and with 6 per cent precision to the wave length $\lambda = 680 \mu\text{m}$ associated with the photosynthesis by chlorophyll a). Could it be that magnetic mirrors with these wave lengths amplify photosynthesis by first amplifying the incoming visible light in a resonant manner?

6. Exotic weak force and biology

The basic prediction of TGD is entire hierarchy of exotic electro-weak and color physics corresponding to preferred p-adic length scales. These p-adic physics in turn involve dark hierarchy. It is clear that dark variants of exotic weak bosons would play key role in living matter. There is evidence that exotic weak interactions is involved with remote mental interactions. According to [J57], even radioactive decay rate of Am241 has been influenced by intent. There is evidence also for weak interactions in astrophysical length scales. The lifelong work of Russian scientist Shnoll demonstrates the fluctuations for the rates of various chemical and radioactive processes vary with periods related to astrophysical phenomena (see [E2], [E2] and [K9]). Exotic weak forces would also explain also the mysterious chiral selection occurring in living matter. These observations together with other applications of exotic weak forces encourage to think that weak MEs could have an important biological role.

Ordinary neutrinos seem to correspond to $k = 13^2 = 169$ space-time sheet. The quantum model of hearing revised so that it is consistent with the vision about dark matter [K61] forces to assume the existence of exotic neutrinos with $k = 127$ space-time sheet (electron length scale) coupling to $k = 113$ weak bosons. This encourages a generalization: perhaps leptons and quarks can reside in many length scales: for instance, at the space-time sheets $k = 151, 157, 163, 167$ corresponding to the biological Gaussian Mersennes. This assumption does not imply any conflict with what is known about weak and color interactions, in particular asymptotic freedom, since the bosons of different physics would couple directly only to the particles of their own physics.

There are several reasons to suspect that above atomic length scales several p-adic length scales can define copies of electro-weak and color physics and their dark variants. This is actually not new finding. The masses of low lying hadrons can be understood if the p-adic prime $p \simeq 2^k$, k integer, characterizing quark can depend on hadron [K51]. The poorly understood aspects related to the

determination of top quark mass suggest that the p-adic length scale assignable to quarks can vary in a wide range [K47]. Also the mass scale of neutrinos seems to depend on environment [K50, K47]. In condensed matter physics the huge variations of electrons effective mass might be partly due the variation of the p-adic length scale assignable to electron.

7. The role of the magnetic fields

The treatment of water by magnetic fields is known to stimulate plant growth and to affect IR absorption spectra, surface tension and crystallization patterns. The effects resemble those achieved by the treatment of healer. The emission of bio-photons in IR and UV range have been frequently measured in the proximity of healers. This is easy to understand if MEs and magnetic fields form magnetic mirrors so that presence of either makes the presence of another probable. For instance, magnetic fields could stimulate the formation of plasmoids.

8. The transfer of intent has EEG correlates.

In one class of experiments described in [J93] the sender and receiver are located separately in sensory shielded rooms and extrasensory transfer of information is attempted while both sender and receiver are connected to electroencephalographs. The sender transmits his intent during randomly selected intervals and receiver attempts to guess the moments of transmission. Experiments demonstrate no conscious ability to guess the moment of transmission. However, a statistically significant correlation between the actual sending time and the alpha wave amplitude was found in the receiver.

Alpha wave synchronization was detected between pairs of qigong masters and their receivers even when they were separated by a distance of 4 km. A possible interpretation is that the low frequency part of EEG, in particular alpha band (perhaps Schumann frequency) are used by the higher level multi-brained magnetic selves which act as relay stations receiving the intent of the sender and communicating it to the receiver. That alpha band is involved fits nicely with the fact that the cyclotron frequencies of most biologically important bosonic ions are in alpha band. Note that the energies of dark EEG quanta are above thermal threshold for $k_d \geq 40$.

This hypothesis is also natural since Schumann frequencies are associated with the oscillations of the magnetic flux quanta also representing sensory canvases and magnetic components of our selves (the quantum energies assignable to Schumann frequencies f_S would come as $E_S(k) = \hbar(k)f_S$). Note however that for the complex structures formed by the magnetic flux tubes of Earth's magnetic field also other resonance frequencies than Schumann frequencies are expected. The time lapse between the sending and onset of the unconscious physiological response in the receiver was found in these experiments to vary in the range 10–17 seconds: this would suggest that $k_d = 54$ level of the dark matter hierarchy is involved.

7.7 The role of dark micro waves in living matter

It has already earlier become clear that microwaves play a fundamental role in living matter and I have performed a considerable amount of work in attempts to integrate various ideas to a coherent overall view. The ideas about dark matter hierarchy provide new insights to the problem although much remains to be understood.

7.7.1 Dark microwaves and metabolism

Already the model for plasmoids leads to the idea that microwave photons could serve as 'food' of plasmoids. The basic objection that microwave photons have sub-thermal energies can be circumvented when microwave photons are dark.

Are dark microwaves produced in protein dynamics?

Micro-waves are produced by the protein conformational dynamics and the rotational transitions of water molecules and their clusters might mimic and amplify the rotational spectra of molecules. This could provide a first principle explanation for why one encounters microwaves in so many strange phenomena related to living matter.

In the most conservative approach, the internal degrees of freedom for atoms and molecules cannot be dark so that the conformational dynamics of proteins could not produce dark photons. It is however

good to avoid too strong prejudices at this stage, and one can indeed imagine the existence of the dark counterparts of atoms and molecules having the same energy spectrum as ordinary atoms. One can also imagine what might be called N -atoms and N -molecules for which the spectrum of transition energies would be scaled up by a factor $N \leq r$, $r = 2^{k_d}$ and the emitted photons would have r -fold MEs as space-time correlates and could decay to bunches of N^k ordinary photons.

If this picture makes sense, the conformational and rotational dynamics of DNA and proteins could produce dark microwave photons at arbitrarily level of dark matter hierarchy. One can argue that the idea about N molecules literally on top of each other from the point of view of M^4 factor of imbedding space looks rather strange. On the other hand, nothing strange is involved if one looks the situation at space-time level. Here only the experiment can decide and the claims of Randell [D17] [D17] might be seen as an experimental support for the notion of N -atom in the case of hydrogen.

Dark microwaves as metabolic currency

If the intensity of the magnetic field is of about .2 Tesla, which by the quantization of magnetic flux corresponds to the p-adic length scale $L(157)$, (80 nanometers), electronic cyclotron transitions generate micro-waves and the system can thus generate its 'food' itself. Also dark microwave photons can result in this manner.

Also the liberation of zero point kinetic energy in the dropping of protons and ions from $k = 151$ to larger space-time sheets generates micro-wave radiation and could be an essential part of the self-organization. In this case however the microwave photons would be ordinary photons and have sub-thermal energy.

The conformational and rotational dynamics of proteins provides a further mechanism producing microwaves and if the notions of inherently dark atom and molecule make sense this dynamics could produce metabolic energy utilizable by plasmoids.

Micro-wave MEs as bridges between space-time sheets

The earlier model for various phenomena discussed in this chapter emphasized the breaking of super-conductivity induced by a transfer of particles between super-conducting and non-super-conducting space-time sheets. In the recent framework the breaking of dark super-conductivity could occur by a phase transition to the ordinary phase. If the atoms and molecules are dark only in the sense they are ordinary particles topologically condensed on dark space-time sheets, their identity is not affected by the process. The mysterious appearance of atoms to places where they should exist is a signature of the phase transition. Sue Benford has documented this kind of phenomenon to be discussed later.

The transfer of charged particles between space-time sheets is possible provided join along boundaries bonds connecting the boundary of a smaller space-time sheet to the boundary of a larger space-time sheet are generated [K13, K14]. Particles simply flow along this bond connecting the space-time sheet to the larger space-time sheet, say magnetic flux tube, and also vice versa.

One can imagine various kinds of join along boundaries bonds and also MEs could act as bridges allowing particles to flow between different space-time sheets. In this case the acceleration of the charged particle in the electric field of ME gives it energy so that the mechanism could act also as a metabolic mechanism. In particular, MEs could drive protons from large space-time sheets to $k = 137$ space-time sheets by providing them with the energy of about .5 eV of metabolic energy quantum. Same applies to electrons.

The transfer could occur in several steps.

1. Quantum-classical correspondence suggests that it should be possible to understand how absorption of photons corresponds to the process in which the 'bridges' are generated by MEs. MEs carry transversal electric field and magnetic fields. There is infinity variety of various kinds of MEs but for the simplest MEs electric and magnetic fields have constant linear direction orthogonal to each. Electric field defines a potential difference which is constant in length scales much shorter than the wave length of ME.
2. By generalizing the quantization of the magnetic flux to that for electric flux one obtains that the the potential difference satisfies $eV = n\omega = nf \times 2\pi$. This means that an ion having a charge e accelerating in the radial field gets energy $E = n\omega$. Thus absorption of photon with energy $n\omega$ corresponds classically to acceleration in the electric field of ME and getting same

energy. For ion having opposite charge acceleration would be replaced by deceleration and one must speak of emission of photon with energy $E = n\omega$. The model for how ADP-ATP process is indeed based on the assumption that metabolic energy generates an electric potential in which protons are accelerated to get energy of .5 eV.

3. The proposed classical picture implies that ordinary micro-wave MEs can induce the transfer of ions to $k = 149$ and $k = 151$ space-time sheets and the transfer of electrons to $k = 157$ space-time sheets. The bridge generated by ME is expected to have a width given by atomic length scale. A good guess is that the thickness of MEs is given by the exotic weak length scale involved with the level of dark matter hierarchy in question.

7.7.2 Poorly understood effects related to micro-waves

Micro-waves span the wave length range 1 mm–30 cm corresponding to the frequency range 300–1 GHz. There is support for the importance of micro-waves for living systems coming from various anomalous phenomena involving micro-waves. The connection with homeopathy has been already discussed and this discussion will not be repeated.

Microwave hearing

Micro-wave hearing [I95] is a phenomenon in which micro-waves in the frequency range .2-3 GHz (wave length range 150-10 cm) induce hearing sensation.

The basic features of the microwave hearing are following.

1. There is evidence that ears are not involved with the micro-wave hearing [I94] . The average pressure of the radar wave at the threshold of hearing is roughly three orders of magnitude less than the average pressure of a sine wave in air at the threshold of hearing air waves.
2. The location of the most sensitive area for hearing radar is remote from the ears, on top of the head.
3. The subjective frequency spectrum seems to include higher frequencies for radar hearing than for normal hearing of air waves.
4. The direction from which sound is experienced to arrive does not change as the head is turned around in the radar field.

For dark microwave photons the energies of photons would higher by a factor $r = 2^{k_a}$ and much above the thermal threshold which could explain the strong physiological effect.

Brain space-time sheet has correct size scale to serve as a receiving (dark) micro-wave antenna: it could also act as active radar generating (dark) microwave photons. That the most sensitive region is at the top of head, would conform with the assumption that dark microwave MEs modulated by audible frequencies induce the formation of plasma oscillations and these generate the sensation of hearing directly. This would suggest that the sensory input in ears could also generate microwave plasmoids as auditory mental images.

Microwave hearing allows to interpret the auditory hallucinations of schizophrenics as messages from various magnetic bodies, not necessarily the personal ones. Perhaps the immune system of schizophrenic fails to eliminate communications from non-personal magnetic bodies. Microwave hearing could also be involved with "God's voice" which according to the theory of Jaynes was a key element of the bicameral consciousness [K71] , [J67] . That micro-wave hearing could also explain the strange buzzing sounds reported by the witnesses of the Fatima apparitions, which served as a clue to the TGD based model of this phenomenon [K42] .

Microwave static and taos hum

Micro-wave static is a strange phenomenon starting after sunset and ceasing after sunrise. It is known to be of biological origin. Taos hum [I125] is in turn a painful auditory experience resembling the sound of diesel engine having all physiological correlates of the ordinary hearing sensation although it has not been possible to detect the sound using microphones. The heard sound also reflects the geometric properties of the acoustic environment.

The interpretation in terms of microwave hearing suggests itself [K40] . Microwave static has a strong correlation with taos hum [I125] : taos hum begins and ends at same time. Physiological evidence suggests that microwave static can generate a response in the entire body of the patient. Perhaps the electromagnetic immune system of the patient is unable to censor out the microwave static.

Tectonic lights and microwaves

Observations interpreted in terms of UFOs are often made near the lines of the tectonic activity and they could represent a life-form using the tectonic dark micro-wave photons energy as their 'food' (quartz crystals generate micro-waves) and therefore following the micro-wave beam emanating from the spot of the tectonic activity. This would explain their random looking butterfly like motion as being due to the random variation of the direction of the microwave beam. The de-coherence of dark microwave photons to ordinary photons could in turn explain the observed but hard-to-understand luminous phenomena associated with tectonic lines.

7.7.3 X-ray images and remote realization of intentionality

M. Sue Benford has discovered rather fascinating and puzzling phenomenon in which some unidentified mechanism causes dots and tracks of size of order millimeter to X ray film [I55] . The interpretation in terms of tracks of ordinary charged particles is not possible. The intention of the experimenter or subject person seems to be strongly involved as well as a non-local information transfer. In particular, the emotional state affects the size of the dots. What makes these experiments so fascinating is that they dramatically differ from the ideal Cartesian experiment in which experimenter's mind does not affect the result of experiment in any manner.

These experiments provide support for the many-sheeted space-time concept of TGD and for a concrete remote realization of intentions as changes on X ray sensitive film by a mechanism involving micro-waves also associated with the conformational dynamics of bio-molecules such as proteins. The mechanism which basically involves a transfer of ions between atomic space-time sheets and superconducting magnetic flux quanta, relates closely to the many-sheeted models of metabolism, quantum control of homeostasis, and molecular machines.

There is a close connection with other well-established anomalous phenomena such as taos hum and micro-wave hearing. The mechanism is involved also with the anomalous phenomena in the field of free energy [K83] . TGD predicts the possibility of plasmoidic life forms and dark micro-wave photons would serve as 'food' of this life forms. This leads to a model of UFOs and UFOs and UFO experiences: the model for Fatima Marian apparition witnessed by as many as 70.000 people was actually the key to the understanding of the role of micro-waves [K40] . The mechanism could also serve as a basic mechanism of psychokinesis and remote mental interactions [K63] . Also a remote information transfer might have been involved with the experiments. The sharing of mental images by quantum entanglement is a general TGD based mechanism making this possible [K63] .

Holography type mechanism has been also suggested as a mechanism of remote mental interactions and is based on the idea that the fields generated by a living system form a representation for the system. In [I104] Benford has analyzed Dela Warr images [J108] , and has shown that they possess hologram like aspects. There is indeed experimental evidence [I91] that holography might be a basic representational mechanism allowing to represent information about body part in the radiation pattern generated by other body parts. The notion of conscious hologram discussed in [K11] allows to understand the hologram like aspects of delaWarr images and the mechanism of bio-holography. As a matter fact, remote quantum entanglement and self-organization induced by the leakage of supra currents and/or by the reduction of charge entanglement induced by W MEs are basic aspects of conscious holograms. The holographic aspects are not considered in the sequel but the model to be discussed is consistent with the notion of conscious holography since the mechanism generating the X-ray images generates also conscious holograms.

I want to thank for M. Sue Benford for very enlightening and detailed discussions concerning axion experiments as well to as yet unpublished experiments in which intentional action induces similar effects on X-ray film. I am also grateful for Keith Fredericks for discussions related to his findings about tracks in nuclear emulsions which he interprets as evidence for tachyons [I83] and for Lian Sidoroff for telling me about the work of Keith Fredericks.

A brief summary of the empirical findings

The effects of several mechanisms to the photosensitive emulsion (X ray dental film) were studied in the experiments. Part of the data are yet unpublished and in the following only the published data are discussed. In the case studied [I55] the so called axion generator developed by a Russian physicist Shpilman was used. The torsion field believed to be generated by the generator is in TGD framework replaced by Bose-Einstein condensate of dark photons associated with MEs. Exotic weak bosons and their dark variants induce long range parity breaking interactions possibly responsible for chiral selection in living matter.

The working hypothesis in [I55] was that the rotating axion generator generates so called axions, neutral pseudoscalar elementary particles, which transform to X-rays in the presence of an external magnetic field and might be detectable in the photosensitive emulsion. The spectrum of the electromagnetic radiation generated by axion generator was found to contain MHz portion and micro-waves in the range .1 – 2.5 GHz. Microwaves modulated by MHz waves are produced also by Priore's machine [I107], which suggests that the model of Priore's machine might apply almost as such also here. Interestingly, the micro-waves in the frequency range .1 – 3 GHz are known to be associated with the micro-wave hearing.

It was found that the film contained dots and tracks. According to the specialists, the dots and tracks could not be due to any known elementary particle traversing through the emulsion. What was strange that the sizes of the dots had sizes of order millimeter. This size is much larger than the typical sizes of dots. The size of the silver grains is below micro-meter [I83] and the number of grains along the track of a charged particle can be counted. This suggests that the interpretation in terms of an ordinary charged particle traversing the emulsion is not correct. What was also strange that the dots and tracks contained trace amounts of S, Mg and Al whereas the background region contained only C, N and O. Where did these elements come from?

In the case of charged particle very many X rays are emitted. The roughest estimate is one ionizing X ray per atom. In the case of axion only single X ray would result and it does not seem that the effect of single X ray could be so dramatic as to be much larger as the effect produced by very many X rays produced by a charged particle. Furthermore, if axion generates X rays it must have a mass measured in several electron volts. This does not conform with the cosmological bounds on axion mass (mass should be below 10^{-3} eV). Thus it would seem that the axion hypothesis is not supported by the experimental findings.

A further strange finding was that the intentional action of the experimenter affects the generation of dots and tracks and that there is a correlation with the emotional state of the experimenter and size of dots. The model for Priore's machine suggests that experimenter generated *W* MEs giving rise to plasmoids producing the tracks and dots, and that axion generator served as a source of metabolic energy in form of dark microwave photons.

The origin of the dots and tracks?

The model for the generation of dots and tracks is essentially same as that for the functioning of Priore's machine.

1. The role of axion generator could be analogous to that of Priore's machine: to produce dark microwave photons providing the energy needed to generate plasma wave oscillation quanta at microwave plasma frequencies making it possible to realize generalized motor actions using by generating plasma oscillation patterns.
2. In the present case the plasma oscillation patterns would be produced in the photographic emulsion. The reason why photographic emulsion can take the role of living matter could be that gelatin is one component of the X-ray emulsion. Gelatin consists of animal proteins and might have inherited some of the many-sheeted space-time structure of living matter making it possible to induce dark plasmoids provided the metabolic energy in form of dark microwave photons are present.

The generalized motor action by the magnetic body of the experimenter would now affect the emulsion instead of brain of the experimenter, where 1 mm sized neuron blobs could correspond to the seats of microwave plasmoids. This picture conforms with the fact that also mere intentional action can affect photographic emulsions. The correlation of the size of dots with

emotional state would be understood if the intensity of classical W boson field (number of W bosons in BE condensate) and perhaps also the thickness of W ME correlates with the emotional state.

3. Dots and tracks can be generated intentionally, even within a very brief time interval measured in minutes. The size scale 1 mm for dots suggests interpretation as a p-adic length scale associated with scaled dark length scale $L(163 + k_d) = \sqrt{r}L(163)$, where $L(163) = .64 \mu\text{m}$ corresponds to the p-adic length scale assignable to Josephson radiation for ordinary value of Planck constant. The estimate for r is from this $r = 2^{k_d}$, $k_d = 21$. Using the previous formula for the dark energy of microwave photon this predicts for the energy of dark microwave photon with frequency $f = .1$ GHz $E = 8.6$ eV, which is somewhat too large. By replacing 1 mm with .5 mm one obtains $E = 2.15$ eV consistent with the model of EEG. For much higher microwave frequencies energies are in UV and are not expected to couple to the cell membrane.
4. Dots and tracks contain S, Mg, Al which should not be there but they are in trace amounts. The phase transition transforming dark space-time sheets to ordinary ones involving possibly also the transformation of inherently dark S, Mg, and Al atoms to ordinary ones could explain this finding. Neither zero point kinetic energy nor atomic and molecular energies are changed in this process. The process involves the dissipation of the energy of plasmoid which could transform to UV photons and X rays by de-coherence.

The dependence of the dot size on emotional state of the experimenter supports the view that the experimenter is the intentional agent producing the dots and tracks. Neuronal columns with height and transversal size scale of order 1 mm are the basic information processing units in the cortex. This is consistent with the assumption that neuronal columns controlled from magnetic body by dark W MEs generating millimeter sized plasmoids via de-coherence. The control by highest levels of dark matter hierarchy could be of special importance in frontal lobes believed to be specialized to intentional actions.

Alternative model for dots and tracks

The original model for dots and tracks was based on the leakage of supra currents to atomic space-time sheets. If join along boundaries bonds connecting magnetic flux tubes to the atomic space-time sheets are formed in the millimeter sized regions then also super-conducting dark ions can leak to the atomic space-time sheets and transform to ordinary matter at the same time. The dots could have been caused by the ionizations caused by these super-conducting ions if they had sufficient energy.

Already the Nobel chemist Langmuir observed for 100 years ago effects with this interpretation when he was desperately to build vacuum tubes and realized that gas was flowing inside the tubes by an unknown [I101] [D29]. Crop circles [K24] are known to involve micro-wave explosions in growth nodes and the mysterious appearance of a layer of magnetized meteoric iron to the plants and soil proposed to involve currents from ionosphere. Leakage of dark ionic supra-currents from magnetic flux tubes explains the phenomenon and provides support for supra conductivity in astrophysical length scales [K24, K23].

The mechanism is involved also with the anomalous phenomena in the field of free energy and the recent experiments of Modanese and Podkletnov [H7] provide additional support for the leakage phenomenon [K83]. An interesting question is whether the dots and tracks in X-ray films disappear if the local magnetic field of Earth is artificially cancelled.

Chapter 8

Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part I

8.1 Introduction

TGD inspired theory of consciousness and the ideas about quantum control allow already now a rather detailed view about conscious brain. There are general theories for qualia, sensory representations, and quantum control based on many-sheeted ionic flow equilibrium. p-Adic space-time sheets serve as correlates for cognitive representations and intentions and p-adic-to-real phase transitions provide the physical correlate for the transformation of intentions to actions.

The role of metabolism for quantum consciousness has however remained poorly understood hitherto. There are also other white regions in the map. How motor control is realized: directly from brain level or from magnetic body as the computer sitting at its own terminal metaphor would suggest? And what is the deeper quantum meaning of neurotransmitters and hormones, and so called information molecules in general? If they were only inhibitors, excitators, and modulators, the organisms would not bother to construct so many different information molecules.

Before continuing I wish to thank for many people for providing very important stimuli: in fact, the strange synchronies encourage me to think that we all might belong to a greater pattern gradually becoming self-conscious. I would like to mention Lian Sidoroff for turning my attention to remote mental actions and bio-photons and for very stimulating discussions and questions. Also the contact by Finnish new energy enthusiasts Juha Hartikka, Jukka Kinnunen and Tapio Tammi, came just in right time to allow to realize the connection with some new physics phenomena suggested by new energy technologies. The material sent for year or two ago by Gene Johnson related to brain metabolism turned also to be very invaluable. I do not know who I should thank for the existence of web: without the availability of information about practically anything between Earth and Heaven this kind of convergence of ideas would be completely out of question.

8.1.1 Dark matter hierarchy, sensory representations, motor action, and metabolism

Dark matter hierarchy forces a profound reconsideration of brain metabolism and allows to develop a detailed model for how magnetic bodies use biological bodies as sensory receptors and motor instruments [K26] leading among other things to a generalization of the notion of genome.

For ordinary quantum mechanics photons at EEG frequencies correspond to ridiculously small energies. Dark matter hierarchy is accompanied by a hierarchy of EEGs and its generalizations with the scalings of frequencies predicted to come in multiples of integer in the most general case. A strong hypothesis is that they come as powers $r = 2^{k_d}$, where the values of k_d are fixed by Mersenne

hypothesis [K26] .

The fact that arbitrarily small frequencies can correspond to energies above thermal threshold at higher levels of dark matter hierarchy implies that photons with arbitrarily low frequencies can have sizable physical effects on matter. This conforms with the findings about the effects of ELF em fields on living matter [K26] , and these effects allow to develop a rather detailed model for EEG and identify the parts of EEG correlating with communications of sensory data to the magnetic body and with quantum control performed by the magnetic body [K26] .

The implication is that the transfer of energy between magnetic bodies and biological body could be major factor in metabolism. The question is whether the magnetic bodies provide metabolic energy for brain or utilize the metabolic energy provided by brain or both. Time mirror mechanism as a mechanism of intentional action would predict that magnetic body uses the metabolic resources of brain during intentional action. Together with the strange findings about ionic currents through cell membrane suggesting that ionic channels and pumps are actually ionic receptors and the ionic currents through them are only small samples about the net currents, this vision leads to a profoundly new view about brain metabolism. Dark matter hierarchy forces a profound reconsideration of brain metabolism and allows to develop a detailed model for how magnetic bodies use biological bodies as sensory receptors and motor instruments [K26] leading among other things to a generalization of the notion of genome.

8.1.2 New ideas

After the writing of the first version of this chapter for about decade ago several new ideas have emerged and the challenge is to unify these ideas.

Three different views about living matter as a macroscopic quantum system

There are three different views about how living system manages to be a macroscopic quantum system.

1. The first vision is based on various kinds of super-conductivities [K13]. Electronic super-conductivity is assigned with the cell membrane and plays a key role in the model of cell membrane as a Josephson junction. Furthermore, the effects of ELF em fields on vertebrate brain [K26] suggest that biologically important ions form macroscopic quantum states and cyclotron Bose-Einstein condensates of bosonic ions have been suggested. The TGD based view about atomic nuclei predicts exotic nuclei chemically equivalent with ordinary ones but being bosons rather than fermions. Also these exotic ions could also form cyclotron Bose-Einstein condensates. Large value of Planck constant would guarantee that cyclotron energies proportional to \hbar are above thermal energy.
2. A more precise view about hierarchy of Planck constants as an implication of the enormous vacuum degeneracy of Kähler action has emerged [K29]. According to this view non-standard values of Planck constant are only effective.

As the idea about the hierarchy of Planck constants emerged, I proposed that favored values of Planck constant could come as powers of 2^{11} . This was just a first guess inspired partially by the observation that the mass ratio of proton and electron is $940/.5 = 1880 \sim 2^{11}$. I managed to find indications supporting this hierarchy and also this chapter contains traces of this idea. I became later skeptic but one could actually imagine a mechanism implying this kind of hierarchy. Dark protons with say $r = \hbar/\hbar_0 = 1836 = 4 \times 3^3 \times 17$ would correspond to approximately same Compton length as ordinary electrons. It is natural to assign this value of \hbar also to electrons and this gives Compton length 44.6 Angstroms not far from the p-adic length scale $L(149) \simeq 50$ Angstroms assigned with the lipid layer of cell membrane. The condition that dark proton corresponds to this Compton length gives $r = 1836^2$: the electron Compton length comes now 8.1 μm , which corresponds to cell size scale. One could continue the resulting hierarchy of Planck constants indefinitely.

3. The notion of negentropic entanglement making sense for rational and even algebraic entanglement probabilities has emerged as a possible characterizer of living matter [K46]. Quantum arithmetics [K94] allows to generalize the notion of rational so that p-adic real correspondence

mediated by canonical identification is fixed uniquely and is both continuous and respects symmetries [K94]. One implication is an explanation for Shnoll effect [K5], which could be important also in living matter.

This raises several questions.

1. How high T_c super conductivity based on dark electron pairs and negentropic entanglement relate?
2. Could it be that electron pairs in valence bonds are the carriers of negentropic entanglement and that they generate the magnetic flux tubes as parts of their magnetic bodies? This makes sense only if the valence electron pairs in living matter have spin 1. The Cooper pairs of high T_c super-conductors are indeed known to have spin 1 [?] If this view is correct, biological evolution would favor the maximization of covalent electron pairs and this indeed seems to be the case.
3. Why large \hbar would make possible negentropic entanglement or even force it? Is there some purely number theoretic reason for this?

Genetic code and dark nucleon states

New realization of the genetic code in terms of dark proton sequences identified as dark nucleons was discovered [L7, K36].

1. The states of dark proton are in natural one-one correspondence with DNA, RNA, tRNA, and amino-acids and vertebrate genetic code is realized in a natural manner. Dark nucleons realized DNA codons as entangled quark triplets. The effective chemical formula $H_{1.5}O$ for water in atto-second time scale supports this view [K25]. How the notion of dark nucleon relates to negentropic entanglement of electrons? Could dark electron pairs and dark nucleons correspond to the same value of Planck constant? Could both dark protons and dark electrons play a key role in metabolism.
2. The simplest guess is that DNA strands are accompanied by dark nuclei with one dark proton per DNA nucleotide. The resulting positive charged would stabilize the system by partially neutralizing the negative charge density due to the phosphorylation (2 negative charges per nucleotide). Dark proton sequences could be associated also with other important bio-polymers. If the spins of the dark protons are parallel the dipole magnetic fields give rise to flux tubes connecting the protons and one can assign to the large \hbar protons a macroscopically quantum coherent phase.
3. The natural guess would be that dark nucleus realization of the genetic code induces the biological realization as evolution assigns to dark nucleon sequences DNA, RNA, and aminoacid sequences with 1-1 correlation between dark nucleon state and basic unit of the sequence. The dark realization of genetic code suggest a totally new view about biological evolution as a process, which is analogous to R&D in high tech industry rather than being completely random [K36]. The candidates for new genes could be tested at dark matter level and in the case that they work they would be transcribed to their chemical equivalents.

New ideas related to metabolism

Also new ideas related to metabolism have emerged at the same time when evidence for quantal aspects of photosynthesis has been emerging [I86, I38, I36, I15].

1. Negentropic entanglement leads also to the idea about energy metabolism and negentropy transfer as different sides of the same coin. The model for DNA as topological in turn suggest that $ADP \rightarrow ATP$ and its reverse can be interpreted as a standardized reconnection process re-organizing connections between distant molecules connected by magnetic flux tubes by the relay defined by ATP molecule. Metabolic energy would - or at least could - go to the re-organization of the flux tube connections and therefore of the negentropic quantum entanglement. The question is how to fuse this vision with the hypothesis about metabolic currencies as differences of zero point kinetic energies for space-time sheets.

2. The radiation from Sun defines the fundamental metabolic currency. Solar radiation cannot be said to negentropic since negentropic entanglement is a 2-particle property. Solar photons could possess a large value of \hbar or - more plausibly - suffer at the magnetic body of the living system a phase transition increasing the value of \hbar . Could the absorption of large \hbar photons arriving from Sun or from magnetic body by electrons generate spin 1 valence electron pairs or provide the metabolic energy needed to re-arrange the flux tube connections between distant molecules by $ADP + P_i \rightarrow ATP$ process?

DNA as a topological quantum computer vision

The vision about DNA as topological quantum computer [K28] has turned out to be very general allowing to imagine several concrete realizations. The essential element is the coding of DNA nucleotides and one can imagine several options.

1. The original proposal for the realization of DNA as tqc is based on the representation of DNA nucleotides A, T, C, G as quarks u, d and their antiquarks and requires scaled up version of QCD [K28]. This idea looks rather outlandish but could be justified by the strange findings of mathematician Barbara Shipman about honeybee dance [A13] and also by the p-adic length scale hierarchy and the hierarchy of Planck constants suggesting scaled variants of QCD like physics also in the length scale range relevant to the living cell.
2. The question whether one could use spin 1 triplet and spin 0 singlet of dark electron pair instead of quarks and their antiquarks to represent codons, is rather obvious. The problem is that $S = 0$ state for electron pair however gives rise to vanishing dipole field so that flux tube structure would not be possible. The generation of flux tube structure along which supra currents can flow is however an essential element of the proposed mechanism of super-conductivity.
3. DNA as topological quantum computer hypothesis lead to the hypothesis that it is $O=$:s to which one must assign the flux tube pair responsible for the representation of the genetic code. Why $O=$ would be in special role? And why should one have a pair of flux tubes? Could this relate to the coding of nucleotides by electron pairs? If there are two parallel flux tubes, one obtains tensor product $3 \times 3 = 5 + 3 + 1$ of electron triplets at the ends of the flux tubes. Could it be that A,T,C, and G are represented in terms of 3 and 1 and that the breaking of rotational invariance implies mixing of singlet and $S_z = 0$ state of triplet so that nucleotides and their conjugates could correspond to the resulting two pairs related by reflection.
4. $ATP \rightarrow ADP + P_i$ would correspond to the reconnection of the flux tubes of the flux tube pair with hydrogen bonds associated with two water molecules. The flux tubes would split and end to water molecules containing valence electron pair so the negentropic entanglement might not be totally lost. The reverse process would create flux tube connection labelled by the spin state equivalent of A,T,C, or G.

Pessimistic generalization of the second law of thermodynamics

The possibility of negentropic entanglement raises the question about the fate of the second law of thermodynamics. The proposal for a generalization of the second law of thermodynamics [K46] based on the most pessimistic vision is that entropy indeed increases also when negentropic entanglement is generated in state function reduction. If the generation of negentropic entanglement is accompanied by a compensating entropic entanglement, how it is generated? Or is the maximally pessimistic generalization really necessary? Is it implied automatically in time scales longer than the characteristic time scale associated with the causal diamonds serving as the basic correlates for conscious selves. One must apply ensemble description in these time scales: does the non-determinism of quantum jump imply second law at the level of ensemble automatically. If this argument is correct, second law would cease to hold in time scales than that characterizing the relevant CD .

8.1.3 Many-sheeted photosynthesis

Photosynthesis is a fundamental metabolic function and a many-sheeted model allows to concretize the general ideas about quantum metabolism. What happens in photosynthesis at the level of energy balance seems to be relatively well-understood [I100, I35] but the detailed molecular mechanisms

remain obscure. Several strange features, such as the appearance of electron pairs, suggest that superconductivity and atomic and molecular Bose-Einstein condensates are involved. p-Adic length scale hypothesis gives very strong quantitative guidelines in the attempt to understand photosynthesis in many-sheeted space-time, and one ends up to a general view about how Bose-Einstein condensates store metabolic energy as zero point kinetic energy and how this energy is utilized by remote metabolism by generating negative energy MEs. What is so remarkable is that the resulting simple model of photosynthesis is successful both at qualitative and quantitative level.

I have included in this chapter the earlier variant of the quantum model developed before 2007 as such to compare it with the recent view about macroscopic quantum aspects of photosynthesis involving several new ideas. Note that year 2007 is special in the sense that during 2007 the first evidence for the quantal nature of photosynthesis emerged.

8.2 General view about sensory representations, motor control, and metabolism

In this section the general after dark matter revolution vision about sensory representations, motor control, and brain metabolism is discussed.

8.2.1 General vision about living matter as a macroscopic quantum system

The following assumptions summarize the general vision achieved before the dark matter revolution. The picture is consistent with the findings of Libet about strange time delays of consciousness [J48, J72] discussed in the article "Time, Space-time and Consciousness" in [L5] and chapter [K88].

1. Magnetic bodies forming a hierarchy are the fundamental volitional agents transforming intentions to actions. Intentions are represented by p-adic MEs transformed to negative energy MEs representing the desire about particular activity communicated to the lower level magnetic bodies in the geometric past and eventually to the material body. Each negative energy ME in the cascade represents a desire to realize some submodule in motor program. Eventually the cascade of negative energy MEs ends up to the glial cells serving as metabolic sources. The desired action is generated in terms of neural communications and of positive energy MEs both representing classical communications to the geometric future. The desire in question could be a desire to perform a particular motor action, a desire to direct attention or select among sensory percepts (binocular rivalry is the standard example), or a desire to remember something. Sensory perception, motor action, and memory would thus be based on essentially the same basic mechanism. The population inverted many-sheeted laser system providing the energy source in brain or body would consist of bosonic ions or of Cooper pairs of fermionic ions in excited cyclotron states.
2. Sensory representations are realized at the magnetic bodies associated with the sensory organs and sensory mental images are shared with the personal magnetic body by negative energy em MEs. Brain constructs only symbolic and cognitive representations, writes the sensory music to notes. The mental images defined by these representations can be shared by personal magnetic body or magnetic bodies associated with the sensory organs in a similar manner. Also classical communications to the personal magnetic body are possible. A tree like structure with the root represented by sensory mental images and branches and leaves represented by various symbolic and cognitive mental images results.

The selective entanglement by negative energy MEs allows to understand the active aspects of sensory experience involving direction of attention and selection between percepts at various levels. In the case of motor actions, the negative energy MEs received from magnetic body communicate the desires of the magnetic bodies about motor actions to be performed and the response by positive energy MEs would realize these desires as nerve pulse patterns.

3. Positive energy interior MEs lie along interior of magnetic flux tubes of the personal magnetic body. These MEs could relate to the classical communication of the symbolic representations constructed from the data processed in the brain to the magnetic body. Sensory perception and

memory differ only is that the time scale involved is different. Declarative memory corresponds to negative energy MEs sent from a point of the personal magnetic body at the distance $L = cT$ to the material body and reflected back as positive energy MEs. Thus the material body serves as the mirror unlike in the original variant of the mirror mechanism of memory. The distance $L = cT$ along magnetic flux proportional to the transverse area S of the flux tube $L \propto S$ tubes codes for the temporal distance to the geometric past by transforming it to cyclotron frequency scale.

8.2.2 A general view about quantum control, coordination and communication inspired by dark matter hierarchy

The general vision about motor action is roughly the following. The dark matter hierarchy with levels labelled by the increasing values of Planck constant defines a hierarchy of intentional agents. Intentions are realized as p-adic space-time sheets transformed to real ones as intention is transformed to desire. Negative energy MEs serving as space-time correlates for dark photons and also dark variants weak bosons and gluons are good candidates for the representations of these desires. A natural guess is that the desires are communicated from given level of dark matter to the next level below it and ultimately the level of ordinary matter represented by the biological body is reached and the signal induces various neural and other activities realizing the desired motor actions. Each level has a lot of freedom to decide about the details of that part of motor action for which it is responsible.

Motor action is an iterative top-down process, a gradual build-up of a four-dimensional space-time statue representing the motor action starting from a rough sketch and adding gradually the details. This view is consistent with how we experience motor control: what happens is that we decide to move hand, rather than initiating consciously some complex neuronal activity in brain leading to the raising of the hand. We need not know how the motor action happens in order to initiate it.

The control signals from the magnetic body must enter to structures with high connectivity and very probably be very simple and symbolic. A reference wave generating complex hologram would be an over-simplified example about an initiator of a complex control action proceeding gradually to the lower levels of hierarchy by similar simple signals. Of course, some linguistic structure based on, say, amplitude modulation is required to avoid interference of the undesired signals with the bio-control. Various gap junction connected structures are a good guess for the relay stations the control commands from the magnetic bodies. Thus gap junction connected neuron groups, astrocytes, and the walls of arteries and perhaps even capillaries are good candidates for receivers at the level of brain. At the level of body various organs, epithelial tissues, walls of arteries, and also skin could be the mediators of the generalized motor actions during sleep.

Dark matter hierarchy and motor control

The following general overview about quantum communication and control emerges from the model for EEG hierarchy as correlate for dark matter hierarchy discussed in detail in [K26] , and from the implications of the model of DNA as topological quantum computer [K28, K31, K4] . Consider first general assumptions about how motor actions would be controlled from magnetic body.

1. Massless extremals (MEs, topological light rays) serve as correlates for coherent states and Bose-Einstein condensates of dark bosons. Neutral massless extremals could be responsible for signals related to control, coordination and communication. Also charged and colored MEs are predicted but their role has not yet been firmly established. Negative energy MEs would be related to motor control and positive energy MEs to communication of sensory data. Zero energy ontology, which has become the cornerstone of quantum TGD [K20, K19] , justifies the notion of negative energy ME.
2. Magnetic body has an onion like hierarchical structure and its layers receive sensory information from biological body and perform motor control. The matter at the layers of magnetic body corresponds to the value of Planck constant which is so large that cyclotron energies are above thermal energy. A fractal hierarchy of analogs of EEG is involved with these communications. The frequencies involved correspond to harmonics of cyclotron frequencies for biologically important ions and to differences and sums of these with Josephson frequencies associated with Josephson junctions defined by the magnetic flux tubes carrying dark supra currents. Magnetic

flux tube refers in the following to ordinary or "wormhole" magnetic flux tube since it is not yet clear which of them of these options if not both are realized [K28]. Flux tubes bind the biological molecules to a weblike structure and are responsible for the macroscopic quantum coherence of living matter.

3. Negative energy control signals from the magnetic body initiate topological quantum computation like processes whose outcome is expressed as four-dimensional self-organization patterns relying basically on gene transcription inducing motor responses in a very general sense. It is also possible that the outcome is expressed as an electromagnetic signal generated by intronic portion of the DNA representing a call of tqc subprogram. The experimental work of Peter Gariaev suggests that polarization coding of DNA sequences is involved with the sub-program calls and TGD provides a model for how this could take place [K28].
4. Harmonics of cyclotron frequencies relate to the control of the biological body by the magnetic body and could be assigned with the magnetic flux sheets going through DNA since it is genome where protein synthesis is initiated and is thus the optimal intermediate step in the cellular control. Differences and sums of harmonics of cyclotron frequencies and Josephson frequencies would be involved with communication of sensory data.
5. One of the basic functions of cell membranes is to perceive the chemical environment using various kinds of receptors as sensors. Neurons have specialized to receive symbolic representations of the sensory data of primary sensory organs about the situation in the external world. A good guess is that in this case magnetic flux quanta are hollow cylindrical structures parallel to the cell membrane associated proteins serving as Josephson junctions. Also magnetic flux tubes parallel to axon serving as templates for axons could define communication lines connecting cell membranes to the cellular magnetic body. Also synaptic contacts should involve similar magnetic flux quanta connecting them to neuronal magnetic body.
6. In DNA as topological quantum computer vision magnetic flux tubes as carriers of supra currents of dark variants of charged particles and connecting cell interior and exterior define braid strands. The quantum phase transitions changing the value of Planck constant and thus length of flux tubes would be fundamental building element bio-control in the scale of biological body and involved with both bio-catalysis and higher biological functions at nanoscale (molecular motors) and in the scale of cells and organs.
7. This picture would explain why the temperature of brain must be in the narrow range 36-37 K to guarantee optimal functionality of the organism [K26]. If interior superconductivity is lost, magnetic body receives sensory data but is paralyzed since its desires cannot be realized. If boundary superconductivity is lost, magnetic body can move but is blind.

There are also additional hypothesis which are natural in TGD framework but whose necessity is not yet clear.

1. In the length scales below the weak length scale L_w also charged weak bosons behave as massless particles and the exchange of virtual W bosons makes in principle possible a nonlocal charge transfer. Dark quark-antiquark pairs associated with the color bonds of the atomic nuclei can become charged via the emission of dark W boson and thus produce an exotic ion. The same can happen at the higher levels of dark matter hierarchy.
2. Besides neutral massless extremals (MEs) TGD predicts also charged MEs obtained from their neutral counterparts by a mere color rotation (color and weak quantum numbers are not totally independent in TGD framework). W ME would represent an exchange of virtual W boson giving rise to em current. Charged massless extremals could be seen as correlates for nonlocal quantum control by affecting charge equilibria whereas neutral MEs would serve as correlates for coordination and communication. Color charged MEs could also induce color charge polarization and flows of color charges and thus generate visual color qualia by the capacitor mechanism discussed in [K32]. The exchange of W bosons appears in an active role in TGD inspired model [L7], [L7] of cold fusion, biofusion [C4], and plasma electrolysis [D28]. The exchange of exotic W 's between nuclei would give rise to exotic nuclei. For instance, chemically equivalent

bosonic counterparts of biological important fermionic ions such as Na^+ , K^+ , Cl^- could be generated and could form Bose-Einstein cyclotron condensates at magnetic flux tubes. Whether biologically important ions can have exotic nuclei having mass number differing from expected could be easily tested.

3. The second nonlocal quantum control mechanism relies on em charge entanglement. Charge entanglement could involve a superposition of pairs ordinary ions/atoms and exotic ions connected by a W massless extremal joining magnetic body and biological body. In quantum jump this state would be reduced to exotic charge state with some probability increasing with the strength of the classical W field. The successful proposal for the protein folding code relying on the assumption that wobble base pairing corresponds to charge entanglement between quark and antiquark (superposition of uu_c and dd_c pairs forming a pion like state) at the ends of the magnetic flux tube connecting tRNA with $N - H$ group of amino-acid backbone [K4] .
4. These nonlocal quantal mechanisms can induce or change electromagnetic polarization in turn inducing ordinary charge flows and in this manner make possible quantum control of nervous system by magnetic body. The generation of nerve pulse could rely on the spontaneous state function reduction occurring for charge entangled state reducing the resting potential below the critical value by this kind of mechanism inducing charge transfer between cell interior and exterior and inducing voltage pulse generating DC supra current [K62] . Also remote mental interactions, in particular telekinesis, might rely on this mechanism. Of course, the interactions between magnetic body and biological body are essentially remote mental interactions.

What conditions the sensory projectors to the magnetic body must satisfy?

General constraints for a rather detailed and testable models for the hierarchy of sensory canvases (magnetic bodies) and for the system projecting sensory data to it. An especially important new element is the model for the generation of ELF MEs acting as sensory projectors.

The projectors to the sensory canvas should satisfy several constraints.

1. Sensory projectors should correspond to magnetic flux quantum structures (tubes or sheets). The magnetic flux tube structures would be to those of Earth's magnetic field plus possibly those generated by the magnetic structures and would have fixed directions by anchoring to the large scale Earth's magnetic field.
2. Projectors must be able to bind neurally represented features to the point of the sensory canvas they project. Binding would be achieved the magnetic flux quanta traverse through synaptic contacts of a larger number of firing neurons.
3. There must exist a fixed frame of reference which does not rotate when head or body rotates or moves in the scale of magnetic body much larger than the corresponding body part. The directions of Earth's magnetic and gravitational fields fix naturally this kind of reference frame. Red blood cells and pyramidal cells are magnetic structures and define naturally compass needles allowing to construct sensory representation providing information about the orientation and configuration of the body with respect to this preferred coordinate frame.
4. The fundamental exterior-interior division of the sensory experience to the bodily sensations and percepts about external world or body as seen by external observer should correspond to fundamentally different sensory representations. Blood-brain barrier is an excellent candidate for the representation of this separation at the level of brain. Neuronal consciousness would represent outsider's cognitive view about the external world and body whereas blood consciousness would represent insider's view about body.

Astrocytes define the analog of a skeleton for neurons having endfeet to the synaptic contacts and might play key role in the binding. Hence astrocytes might act as higher level sensory organs integrating the sensory input of synchronously firing neuron groups. The myelination of axons by oligodendrites is usually regarded merely as an insulation allowing to achieve rapid neuronal communications through long distances. Myelin sheaths could also serve as sensory receptors scanning for nerve pulse activity along axon.

Communications and energy transfer at cellular level

The communication and energy transfer at cellular level could rely on Bose-Einstein condensed and coherent photons at the lowest level of dark matter hierarchy. MEs defining single sheeted covering of M^4 with lengths given by typical distance between red blood cells and ordinary cells would define the space-time correlates for these photons. The wavelength range involved would cover visible wave lengths so that the identification as bio-photons [K11] , [I64] might make sense.

At higher levels of the dark matter hierarchy MEs would have $r = \hbar/\hbar_0 = 2^{k_d}$ if Mersenne hypothesis holds true. Each of them would carry the energy $E = \hbar_0\omega$ of a visible photon, so that the relationship $E_k = \hbar(k)\omega = r\hbar_0\omega$ would have a space-time correlate. Their decay to ordinary photons by de-coherence would produce r ordinary photons. This would make possible coherent liberation of large amounts of energy and momentum.

Besides chemical signalling genuine quantum communication based on bound state entanglement between red blood cell colony and neurons can be considered. Charged entanglement induced by W MEs is one option and state function reduction of this entanglement inducing deviation from charge equilibrium could induce Ca^{++} waves just as it would induce nerve pulses. The blood cell colony, the activated synchronically firing group of neurons, and astrocytes could entangle to form single quantum system and communication would be a cellular variant of telepathy. The entanglement of the blood cells with the synchronically firing neuron groups could be crucial for the assignment of features represented by neuron groups to the points of the magnetic sensory canvases.

Charged entanglement between magnetic body of some gland and corresponding hormones carried by blood flow represents a possible example of quantum communications. Hormone would be like an old fashioned postman but the letters would contain quantum links to the quantum web. Nerve pulse transmission would be a more modern communication method involving electronic transfer along axons: postman mechanism would be realized only at synaptic contacts. Quantum links could ultimately refer to the primary sensory input at the level of sensory organs so that sensory input would be associated with cognitive mental images produced by the neural activity. Besides carrying the quantum links, neural transmitters would induce neuronal chemical qualia at the synapse.

Emergence of symbols at molecular level and new view about hydrogen bond, water, and bio-catalysts

The hierarchy of dark matter leads to novel ideas about what distinguishes living matter from ordinary matter. The emergence of symbols and symbolic dynamics and what might be called "molecular sex" could be a fundamental step in the process and I have considered two visions for how this would take place.

1. First vision

First vision is relies on the model of DNA as tqc based on braids and has quite close contact with empirical reality [K8, K28, K31] . In this case DNA nucleotides are analogous to colors of braid strands and base pairing corresponds to molecular sex for DNA molecules. The color of braid strand implies long ranged highly selective interactions between DNA and distant molecules, such as lipids of the lipid layer of cell membrane or amino-acids. Free amino-acids inherit the colors of the first two nucleotides in the codon XYZ whereas the color of the third nucleotide corresponds to a quantum superposition of colors for codons coding for the amino-acid: this defines the quantum counterpart of wobble base pairing. Amino-acids can be divided into amino-acids and their conjugates analogous to opposite sexes and generalized base pairing determines the interactions of the amino-acids to a high degree. Hydrogen bond can be identified as a special case of flux tube. There are also flux tubes connecting acceptors of hydrogen bonds acting as plugs in the connection lines formed by the magnetic flux tubes and Y corresponds to this kind of plug at the level of amino-acids.

One of the implications is a code for protein folding [K4] .

1. Hydrogen bonds play a key role in bio-catalysis but are not understood completely satisfactorily in the standard chemistry. Hence the basic question is whether hydrogen bonds can be regarded as or are accompanied by short (wormhole) magnetic flux tubes: note that the subject-object asymmetry of directed attention would correspond to donor-acceptor asymmetry of they hydrogen bond. If this is the case, the identification of the magnetic flux tube connection as a generalized hydrogen bond becomes natural. At least the atoms able to form hydrogen bonds

could form flux tube contacts so that the model would be very predictive and would conform with the known important role of hydrogen bonds in bio-catalysis.

2. The fact that hydrogen bonds connect base pairs suggests a generalization of the notion of base pairing stating that under some conditions amino-acids coded by XYZ and UY_cV can behave like base pairs. These amino-acid pairs correspond to pairs of amino-acid residues which are hydrophilic *resp.* hydrophobic and hydrophobic residue do not form hydrogen bonds in general. These flux tubes would thus be more general and in general long. The model for DNA as topological quantum computer requires this kind of flux tubes and they would in general connect atoms or molecules which act as acceptors in hydrogen bonding: $O =$ atom in amino-acid and aromatic ring are basic examples.
3. If one assumes that both $N - H$ and $O =$ associated with the constant part of the amino-acid can act as flux tube terminals and represent Z and Y nucleotides of the codon XYZ coding for the amino-acid, one obtains $Y = Z$ pairing of $O = -O =$ flux tubes are allowed and $Y = Z_c$ pairing if only hydrogen bond like pairings are allowed. Direct check shows that $Y = Z$ pairing is surprisingly successful.

The phase transitions changing Planck constant change the length of flux tube and these phase transitions could be a main tool of bio-catalysis. The contraction of flux tubes connecting bio-molecules brings them near to each other and this explains why they are able to find each other in miraculous manner. Also a detailed understanding about DNA as topological quantum computer emerges [K28] : the acceptors of hydrogen bond (aromatic rings, $O =$ atoms, ...) serve as fundamental plugs at which flux tubes terminate and continue further. Also a direct connection with the basic metabolic process $ATP \rightarrow ADP + P_i$ emerges: this process can be identified as temporary splitting of the flux tube implied by the reconnection process between the flux tube connection the $O =$ atoms of second and third phosphate of ATP and hydrogen bond connecting two water molecule. Flux tube connections would also provide an explanation for the properties of gel phase in cell interior and the phase transitions changing Planck constant would induce the phase transitions of gel phase (say gel-sol transition) [K62] suggested to be a basic mechanism behind various biological functions in molecular and cell scale [I113] .

2. Second vision

The mathematical realization for the hierarchy of Planck constants leads to a generalization of the notion of imbedding space and this leads to four kinds of phases resulting as combinations of phases with increased or reduced unit of spin and quantum numbers associated with CP_2 degrees of freedom. Each phase corresponds to its own Planck constant and is characterized by a discrete symmetry group.

Especially interesting are phases with a maximal value of Planck constant involving charge fractionization and increase of spin unit. The free electron pairs of aromatic cycle are reasonable candidates for dark electrons of this kind. This means that one can consider variants of hydrogen atom with a fractional electron charge and the obvious idea is that the values of fractional charge would define "names" and their "conjugate names". Thermal stability poses strong constraints since atomic and molecular energy scales are reduced as Planck constant increases.

The notion of fractional electron inspires the notion of "half" hydrogen bond for which electron has a fractionized fermion number. The full hydrogen bond would be formed in the fusion of half hydrogen bonds and give rise to a structure analogous to a full electron shell expected to be especially stable. Catalyst sites might correspond to half hydrogen bonds and the basic recognition mechanism could be the fusion of half bond and its conjugate to form a full hydrogen bond. One could speak about "molecular sex". The sequences of half bonds would represent words so that molecules would have names. Also interpretation as quantum computer codes might make sense.

The problem of this vision is the lack of direct contact with experimental facts and for this reason it will not be discussed in the sequel.

8.2.3 Some mechanisms liberating metabolic energy and connection with free energy phenomena

In this section possible mechanism liberating metabolic energy are discussed. All these mechanisms can be combined with time mirror mechanism.

Some mechanisms liberating metabolic energy

Several mechanisms liberating metabolic energy are possible and very probably many of them are important.

1. The dropping of ions from space-time sheet to a larger one liberates energy. The liberated energy is essentially the difference of the zero point kinetic energies associated with the space-time sheets. Zero point kinetic energy derives from Uncertainty Principle: the smaller the box where particle is forced to move, the higher the momentum uncertainty and the larger the zero point kinetic energy.
2. The ion dropped to a magnetic flux tube can have very high cyclotron energy gradually dissipated as ELF MEs when the ion drops from the cyclotron state with magnetic quantum number $n \simeq f_h/f_{ELF} \gg 1$ by a stepwise process $n \rightarrow n-1 \rightarrow n-2 \dots$ to the ground state. The energy liberated in this process can be utilized by magnetic bodies at various levels of dark matter hierarchy. The mechanism is emission of negative energy dark photons inducing a coherent dropping of ions to lower cyclotron states. Magnetic bodies could share a considerable portion of metabolic energy used in brain.
3. A variant of this mechanism involves dropping of a photon BE condensed at ME parallel to a linear structure and having a frequency which is multiple of f_h to a magnetic flux tube transversal to the linear structure and its absorption by a super-conducting ion. Also this mechanism generates ELF MEs with a fixed f_h/f_{ELF} ratio for a given ion at the super-conducting magnetic flux tube.

Liberation of metabolic energy via the formation of bound states

The formation of bound states liberates also energy. At the level of conscious experience the formation of bound states corresponds to a fusion of mental images to higher level mental images and a loss of consciousness at the level of fusing selves. Sharing of mental images corresponds to fusion of sub-selves of two unentangled selves to single sub-self. The sharing of mental images is allowed only by the TGD based definition of subsystem relying on the notion of length scale resolution. For instance, the fusion of left and right visual fields to single visual field would give rise to stereo vision in this manner.

Binding energy could be liberated as coherent photons at some level of the dark matter hierarchy and utilized for metabolic purposes. The beautiful aspect of this mechanism is that the liberation of metabolic energy is accompanied by the generation of higher level mental images, and the higher the amount of energy liberated, the longer lasting the mental image is. The value of Planck constant is even more important since the de-coherence time is expected to be proportional to \hbar .

1. Gravitational binding energies for blocks of water in the biologically most interesting length scale range $L(151) = 10 \text{ nm} - L(167) = 2.5 \mu\text{m}$ correspond to frequencies in ELF range. The immense spin glass degeneracy implied by space-time surfaces differing only by classical gravitational energy encourages to think that the generation of gravitationally bound states generates ELF MEs. The objection is that the energy of one ELF ME is quite too low and that one needs large number of ELF MEs to achieve statistical reliability for the sensory representations.
2. The role of the metabolism in the generation of the bound state entanglement suggests that the natural energy scale is in the range of molecular and atomic binding energies. Bound state energies are typically measured in electron volts from the bond energy of hydrogen bond. At DNA level the generation of hydrogen bonds correlate gives rise to generation of projector MEs. If so, hydrogen bonds connecting blood and cellular liquid to cluster would be responsible for the generation of the hydrogen bonds. This is consistent with the idea that water liquid crystals amplify and represent. There is however no obvious mechanism for the generation of ELF MEs.
3. The formation of water clusters is also a good candidate for the mechanism generating bound states and could play crucial role in the metabolism. The binding energy .485 eV of hydrogen bond which is very near to the energy associated with the p-adic length scale $L(163)$ is expected to define the length of ME generated in this process. This process could be especially important at DNA level.

Liberation of zero point kinetic energy in dropping of ions to larger space-time sheets as a source of metabolic energy

In TGD the simplest manner to liberate usable energy is the dropping of ions from the atomic space-time sheets to super conducting space-time sheets. Since the difference of the zero point kinetic energies is inversely proportional to the mass of the ion, proton is optimal in this respect. The energy liberated when the proton drops from the atomic space-time sheet to much larger space-time sheet is about $3\pi^2/2m_p a^2 \simeq .4932$ eV for $a = L(137) = L(151)/128 = .78$ Angstrom and very near to the metabolic energy liberated when single ATP molecule is utilized. This energy is also amazingly near to the energy $E = 2\pi/L(163) = .4921$ eV defined by the p-adic length scale $L(163)$ defining one of the miracle length scales associated with Gaussian Mersennes. With the scaling $L(151) = 10$ nm $\rightarrow xL(151)$, $x = 1.002$, allowed by experimental uncertainties these energies are identical.

The dropping of the protons from the atomic to the super-conducting space-time sheets explains also the strange findings of Irving Langmuir [D29] and the the over unity energy production in water hydrolysis (also involved with the utilization of ATP!). In the generation of single ATP molecule 3 protons are accelerated in the electric field generated by the liberation of the metabolic energy. These observations do not leave much freedom of choice: the flow of protons between super-conducting and atomic space-time sheets is the basic mechanism of the energy economy in the living matter: energy is liberated when the proton drops to the atomic space-time sheet and the charging of the energy batteries means that the protons are kicked back to the atomic space-time sheets.

Fractality suggests that also other ionic flows define similar cycles in smaller energy scales and ATP cycle takes only care of the most roughest energy metabolism. For instance, the dropping of Ca^{++} ion would give rise to energy of in various biologically important ions would liberate energy of about .01 eV if proton liberates energy of .5 eV. The corresponding photon wave length is about 100 microns. The excitation of high n cyclotron states is possible also now and the generation of ELF MEs at multiples of cyclotron frequencies could give rise to sensory representations and contribute to EEG.

Connection with free energy anomalies

1. Anomalies discovered by Langmuir

The first class of anomalies is known more than a century and were discovered by the nobel chemist Irving Langmuir [D29] while developing the first electric lamps based on electrode consisting of tungsten wires. Langmuir made three discoveries which have been forgotten since then, perhaps because they are very difficult to understand in the framework of existing chemistry.

1. The first observation was that the heating of tungsten wire in vacuum to get rid of the gas inside it liberated practically unlimited amount of gas. Langmuir stopped the process when an amount of gas equivalent with 7000 volumes of tungsten wire had been evaporated. The question Langmuir posed himself was 'Where this gas comes'. I do not know whether Langmuir found any satisfactory answer but a very attractive possibility is that the heating allows the transfer of gas ions from super-conducting magnetic flux tubes to the atomic space-time sheets. This would indeed imply that the tungsten wire could act as effectively endless source of gas.
2. The second observation of Langmuir was that the energy liberated in the electrolysis of water to hydrogen and oxygen in presence of electric current in electric voltage in Volt range liberated energy which was by a factor of order 10^3 higher than the energy deduced from the binding energy of the hydrogen molecule. This suggests strongly that the electrolysis somehow generated bound states and that binding energy was liberated. The simplest explanation would be the dropping of ions to the magnetic flux tubes by a process in which they emit the difference of zero point kinetic energies for initial space-time sheet and magnetic flux tube as the kinetic energy as a photon emitted in the process. The energy could also be liberated when the magnetic field penetrates to matter, say metal, implying that the hydrogen atoms collide with the atoms of the metal. The basic function of the electric voltage and electron current in this process would be the splitting of the bonds binding hydrogen to the water.

One can consider also the possibility that the binding of the hydrogen atoms to hydrogen molecules did not occur as two-particle process but involved the formation of water clusters

and the liberation the binding energy.

Similar process might be involved with the generation of ATP which involves acceleration of hydrogen ions in membrane potential. Therefore the energy liberated in generation of ATP would be many orders of magnitude higher than expected and could give rise to generation of bound states as well as generation of MEs projecting to the sensory magnetic canvas.

3. The third strange observation of Langmuir was that the heat conductivity of the hydrogen gas created in the lamp was anomalously high. This could be understood if the hydrogen atoms or ion propagating along magnetic flux tubes during the conduction of the gas hydrogen ions liberated their energy when the magnetic field penetrated to a target material forcing hydrogen atoms to collide with the atoms of the material.

2. Strange properties of Brown's gas

There is also a connection with the strange properties of the so called Brown's gas discovered by Prof. Yul Brown [J30]. Brown's gas results in the electrolysis of water using electric current running between oppositely charged plates in a voltage which is below 1.7 V. What is believed to occur is the electrolysis of water to oxygen and hydrogen atoms. The flame of hydrogen resulting in the electrolysis appears to have low temperature. When the flame is directed to a metal, it melts and one of the applications is welding of metals. The temperature of the metal remains the melting temperature during the melting. The process involves a liberation of energies which are several times higher than expected on basis of the binding energy of hydrogen atoms to oxygen and the electric power fed to the system.

The TGD based explanation would be that hydrogen atoms and/or ions drop at larger space-time sheets such as magnetic flux tubes of Earth and get additional kinetic energy as the increment of the zero point kinetic energy resulting from the localization inside space-time sheet. The estimates for the molecular weight of Brown's gas are consistent with the molecular weight of H_2O but also with the atomic weight of oxygen in a good approximation. If Earth's magnetic field penetrates to the atomic space-time sheets of the metal, then the hydrogen atoms flowing along magnetic flux tubes enter to the atomic space-time sheet of metal and collisions with the atoms of metal lattice occur and heat it and induce a phase transition leading to the melting of the metal. The liberation of the zero point kinetic energy means effective over-unity energy production in case that the ions at the magnetic flux tubes interact with a matter with the binding energy being liberated. If this interpretation is correct, living matter would construct the sensory representations using the same mechanism that explains the strange properties of Brown's gas.

3. Biefeld-Brown effect

Also Biefeld-Brown effect allows explanation as a recoil effect in many-sheeted space-time. For long time ago T. T. Brown observed [H1, H2, H9] that when capacitor plates are loaded with opposite charges by coupling the capacitor to a voltage source, it jumps to the direction of the second plate. The magnitude of the effect depends on the voltage and begins to decrease above some critical voltage and eventually changes its sign. What is strange is that neither energy nor momentum conservation do not seem to hold true if one assumes that only electric energy is liberated: momentum and energy simply seem to appear from nowhere.

The explanation is in terms of a recoil effect in many-sheeted space-time. When the voltage is coupled on, the ions with opposite charges rush to the capacitor plates. By their inertia some of them leak to larger space-time sheets (the mechanism of auroras and breakdown of super-conductivity is essentially the same [K14]). The difference of the binding energies is liberated as additional kinetic energy and momentum of the dropped ion and the recoil momentum is obtained from the elementary text book formulas $E_f = E_i + \Delta E$, $E = p^2/2m$ as

$$\Delta p = -p_i \left(\sqrt{1 + \frac{\Delta E}{E_i}} - 1 \right) ,$$

where ΔE denotes the difference in zero point kinetic energies for a charged particle of mass m and subscripts i and f refer to initial and final states of the charged particle. These recoil momenta are absorbed by the entire system and give rise to a recoil effect if the recoil momenta from the plates do not

exactly compensate each other. This is not expected to happen since the positive and negative charge carriers have widely different momenta due to the widely different masses and different velocities.

For definiteness assume that there are only electrons and ions of single type; that they drop to single space-time sheet only; and that capacitor plates have opposite charges during loading so that ionic and electronic currents are of opposite sign at the capacitor plates during loading. Under these assumptions the ratio of the momenta is

$$\frac{p_i(e)}{p_i(I)} = \frac{m_e n_I}{m_I n_e} ,$$

where $n(e)$ ($n(I)$) refers to the density of the electrons (ions). Combining this with the previous equation, one has

$$\frac{\Delta p(e)}{\Delta p(I)} = - \frac{m_e n_I \left(\sqrt{1 + \frac{\Delta E(e)}{E_i(e)}} - 1 \right)}{m_I n_e \left(\sqrt{1 + \frac{\Delta E(I)}{E_i(I)}} - 1 \right)} .$$

When several ions are present, one must construct a more elaborate model. Also an effect tending to change the mutual distance of the plates is predicted.

The effect is proportional to the charge of the capacitor plate and thus to the voltage but depends on voltage in nonlinear manner. since the recoil momenta due to electrons and ions depend on nonlinear manner on voltage. The change of the sign of the effect when voltage increases should be due to the fact that the velocities gained by ions and electrons depend on the voltage in different manners. The electronic band structure of the conductor could play an important role in the effect.

This mechanism is obviously ideal mechanism of locomotion in living matter and it would be surprising if bio-systems would not have invented it.

8.2.4 The challenges posed by the new ideas

After writing the first draft of this chapter for more than decade ago several new insights and ideas have emerged. Therefore I decided to try to fuse these new ideas with the older vision. This required re-organization of the entire chapter and I was also forced to split it into two parts separating the stuff strictly related to metabolism. As usual there was also some obsolete stuff related to assumptions which in hindsight look adhoc.

Unification of different views about how living matter is macroscopic quantum system

The identification of dark matter realized a hierarchy of phases labeled by the value of Planck constant [K29], the idea that negentropic entanglement possible for algebraic entanglement probabilities characterizes living matter [K46], and living matter as super-conductor [K13] are three separate ideas of TGD inspired theory of quantum biology and it now seems possible to unify these ideas.

1. The view about hierarchy of Planck constants has simplified considerably. One can speak about effective value of Planck constant and identify the integer characterizing the number of sheets of the local covering of imbedding space allowing a convenient description for the fact that the correspondenc between canonical momentum densities and generalized velocities defined as time derivatives of the imbedding space coordinates is one-to-many.

In fact, it seems that the time derivatives in the interiors can have this kind of multi-valued relationship to canonical momentum densities. The space-time surfaces would be multi-branched and could be seen as surfaces in the covering space of the imbedding space. The space-like 3-surfaces at the ends of space-time sheets at light-like boundaries of CD and the light-like 3-surfaces at which the signature of the induced metric changes would be analogous to the points at which a cut of analytic function begins: origin for \sqrt{z} is the simplest example about this. The branching of the space-time surfaces would take place at these 3-surfaces. The branching would be n_1 -fold at space-like 3-surfaces for each branch emerging in n_2 -fold branching at light-like 3-surfaces. At partonic 2-surfaces $n = n_1 n_2$ branches of the space-time sheet would degenerate to single one. That the branchings occur at two kinds of 3-surfaces corresponds to the effective

2-dimensionality forced by strong form of holography in turn forced by the strong form of general coordinate invariance.

This brings strongly in mind stacks of branes and one can expect similar mathematical structures such as appearance of dynamical gauge group $U(n)$ having interpretation in terms of finite measurement resolution and characterizing inclusion of hyper-finite factors of type II_1 with included factor defining analogs of local gauge transformations generating states equivalent within measurement resolution.

2. The idea about living matter as something residing in the intersection of real and p-adic worlds - intersection of matter and cognition- is very powerful [K52, K46]. One implication is the notion of negentropic entanglement possible for rational or quantum rational [K94] entanglement probabilities (and also entanglement coefficients but in larger algebraic extension). Negentropic entanglement is not generic but is favored and stabilized by NMP. The natural idea is that negentropic entanglement at molecular level distinguishes between living and inanimate matter.

Also bound state entanglement is stable under NMP but in general entropic. Negentropic entanglement can be however stable even when binding energy is formally negative. The natural crazy idea is that so called high energy phosphate bond formally corresponds to negative binding energy and carries entanglement negentropy. This leads to the idea that energy metabolism is basically about transfer of conscious information or quantum communication meaning rearrangement of the magnetic flux tubes connecting distance molecules serving as a correlate and a pre-requisite for negentropic entanglement.

What could be the carriers of the negentropic entanglement in living matter?

1. The first guess is that they are electrons of electron pair with a vanishing spin. The geometric size of an electron pair assignable to a valence bond cannot however scale like \hbar . One can however assign the large value of \hbar to the magnetic body of the electron pair. The larger the value of \hbar , the larger the magnetic body. Support for the fundamental role of electrons in biology comes from the observation that the time scale associated with electron's CD is .1 second and corresponds to the fundamental biorhythm [K26].
2. Another key hypothesis is that electronic super-conductivity [K13] is a key aspect of living matter and this suggests that the electron pairs associated with covalent bonds and having large \hbar are responsible for this super-conductivity and that negentropic entanglement characterizes large \hbar phase. This suggests a connection between several ideas: dark matter hierarchy as hierarchy of Planck constants, bio-systems as super-conductors, negentropic entanglement characterier of living matter, and metabolism as transfer of negentropic entanglement in some sense.

This looks nice but one encounters a difficulty. For ordinary atoms the spin of electron pair in the valence bond however vanishes so that also the dipole contribution to the magnetic field of the pair vanishes. This does not favor the idea about electrons pairs forming a Bose-Einstein condensate connected by flux tubes to a larger structure.

1. Could one assume that dark valence electrons pair to form $S = 1$ states in living matter so that the resulting magnetic field would be dipole field in the lowest order and the flux tubes would naturally connect electron pairs in the direction of the flux tubes to larger quantum coherent structures and one would obtain super-conductor? This idea is not so unrealistic as it looks first since spin 1 states are indeed assumed in the model of high T_c super-conductivity. These states couple to orbital angular momentum $L = 1$ to form $J=2$ Cooper pairs [K13].

Electronic Cooper pairs at valence bonds could generate the magnetic body. The flux tubes of the magnetic body would in turn bind the proteins to quantum coherent larger scale structures. By their small mass as measured in the protein mass scale electron pairs would obey a very swift dynamics whereas the the much slower dynamics of proteins would be determined by the electromagnetic forces due to them. Electronic super-conducting phases could control the protein dynamics in the sense that quantum jumps for the macroscopic quantum state of super-conducting electrons would induce large scale conformational changes.

2. The second guess is based on the idea that the electron pairs form a super-conductor like macroscopic quantum phase made possible by the overlap of the wave functions for large values of \hbar . Negentropic entanglement could be between the members of electron pairs and between the pairs themselves. The latter option make possible quantum communications involving entanglement between distance biomolecules at the ends of the magnetic flux tubes connecting them. This clearly favors bio-molecules possessing maximal number of electron pairs since the density of electron pairs is maximized in this manner.
3. Especially important transformations would be the phase transitions reducing or increasing \hbar . They would induce the scaling of flux tube lengths and compression or extension of the protein system such as cytosol [K8].
4. Suppose that electrons with dark magnetic flux tubes with size scale of Compton length proportional to \hbar and having negentropic entanglement characterize bio-molecules but not the molecules of inanimate matter for which electron pairs at valence bonds have vanishing spin. In this framework metabolic energy could help to generate negentropic entanglement or make possible the re-organization of the negentropic entanglement using $ADP + P_i \rightarrow ATP$ process as a manner to reconnect the magnetic flux tubes serving as correlates for this entanglement. The latter option looks more plausible. The aging of the organism could basically mean a loss of negentropic entanglement implied by the loss of spin 1 electron pairs associated with the valence bonds.
5. The photons of sun-light should arrive along magnetic flux tubes with large value of Planck constant. They could leave Sun as large \hbar photons or transform to such in Earth's magnetosphere. The latter option is more plausible. The simplest option is that they provide the dark metabolic energy needed to manipulate the negentropic entanglement between bio-molecules.

If this view is on the correct track, biological evolution would tend to maximize the number of negentropic covalent electron pairs and simple checks show that basic biomolecules indeed tend to maximize this number and phosphates crucial for metabolism are especially negentropic. Also the idea about peptides as information molecules conforms with the idea about electron pairs as carriers of negentropic entanglement. Peptides are also molecules of emotion and this suggests that the large \hbar negentropic entanglement is crucial for understanding emotions. One can naturally assign positive emotions to the generation of negentropic entanglement and negative emotions to its loss.

Generalization of second law and living systems

In TGD Universe the generalization of negentropic entanglement is possible and forced by NMP [K46]. Does this mean that second law is lost? One can argue that this is not the case and experimental evidence supports this view. For a given CD the entanglement can be negentropic below the time scale characterizing it. Above this time scale ensemble description is necessary and second law holds true and is basically due to the non-determinism of quantum jump just as it is for the ordinary entanglement.

A more pessimistic view is that the generation of negentropic entanglement is accompanied by generation of a compensating entropic entanglement somewhere else. Living matter would differ from inanimate matter in that it has discovered dump pit. One can try to formulate this conjecture more precisely and try to identify the mechanism generating the entropic entanglement.

1. If the end products of biological processing are molecules characterized by the ordinary value of Planck constant, the entanglement assignable with them - in particular covalent electron pairs - is entropic. One could interpret the transformation of negentropic electronic entanglement to entropic one as a realization of the strong form of Second Law. In photosynthesis involving photons from Sun would induce a phase transition increasing the Planck constant for the pairs and making them negentropic again. Biological death would mean the transformation of spin 1 negentropic electron pairs to ordinary spin 0 entropic electron pairs. The basic difference between bio-chemistry and ordinary one would be the presence of these spin 1 pairs of electrons.
2. One can also consider the possibility that also the end products of metabolism have nonstandard value of Planck constant and that only the bio-molecules containing un-paired electrons-that is

free radicals [I17] such as O_2 are entropic. Free radicals are known to cause damage to DNA and believe to be responsible for degenerative diseases, cancer, and senescence. The reason is that they are very reactive and reaction induce formation of electron pairs. This would induce transformation of large \hbar electron pairs in living matter to ordinary electrons pairs with the unpaired electrons of free radical and would tend to reduce the negentropy. This might happen in cell respiration believed to produce CO_2 and H_2O as "wastes". The attribute "waste" would apply naturally if the valence electron pairs are ordinary ones for CO_2 and H_2O . One can however imagine also the transformation of these electrons to electron pairs with larg \hbar in chemical reactions so that the situation remains unclear.

3. One can also wonder what is the Planck constant the valence electron pairs of the ordinary water. Could it be large and could the water resulting as the end product of metabolism have ordinary value of Planck constant?

Realizations of the genetic code

TGD suggests several realizations of the genetic code [K36, K84, K1, K95]. This would conform with what we know about information society in which there is a proliferation of codes basically due to the fact that the basic feature of computers is that they are able to emulate each other and with the fact that living matter is basically information processor.

1. I discovered one new realization of the genetic code by accident as I constructed a model for dark proton and observed that the states of dark proton are in one-one correspondence with the DNA, RNA, tRNA, and amino-acids [K36, L7]. DNA sequences would correspond to dark nuclei realizes as strings formed from dark proton sequences. They would be accompanied by magnetic flux tubes generated the magnetic fields of dark protons if their spins are along the flux tube direction. The observation that water obeys the effective chemical formula $H_{1.5}$ in attosecond time scale suggests that 1/4 of protons of water are dark [K25].
2. The vision about DNA as topological quantum computer is very general [K28]. The essential element is the coding of DNA nucleotides and one can imagine several options. One realization is based on the representation of DNA nucleotides A, T, C, G as quarks u, d and their antiquarks and requires scaled up version of QCD. If quark pairs are unavoidable, one must understand how the correspondence of A,T,C,G with quarks and antiquarks emerges.

Second option would be use spin 1 triplet and spin 0 singlet formed from two dark electron pairs with mixing of singlet and $S_z = 0$ state of triplet. The pair of electron pairs would be assigned to a pair of magnetic flux tubes emanating from $O =$. This option would allow unification of DNA as topological quantum computer conjecture with the conjectures about dark high T_c super-conductivity and negentropic entanglement. Now one should understand the coding of A,T,C, G by the pairs of electron pairs. Basically one should understand two correspondences: the correspondence of dark protons with DNA, RNA, tRNA, and aminocids inducing genetic code and the correspondence of pairs of electron pairs with these.

3. One can also imagine codes based on field patterns and dynamical realizations of the genetic codes [K36, K84, K1, K95].

Flux tubes and DNA

The model of DNA as topological quantum computer gives useful guide lines in the attempt to form a vision about flux tubes. It was assumed that braid strands defined by "wormhole magnetic" flux tubes join nucleotides to lipids and can continue through the nuclear or cell membrane but are split during tqc. The hydrophilic ends of lipids attach to water molecules and self-organization patterns for the water flow in gel phase induce a 2-D flow in the lipid layer which is liquid crystal defining tqc programs at the classical level as braidings. The flow indeed induces braiding if one assumes that during topological computation the connection through the cell membrane is split and reconnected after the halting of tqc.

The challenge is to understand microscopically how the flux tube joins DNA nucleotide to the phospholipid [I33]. Certainly the points at which the flux tubes attach should be completely standard

plugs and the formation of polypeptide bonds is an excellent guide line here. Recall that phospholipid, the tqc dancer, has two hydrophobic legs and head. Each leg has at the hydrophilic end O=C-O-C part joining it to glyceride connected to monophosphate group in turn connected to a hydrophilic residue R. The most often appearing residues are serine, inositol, ethanolamine, and choline. Only three of these appear in large quantities and there is asymmetry between cell exterior and interior.

1. *Are the flux tubes beginning from $O=:s$ special?*

Let us denote by $= O_1$ and $= O_2$ the two oxygens (maybe analogs of right and left hemispheres!) in question.

1. The proposal is that DNA nucleotide and $= O_1$ are connected by a flux tube: the asymmetry between right and left lipid legs should determine which of the legs is "left leg" and which $O =$ is the "left brain hemisphere". $= O_2$, the "holistic right brain hemisphere", connects in turn to the flux tube coming from the other symmetrically situated $= O_2$ at the outer surface of the second lipid layer. Besides this $= O_1$ and $= O_2$ are connected by a flux tube serving as switch on both sides of the membrane.
2. During tqc the short $O = -O =$ flux tube would experience reconnection with a flux tube acting as hydrogen bond between water molecules so that the connection is split and $O =:s$ form hydrogen bonds. The reversal of this reconnection creates the connection again and halts the computation. The lipid residue R couples with the flow of the liquid in gel phase. Since $= O$ is in question the quark or antiquark or a pair of electron pairs at the end can correspond to the DNA nucleotide in question. The necessary complete correlation between quark and antiquark charges at the ends of flux tubes associated with $= O_1$ and $= O_2$ might be understood as being due to the minimization of Coulomb interaction energy. In the case of pair of electron pairs the correlation could come from the minimization of the magnetic energy.
3. If one is ready to accept magnetic flux tubes between all acceptors then the aromatic rings of nucleotides known to be acceptors could be connected by a flux tube to the $O =$ atom of the lipid or to some intermediate $O =$ atom. The phosphate groups associated with nucleotides of DNA strand contain also $= O$, which could act as a plug to which the flux tube from the nucleotide is attached. The detailed charge structure of the aromatic ring(s) should determine the quark-nucleotide correspondence. The connection line to the lipid could involve several intermediate $O =$ plugs and the first plug in the series would be the $O =$ atom of the monophosphate of the nucleotide.

There is a strong temptation to assume that subset of XYP molecules, $X = A, G, T, C$, $Y = M, D, T$ act as standard plugs with X and phosphates connected by flux tubes to a string. This would make it possible to engineer braid strands from standard pieces connected by standard plugs. DNA nucleotide XMP would have flux tube connection to the aromatic ring of X and the $O =$ of last P would be connected to next plug of the communication line. If so, a close connection with metabolism and topological quantum computation would emerge.

1. Phosphorylation [I34] would be an absolutely essential for both metabolism and buildup of connection lines acting as braid strands. Phosphorylation is indeed known to be the basic step activating enzymes. In eukaryotes the phosphorylation takes place amino-acids most often for ser but also thr, and trp with aromatic rings are phosphorylated. Mitochondrions have specialized to produce ATP in oxidative phosphorylation from ADP and photosynthesis produces ATP. All these activities could be seen as a production of standard plugs for braid strands making possible directed attention and quantum information processing at molecular level.
2. As already noticed, $O = -O =$ flux tubes could also act as switches inducing a shortcut of the flux tube connection by reconnecting with a hydrogen bond connecting two water molecules. This is an essential step in the model for how DNA acts as topological quantum computer. De-phosphorylation might be standard manner to realize this process.
3. This picture would fit with the fact that XYP molecules, in particular AMP, ADP, and ATP, appear in bio-molecules involved with varying functions such as signalling, control, and metabolism. $= O$ might act as a universal plug to which flux tubes from electronegative atoms of information

molecules can attach their flux tubes. This would also provide a concrete realization of the idea that information molecules (neurotransmitters, hormones) are analogous to links in Internet [K62]: they would not represent the information but establish a communication channel. The magnetic flux tube associated with the information molecule would connect it to another cell and by the join to = O plug having flux tube to another cell, say to its nucleus, would create a communication or control channel.

2. DNA as topological quantum computer hypothesis and electronic super-conductivity

The vision about DNA as topological quantum computer is very general. The essential element is the coding of DNA nucleotides and one can imagine several options.

1. One realization is based on the representation of DNA nucleotides A,T,C, G as quarks u, d and their antiquarks and requires scaled up version of QCD. The motivation for this realization came from the observation of Barbara Shipman that the mathematical description of honeybee dance suggests that quarks play a role in living matter [A13].
2. Second option that one can imagine would use spin 1 triplet and spin 0 singlet of dark electron pair. Spin 0 state for electron pair however gives rise to vanishing dipole field so that flux tube structure would not be possible. Can one circumvent this option or are quark pairs unavoidable?
3. DNA as tqc lead to the hypothesis that it is O= to which one must assign the flux tube pair responsible for the representation of the genetic code. Why O= would be in special role?

- (a) If there are two parallel flux tubes, one obtains tensor product $3 \times 3 = 5 + 3 + 1$ of electron triplets at the ends of the flux tubes. Could it be that A, T, C, and G are represented in terms of 3 and 1 and the breaking of rotational invariance implies a mixing of singlet and spin 0 state of triplet so that nucleotides and their conjugates could correspond to the resulting two pairs related by reflection?

One can however argue that for $S_z = 0$ states the direction of the magnetic flux tubes is orthogonal to that in other cases. An alternative possibility is that one uses only the four $S_z \neq 0$ states of spin 2 5-multiplet obtained in the tensor product. The breaking of the full rotational symmetry down to SO(2) symmetry around flux tube direction could be used to justify this option.

- (b) The coding would be also consistent with quantum classical correspondence since it would reduce at classical level to a coding in terms of directions of magnetic fields in the two flux tubes: the directions could be parallel and in two directions or antiparallel giving also two options: four altogether. Notice however that one must be able to distinguish between two different configurations in which the directions of magnetic flux are opposite for the flux tubes of the pair. Classically this is achieved if the flux tubes form either a right-handed or left-handed double helix. Double helix could also resolve the problem posed by the fact that in $S_z = 0$ case the flux tubes cannot be parallel to their common axis at the flux tube end.
- (c) This option would allow a unification of DNA as topological quantum computer conjecture with the conjectures about dark high T_c super-conductivity and negentropic entanglement.

$ATP \rightarrow ADP + P_i$ would correspond to the fusion of flux tube pair with two hydrogen bonds associated with water molecules so what they could become short-circuited with water molecules. The reverse process would create flux tube connection labelled by the spin state equivalent of A, T, C, or G. The possibility of 5-plet allows also to consider the possibility of five codons instead of four.

Whatever the correct option is it must explain how the correspondence between A,T, C, G and secondary codons emerges.

1. If the pairs of spin triplet electron pairs appear in the correspondence, one must understand why the spin state of the pair of electron pairs at the O= of the phosphate attached with the DNA nucleotide correlates with the character of the nucleotide. Phosphate has also two O⁻:s

containing two electron pairs. Minimization of the magnetic energy is the explanation which is easiest to imagine. Maybe the total magnetic energy of the pair in the magnetic field of the flux tube structure assignable to the nucleotide plus the de-oxyrribose preceding it. T and C contain also O= but not A and G. and A and T and C and G are conjugates.

By studying the chemical structure of DNA [I80] one finds that the pairs AT and CG contain two O=:s which belong either to same nucleotide (to T in A-T) or to different nucleotides (C-G). This suggests the coding in which there are flux tube pairs connecting the two phosphate O=:s at the two sides of the double strand and going through the two intermediary O=:s. The rule would be that the spin states are conjugates at the ends of the flux tubes. A-T and T-A pairs could correspond to parallel flux tubes with same direction of the flux and G-C and C-G to parallel flux tubes with opposite directions of the magnetic fluxes.

2. If quark pairs are unavoidable, the correspondence of A, T, C, G with quarks and antiquark must relate to quark charges coming as $\pm 2/3$, $\pm 1/3$. Also in this case the coding mechanism based on the flux tubes connecting O=:s is natural.

The conclusion would be that the original view about secondary realization of genetic code can be replaced with the realization based on spin 1 dark Cooper pairs of electrons between which the entanglement is negentropic. Quark color plays no special role in the model of DNA as topological quantum computer [K28] so that the model remains as such. One implication would be however that the magnetic flux tubes carrying dark electron pairs at their ends could be of astrophysical size.

Challenges

This picture raises challenges. For instance, one should be able to answer the following questions.

1. The basic idea is that the differences of vacuum energies for electrons and protons or their Cooper pairs define fundamental metabolic currencies quantized by p-adic length scale hypothesis. The $ADP \rightarrow ATP$ should thus involve kicking of an electron or proton pair of both to a smaller space-time sheet and its reverse its dropping so that metabolic energy is liberated. The challenge is to relate the proposed transfer of electrons and protons between space-time sheets with different p-adic length scale to the proposed general vision. How the short-cut of the flux tube pair gives to two hydrogen bonds in $ATP \rightarrow ADP + P_i$ gives rise to a dropping of electron pair to a larger space-time sheet. At which end this dropping takes place? At the valence bond of water molecule? Could also proton drop? One can say that the electron pair binds ADP and P_i together. Could the dropping cause the splitting of the valence bond?

One could consider instead of dropping a process in which the bond length and thickness is scaled up by a power of two so that zero point kinetic energy is scaled down. This kind of scaling would occur in a process scaling \hbar for flux tubes but this process would not change the energy. If the length of bond is scaled up this process magnetic energy is not affect but cyclotron energy is scaled down since B would scale like $1/\hbar^2$ and cyclotron energy $\hbar B/m$ like $1/\hbar$. The increase of \hbar would liberate cyclotron energy as photons.

2. The sending of negative energy photon (phase conjugate photon) to the geometric past as a basic aspect of metabolism should be also understood in detail. How the absorption of the negative energy photon induces the dropping of the electron pair to a larger space-time sheet? How this dropping appears in $ATP \rightarrow ADP + P_i$. Does it destroy the high energy phosphate bond between P_i and ADP. Is it possible to get energy without the mediation of ATP just by sending negative energy photons?
3. One should understand metabolism in terms of dark nucleons and dark electron pairs. 4 protons and 4 electrons involved with the basic step. At the other side of the mitochondrial membrane protons are fused with oxygen to form water molecules and this induces a transfer of protons through the membrane from the other side liberating chemical energy making possible $ADP + P_i \rightarrow ATP$. Again one can make questions.

Could the four protons be dark? Could they form two Cooper pairs or a dark nucleus consisting of four protons? Could also proton Cooper pairs with spin 1 give rise to magnetic flux tubes and protonic super-conductivity or super-fluidity? Are proton spins parallel and along a flux tube

associated with dark nucleus? Could also DNA and proteins as polymers involve magnetic flux tubes formed by a sequence of charged particles with spins parallel to the flux tube generating the magnetic field giving rise to the flux tube. This would give a net angular momentum to the flux tube. Could it be that this angular momentum is compensated by a rotational motion and generation of flux tubes generates rotational motion by angular momentum conservation?

8.3 General vision about metabolism

8.3.1 About metabolism in general

I summarize the basic facts about blood circulation and red blood cells in the hope of helping the non-biologist reader to get overall view. I hope that the non-professional style of the representation and the unavoidable in-accuracies do not irritate biologists. I introduce also some strange findings and propose how quantum view could allow to understand them.

Cellular respiration

Mitochondria act as power plants of the animal cell. Mitochondria are coded by their own DNA and the DNA is inherited from mother and thus not copied in cloning. If mitochondria contribute to consciousness, as one might suspect, then clones do not experience the world in a similar manner.

ATP is the universal energy currency and TGD based model for ATP generation will be discussed later. Suffice it to say that the energy is transferred to ADP by phosphorylating it in the presence of a suitable ATPase enzyme which usually also catalyzes the transfer of the phosphate molecule from ATP to the client molecule.

Cellular respiration is the basic metabolic process in animals whereas in plants photosynthesis replaces cellular respiration and allows plants to produce glucose used by animals for their metabolism. The basic formula for the respiration is familiar from school days: $C_6H_{12}O_6 \rightarrow 6CO_2 + 6H_2O$ and tells that one glucose molecule is transformed into carbon-dioxide and water and gives in this process the energy stored in it in the photosynthesis. The actual process is however considerably more complex than this oversimplified representation suggests. There are several forms of cellular respiration. Glycolysis is anaerobic respiration mechanism and converts glucose to pyruvate (in particular in neurons and glia). 2 ATP molecules per one glucose molecule are produced and this is enough for the continuation of the glycolysis which itself requires some energy.

Aerobic respiration involves a further processing of pyruvate which is transported to the mitochondria where it is used in Krebbs cycle for synthetizing the high energy compounds whose oxidation leads to the generation of ATP. This process is possible only if cell receives oxygen from blood flow. 30-35 ATP molecules per one glucose molecule are produced in this process [J89]. Also fats function as energy reserves: when oxidized they produce 9 times higher energy yield than pyruvate molecules but the rate of the process is slower by a factor of 1/8. Brain does not utilize fat as an energy reserve: rather, astrocytes store the energy reserves of glucose to glycogen which they both synthesize, store, and catabolize.

Lactate and alcohol fermentation represent further anaerobic respiration mechanisms. Lactate fermentation is utilized by muscle cells and after maximal exercise the overproduction of the lactate acid is responsible for the characteristic muscle pain. Some plants utilize alcohol fermentation.

Blood circulation

Blood circulation could be regarded as a logistics of the living system. Logistics involve the delivery of both energetic and structural components such as glucose molecules, oxygen, and proteins. Blood circulation supports a chemical signalling system based on hormones. Blood acts as a buffering system based on phosphates and proteins and has defensive functions similar to those of immune system. Blood serves also as a reservoir of body heat and blood flow can control the body temperature by convection and conduction mechanisms.

There is a strict separation of the oxygenated and de-oxygenated blood corresponding to pulmonary and systemic flows. The first type of blood vessels are arteries which have walls consisting of smooth muscles which can constrict and dilate and in this manner control the rate of the blood flow. The

rate of blood flow depends also on its velocity controllable by the rate of the heart beat. Blood flow is known to be controlled both by hormonal and neural control mechanisms.

Besides arteries there are capillaries which have walls consisting of single layer of cells, endothelium. Capillaries lack the smooth muscle so that the flow to the capillaries must be regulated by precapillary spincters containing smooth muscle and joining arteries to capillaries: their dilation or constriction controls the flow into the capillary. The basic mechanism for transferring molecules from capillaries to cells is diffusion. Lipid soluble molecules like oxygen and carbon monoxide diffuse through cell membranes automatically whereas water soluble molecules can diffuse only through pores. The size of the pores varies and in brain the pores are very small so that blood brain barrier results.

Oxygen is bound to hemoglobin which is a tetramer of four identical myoglobin proteins. Red blood cells transfer the hemoglobin near cell and oxygen diffuses through the wall of the capillary and through the cell membrane to neuron and eventually reaches the mitochondria. Glucose is the energy carrier molecule transferred by blood and glycolysis and aerobic cellular respiration transform the energy stored in the glucose to ATP.

Red blood cells

Red blood cells, being carriers of oxygen, are expected to be especially important for consciousness. Being not a professional biologist I freely use the popular article [I41] in which besides standard facts also the importance of red blood cells and astrocytes for consciousness is also advocated.

Some poorly understood aspects of the blood flow support the idea that blood behaves like a coherent conscious unit under some conditions.

1. The first, already mentioned, mystery is that a heightened neuronal activity induces a rush of blood cells to the neurally active regions but is accompanied by a very low oxidative metabolism.
2. Second mystery is how the signal about the need for the increased blood flow is mediated to the pre-capillaries to relax smooth muscle when blood is needed. Signalling is up-stream and signalling mechanisms based on the diffusion of chemicals like NO, CO_2 and protons, extracellular K^+ and purines have been proposed but no consensus about the mechanism has been reached. An alternative mechanism is based on direct communication to an appropriate magnetic body which in turn would perform the needed motor action.
3. A further mystery is that red blood cells exhibit a coordinated group response to threats [I79]. In light of this the observation that sea stars have a hemal system with no obvious function and, although possessing no brain, are capable of displaying rather refined intelligent behavior [I41], is rather suggestive.

With these observations as a context, it is interesting to try to interpret basic facts about blood flow.

1. Red blood cells are distinguished by their unique role in the oxygen transport and by their anaerobic metabolism (it would not make sense for red blood cells to consume oxygen molecules!). Red blood cells exhibit many characteristics of prokaryotes and might be called metakaryotes: indeed, at some stage of development mammalian red blood cells eject their nucleus and organelles. It has been found that neural cells can be trained to become red blood cells, which supports the view that the role of blood flow is more than mere logistics. Red blood cells are the only cells which are unable to divide and become cancerous.

If one takes seriously the proposal that magnetic bodies perform quantum control through magnetic flux sheets traversing genomes and receive sensory input via flux quanta associated with proteins traversing cell membranes, this means that red blood cells would communicate only somatosensory input to the respective magnetic body and magnetic and motor control performed through them would be very primitive: perhaps control of motion of blood cell.

Blood cells would correspond to $k_{em} = 1$ level of dark matter hierarchy assigned to prokaryotes. $k_{em} = 1$ and flux quantization for planar flux sheets of thickness $L(169) = 5 \mu\text{m}$, lower bound for the size of cell nucleus, would give length of $\lambda L(169) = 5 \text{ cm}$ for $\lambda \simeq 2000$. Blood cells could perhaps organize to thread like structures parallel to the blood veins.

2. Red blood cells and their hemolymphatic counterparts contain iron and are good candidates for magneto-receptors [J51, J107] . The orientation of the magnetic structures with Earth's magnetic field and the fact that liquid codes the direction of the gravitational field to pressure gradient define a good candidate for a preferred coordinate system used already by honeybees containing magnetite and ferritin in their abdomens [I43] . Red blood cells could serve as compasses and code for the orientation of the body with respect to the magnetic field and gravitational fields and a grid of blood cells could code for the local variations of the magnetic field making possible navigation using magnetic field. This information could be represented at the $k_{em} = 1$ somatosensory magnetic body assignable to the blood flow.
3. The velocity of the blood flow in capillaries is about mm/s so that scaling law gives $f = v/L = 1$ kHz, which happens to be the kHz frequency of neural synchrony.
4. Red blood cells exhibit a high capacity for chemiluminescence and it is possible to make red blood cells bioluminescent by genetic engineering. Red blood cells are known to absorb light through the skin and thus might serve as photo-receptors in dermal optics [J41] . In [I41] it is proposed that red blood cells give rise to primitive vision and be responsible for blind sight. Ocular blood vessels are indeed very near to the surface. DNA is believed to generate bio-photons whereas mammalian red blood cells which have no DNA are indeed known to not emit bio-photons [J55] . Perhaps red blood cells 'see' the bio-photons generated by DNA: this would conform with the general idea that DNA generates 4-D templates consisting of coherent photons and guiding the biological self-organization.

The large number of mitochondria in the heart muscle, liver and red muscle cell give them their red color. Whether this color is always related to the color of haemoglobin is not clear to me. At least, the idea about a communication system between red blood cells and mitochondria based on red light is worth of demonstrating to be wrong. Unfortunately, I do not know how near the average wave length associated with this red color is to the 'miracle wave length' of 640 nm associated with the photons of photosynthesis.

8.3.2 Cellular respiration and photosynthesis

Photosynthesis [I35] in which photon energy is chemically stored and cellular respiration in which it is liberated are the fundamental processes of energy metabolism and in some sense duals of each other.

1. Photosynthesis produces from CO_2 and water in presence of sunlight carbohydrates carrying the metabolic energy and serving also as building bricks of more complex bio-molecules. The photon-dependent part of the process extracts the energy of photons and stores it temporarily to ATP and ADPH. This temporarily stored energy drives both the light-dependent and -independent parts of the process and the surplus energy of ATP and ADPH is stored as a chemical energy of carbohydrates (sugars) produced in the process.
2. In cellular respiration the carbo-hydrades are transformed to carbon monoxide and water and metabolic energy is extracted as the energy of ATP molecules serving as a universal metabolic currency to be used for varying purposes.

Both processes are far from being completely understood and the extreme energy efficiency of these processes leaves room for a macroscopic quantum coherence. TGD proposal is that at the deeper level these processes allow interpretation as a transfer or redistribution of negentropic entanglement. The great challenge would be the interpretation of photosynthesis from this point of view.

Cellular respiration

Cellular respiration [I7] a process which converts the chemical energy of nutrients - typically bio-molecules (hydrogen sulfide is however an exception) - to metabolic energy carried by ATP molecule [I3]. Besides this also waste products are generated.

Oxidation and redox reaction [I29] are the key concepts needed in the description of this process.

1. Oxidation means donation of valence electron so that the oxidation state [I30] of the atom is changed. Typically the electron is paired with an electron of the receiving atom so that an

electron pair assignable with a valence bond is formed: the oxidation state of the atom increases by one unit. Typically oxygen receives the electron and this has given the name for the process. Reduction is the reverse of this process: atom or molecules donates an electron to the acceptor.

2. A simple example is H_2O containing two valence electron pairs resulting in the oxidation of hydrogen atoms. Second example is CH_4 : Carbon has received four electrons from hydrogens and is thus reduced. For CO_2 carbon has given four electrons so that it is oxidized. In $PO_4C_3H_3$ (phosphate, which is the key molecule in metabolism) phosphorus has given five electrons and thus oxidized. Naively would expect that P tends to receive three electrons since this is the number of electrons lacking from the higher electron shell of P .
3. Electron pairs appearing in valence bonds are in general much less active than lonely electrons appearing in the highest electron shell. Molecules or atoms containing unpaired electrons are known as radicals. Molecular oxygen $O_2 = O - O$ crucial for cell respiration contains two unpaired electrons and is stable free radical. It reacts with carbo-hydrates, fats, and proteins and helps to liberate metabolic energy which goes to ATP.

Cellular respiration, which can be seen as a reversal of the photosynthesis, is a stunningly complex process consisting of 4 basic steps.

1. At the first step glucose is converted into pyruvate in glycolysis [I18] in cytosol. The free energy is released in this process as NADH and ATP. The process requires 2 ATPs as a fuel and produces 4 ATP molecules so that the net gain is 2 ATP molecules. Also 2 NADH molecules carrying metabolic energy are formed. This step precedes also anaerobic respiration.
2. At the next step pyruvate breakdown (pyruvate decarboxylation) in mitochondrion to acetyl-CoA [I1]. This produces one molecule of NADH and one molecule of CO_2 , which could be seen as waste product.
3. Acetyl-CoA goes through Krebs cycle [I23]. This process is an oxidation of Acetyl-CoA producing CO_2 and H_2O as "wastes". In this process the oxygen brought by blood circulation is utilized. In the process NAD is reduced to NADH [I25] meaning formation of electron pair. Note that NAD and NADH contain two phosphate molecules, which appearing also in ATP.
4. Oxidative phosphorylation via electron transport chain [I13] is the next step in the process. It is electrons rather than electron pairs that are transported in this chain. They are produced in the oxidization of water. In this process ADP receives one phosphate molecule transforming to ATP is the next step in the process. Cytochrome c oxidase [I11] is also involved with the process. O_2 receives four electrons from cytochrome c molecule and is thus oxidized. O_2 then combines with four protons to form two H_2O molecules. Cytochrome c receives its electrons from four NADH molecules transforming to NAD^+ ions. Electron transport chain is involved also with the photosynthesis.

The change in the membrane potential induces the transfer of 4 protons through membrane and the Coulombic energy liberated in this process drives the F_0F_1 machine acting somewhat like a turbine of a power plant and generating ATP from $ADP + P_i$ in synthetize ATP [I5].

Photosynthesis

Photosynthesis [I35] is performed in plants and algae and interpreted as a process extracting metabolic energy from solar radiation. In the presence of electron donor photosynthesis generates from carbon dioxide CO_2 and photons carbohydrates and oxidized donor. The process consists of two sub-processes: the process extracting the energy needed to drive the process and the process storing solar energy to chemical energy carried by a carbohydrate polymer (sugar).

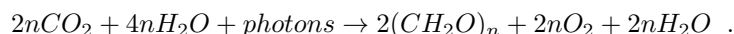
1. The general equation for photosynthesis is in a schematic form given by



One could say that DH_2 molecules gives its two hydrogen atoms for the carbohydrate and receives oxygen atom from CO_2 molecule in the process. In the initial state the electron donor

D is reduced by the two electrons from H_2 . In the final state D is oxidized since it has donated two electrons to O . The elementary step of the process involves two CO_2 and DH_2 molecules and involves the transfer of four protons and electrons.

2. In oxygenic (as opposed to anaerobic) photosynthesis DH_2 is replaced with water molecule. The equation is now however slightly different



The process produces oxygen from carbon di-oxide whereas cell respiration does the opposite.

3. Water can be supplied by some other compound. For instance, arsenite molecule AsO_3^{3-} can replace water:



Photosynthesis takes place in two steps.

1. In the first step light-dependent reactions or light reactions capture the energy of light and store it temporarily to ATP and ADPH molecules.
2. In the second step light-independent reactions store part of the energy of ATP and NADPH to the chemical energy of sugar molecules. This step involves the capture and reduction of carbon dioxide to produce also oxygen necessary for the cellular respiration. The energy stored to the carbohydrates serves as metabolic energy to be used in the cell respiration to generate ATP and NADPH.

This short overall description of course gives only a very rough overall view about extremely complex process. A more detailed description is given in Wikipedia article [I35], where also excellent illustrations about the process can be found.

Photosynthesis is performed by plants and algae and involves photosynthetic membranes and organelles known as chloroplasts [I9].

1. Chloroplasts capture the light energy and store it to ATP and NADPH in a complex process known as photosynthesis. Chloroplasts contain pigment molecules such as chlorophyll [I8], carotene and xanthophyll. Chlorophyll gives plant leaves their green color since these wave lengths are not absorbed by the chlorophyll molecules.
2. Chlorophyll molecules contain so called antenna proteins giving rise to a light harvesting complex which absorbs photons from the incoming radiation. The light energy from the antenna proteins is transferred to chlorophyll molecules. Chlorophyll molecules are arranged in and around photosystems embedded in thylakoid membranes of chloroplast.
3. There are two photosystems in which photon absorption takes place: P680 and P700. They are named after the wavelength at which the absorption of light is maximum (680 *resp.* 700 nm).

Photosynthesis gathers the energy needed to drive it from the radiation. In light-dependent reactions that ATP and ADPH needed to drive light dependent reactions are formed. In light-independent reactions part of the energy of ATP and ADPH is stored as the chemical storage as CO_2 is reduced to sugar carrying the energy. Only this part of the process is visible in the general equation for the photosynthesis.

1. Light-dependent reactions

Light dependent reactions [I24] take place in the thylakoid membranes of chloroplasts [I9].

1. There are four protein complexes known as photosystem I and II, cytochrome *bf*6 complex, and ATP synthase. The first two absorb the photons and donate the resulting energetic electrons. The third generates ATP and fourth ADPH in a sequences of reduction processes generated by electron known as electron transport chain [I13]. One can imagine that electron falls down along stairs and loses energy at each step received eventually by ATP and NADPH.

2. What happens that chlorophyll molecule in photosystem II absorbs photon and gives one electron in an excited state with higher energy. The electron is highly unstable and flow through electron transport chain and end up to photosystem I where it absorbs another photon. The final electron accept or is NADP which transforms to NADPH as it receives proton and electron.
3. Proton gradient over the cell membrane appears as in cell respiration and is used to generate ATP molecule during the first step. The process is catalyzed by ATP synthase also now. Chlorophyll molecule regains the lost electron from water molecule in photolysis releasing O_2 molecule. Also now 2 water molecules and 2 chlorophyll molecules are involved. 4 protons are released in the oxidation of the water molecule.

The so called Z scheme [I35] describes how the light-dependent reactions are though to occur in thylakoid membranes of the chloroplasts to synthesize ATP and NADPH driving the light-independent reactions storing part of the energy of photons chemically to the energy of sugar molecules.

1. Oxygen evolving complex [I35] is not well understood. What this complex does is oxidation of two water molecules to O_2 and 4 protons and 4 electrons. They replace the lost electrons of two chlorophyll molecules. Photosystem II is the enzyme that catalyzes the oxidation of water leading to a production of O_2 and for protons and electrons. What happens in the oxidation of water molecules might relate closely to the TGD inspired proposal that $ATP \rightarrow ADP + P_i$ process involves a reconnection of a flux tubes with hydrogen bond flux tube connecting two water molecules.

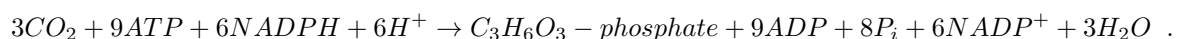
The resulting four electrons which are given to the chlorophyll a molecules to compensate the electrons that they have lost. The four protons are later used to transform $NADP^-$ obtained when electron originating from chlorophyll is absorbed by NADP to NADPH.

2. In photosystem II the electron in chlorophyll a molecule is excited to a higher energy state by photon absorption. The electron is highly unstable and goes down along electron transport chain losing energy produces ATP. Does the production of ATP proceed just as in the case of cell respiration. Four protons, four electrons and one O_2 molecule These would be produced in the first step of the process. One half of the products of the process splitting water molecules would produce ATP and one half would produce....
3. The electron ends down to the photosystem II where it absorbs second photon and goes down to second electron transport chain to be finally absorbed by NADP molecule. $NADP^-$ absorbs proton produced in the oxygen evolving complex to give NADPH. ATP and NADPH drive the electron transport chains.
4. The process must return O_2 molecule and four protons and electrons to two water molecules and this indeed takes place when ATP and ADPH are used. Thus the net effect of the oxidation and reduction of water would be generation of sugar binding the energy of photons to metabolic energy.

It would seem that the pairing of dark electrons occurs when the photons are absorbed by NADP ADP. This would suggests that paired dark electrons appear ADP, P, and NADP. At this stage electrons are not paired. Pairing would occur only when ADPH and ATP and carbohydrate are formed.

2. Light-independent reactions

In light-independent reactions the enzyme RuBisCO captures CO_2 from atmosphere and in process required the newly formed NADPH, known as Calvin-Benson cycle [I6] , releases there carbon sugars, which are later combined to form sucrose and starch. The overall reaction is



Note that 9 ATP molecules and 6 NADPH energy carrying molecules produced by light dependent reaction are used to drive the overall reaction. The sugars are used to build cellulose, and precursors of lipid and amino-acid synthesis or as a fuel of cellular respiration.

8.4 TGD inspired view about metabolism

The notions of negentropic entanglement, dark matter as phases with non-standard value of (effective) Planck constant, high T_c electronic super-conductivity, and dark protons providing representation of genetic code, are the basic building bricks in TGD based quantum model of living matter. This picture leads also to a quantum model of metabolism having deeper interpretation in terms of a transfer of negentropic entanglement. For quantal aspects of metabolism evidence has been accumulating since 2007 [I86].

8.4.1 Negentropic entanglement and covalent bond

The great idea is that living matter resides in the intersection real and p-adic worlds- in the intersection of matter and cognition. This would among other things mean that entanglement probabilities are rational or quantum rational.

p-Adic physics leads to the notion of negentropic entanglement possible when entanglement probabilities are rational or quantum rational numbers [K94] (which belong to algebraic extension of rationals by p :th root of unity). One can ask why entanglement probabilities should be restricted in this manner. In non-generic case this is certainly not true. The answer is that Negentropy Maximization Principle [K46] takes care that system ends up to a situation when entanglement is rational or quantum rational.

The natural question is how the quantum rational entanglement is realized in living matter. The basic characteristic of quantum rational entanglement is that it is stable with respect to NMP just as bound state entanglement. It seems however un-necessary to assume that negentropic entanglement reduces to a bound state entanglement so that one could assign binding energy to it. This suggests that the somewhat fuzzy notion of high energy phosphate bond corresponds to negentropic entanglement and indeed carries what might be called negative binding energy.

This vision leads to the idea that energy metabolism is basically needed for a redistribution of negentropic entanglement and the model for DNA as topological quantum computer leads to a model of $ADP + P_i \rightarrow ATP$ process as a process generating magnetic flux tube connection between two systems A and B by reconnecting two flux tubes short-circuited to water molecules. This short-circuit would take place by a reconnection with a magnetic flux tube assigned with a hydrogen bond [I21]. One might interpret this process as assigning to this particular flux tube the negentropy associated with ATP and other molecular nodes associated with the flux tube connection. This assignment might be regarded as information transfer.

Are large \hbar electron pairs in covalent bonds of bio-molecules responsible for negentropic entanglement?

In what degrees of freedom the negentropic entanglement distinguishing biomolecules from the ordinary ones resides? A little thinking leads to a rather obvious first guess. This vision is consistent with other visions about how living matter manages to be a macroscopic quantum system.

1. The only degrees of freedom one can imagine are electronic. The carriers of negentropic entanglement would be paired electrons assignable to covalent bonds. These pairs need not be ordinary spin 0 electron pairs appearing in molecules in vitro which are expected to be able to have only entropic entanglement. Whether the entanglement is assignable to the electrons of the pairs or to pairs of pairs, remains open at this moment, although the latter option is much more attractive.
2. This pairing of electrons is very similar to the formation of Cooper pairs and could be seen as a super-conductivity in atomic or molecular scale. Therefore one obtains a connection with the hypothesis that living matter is high T_c super-conductor [K13].
3. The hierarchy of Planck constants suggests another manner to realize living matter as a super-conductor. This suggests that the outer valence electrons can topologically condense to space-time sheets with non-standard value of Planck constant. As a matter fact, this hypothesis was introduced as the first application of the hierarchy of Planck constants in order to explain the claimed strange properties of so called ORMEs suggesting strongly super-conductivity at

room temperature [K13]. These electron pairs were associated with outer shells of atoms. TGD inspired model for high T_c super-conductivity indeed assumes that Cooper pairs correspond to a non-standard value of Cooper pairs but did not yet identify them as valence electron pairs [K13]. Not that a high T_c super conductor Cooper pairs are however formed from unpaired valence electrons (one in the case of copper).

The challenge is to show that negentropic entanglement is possible only for non-standard values of Planck constant characterized by integer - call it n : the number theoretically inspired guess is that the p-adic prime characterizing the quantum rationals involved with negentropic entanglement is a factor of n .

This would mean that three different manners to see living matter as a macroscopic quantum system in TGD Universe would be equivalent. If this picture is accepted, one ends up with a very general vision.

1. All covalent bonds of bio-molecules can be in negentropic state. For their organic counterparts covalent bonds are expected to carry ordinary spin zero electron pairs with entropic entanglement.
2. Negentropic entanglement requires in the most general situation that entanglement probabilities are algebraic numbers and rational entanglement corresponds to the simplest situation. Quantum arithmetic generalization of the notion of rational number however is however the p-adically favored option. Also quantum rational entanglement is negentropic and characterized by prime p . The following argument suggests that negentropic entanglement requires non-standard value of Planck constant.

It would not be too surprising that the entanglement probabilities were proportional to $1/n$, where n characterizes the Planck constant so that negative entropy would be possible only when p is a factor of n . The two manners to have macroscopic quantum coherence - negentropic entanglement and large \hbar - would not be independent mechanisms but different facets of one and the same mechanism. For $n = 1$ only ordinary entropic entanglement would be possible so that ordinary chemistry would be entropic.

3. How the value of the p-adic prime p characterizing the negentropic entanglement in quantum arithmetics correlates with the value of Planck constant? Could the integer defining \hbar have p as a factor so that the p-adic prime p and the value of \hbar would correlate? Are prime values of n favored?
4. Paired valence electrons would be negentropically entangled. What can one say about the character of this entanglement?
 - (a) For ordinary molecules these electrons pair to spin 0 state. For high T_c super-conductivity electron pairs have spin 1 [K13], and suggest themselves strongly also now.
 - (b) For spin singlet states the entanglement probabilities in spin degrees of freedom are uniquely fixed and equal to $P = 1/2$. For spin 1 states only the state with vanishing spin projection is entangled and the mixing with spin 0 state could give rise to two un-entangled states. Therefore negentropic entanglement in spin degrees freedom is not a plausible source of negentropy and it should therefore be between electron pairs. Also the fact that entanglement should generate long range correlations between distance bio-molecules, suggests the same.
 - (c) The $1/p$ -proportionality of the entanglement probabilities for $p > 2$ requires that the entangled degrees of freedom are not spin degrees of freedom so that entanglement between spatial wave functions remain. The simplest situation involves p state pairs. This however not the only possibility. Even two states is enough. The naive guess is that the n -sheeted character of space-time region gives rise to n -fold degeneracy of states so that entanglement involves sum over n state-pairs and factor $1/n$ emerges naturally.

Is the number of covalent electron pairs maximized in living matter?

If the negentropic entanglement is between electron pairs, the amount of negentropy would depend on the number of electron pairs and one would expect that this number them. This would mean also maximization of the density of Cooper pairs. Also the assumption that the entanglement is between electron pairs favors maximization of the covalent bonds since this maximizes the quantum coherence by magnetic flux tubes. Does this maximization take place in living matter?

1. Carbon and silicon tend maximize the number of covalent bonds since they have maximum number of valence electrons. Glucose has the chemical formula $C_6H_{12}O_6$ is the basic metabolite and maximizes the number of valence electron pairs per Carbon atom: this number is four. Hence glucose could be interpreted as an optimal carrier of negentropic entanglement.
2. Phosphate is the basic building brick of metabolism. Phosphate having the chemical formula PO_4H_3 is so called oxidation state. Although the formal valence of phosphorus is -3 it behaves in phosphate with valence 5 so that the number of valence electron pairs is as high as 8!

Even more interestingly, quite recently it has been found evidence that oil droplets can be regarded as a primitive life form. The TGD inspired model [K31] led to the identification of the counterpart of the phosphate as nitroglycerin [I28], which is also an oxidation state maximizing the number of electron pairs.

Also arsenic based life [I22] has been suggested and there are even indications for its realization. Arsenic is analogous to phosphorus has been proposed as possible counterpart of phosphorus.

3. Each nucleotide of DNA strand contains phosphate group giving it high negentropy and also *A, T, C, G* have rather high negentropy. For *A* the number of electron pairs is maximal- 24- and *G* comes next. This might explain why just ATP defines the standard metabolic currency. Note that also GTP is used as a source of metabolic energy in protein synthesis.
4. Peptides are often called information molecules and are also known to correlate strongly with emotions and emotional expression so that they have been called molecules of emotion [J85]. Peptides as amino-acid sequences as also hormones, neurotransmitters, hallucinogens, alcohols and other neuro-chemicals contain a large number of covalent electron pairs. This would support the view that the excretion of hormones and all similar compounds is basically a process of sending flux tubes connecting the sender of the signal with the target by negentropic entanglement. The binding of the chemical to the corresponding receptor would build the entanglement bridge having magnetic flux tube as a correlate.

It would be natural to assign to the generation negentropic entanglement positive emotional coloring and negative emotional coloring to its reduction. The re-distribution of negentropic entanglement d between biomolecules using metabolic activities could therefore give rise to emotions with both colorings.

There are several questions to be answered.

1. Atomic electrons are at overlapping atomic orbitals but what about spin 1 super-conducting valence electron pairs with large \hbar ? Could it be that these electrons reside in a region where the Coulomb forces by atoms associated with the valence bond compensate each other so that the electron pair sees very small force. Could this make the delocalized electron pairs effectively free? Could the large value of Planck constant provide them the ability to control the distance of the composite atoms?
2. Can one understand high energy phosphate bond from negentropy maximization? Negentropic entanglement could bind particles without binding energy. This of course need not be always the case but could one assign to the electron pairs of phosphate negative binding energy? This negative binding energy could be caused by the Coulomb repulsion between the electron pairs and the stability of phosphate would be due to the negentropic entanglement between the pairs.
3. H_2S is used as a nutrient by some groups bacteria. H_2S is oxidized just as water. Are the electron pairs of H_2S ordinary or dark? At what step they are transformed to dark electrons if this they are ordinary in H_2S ? Is this transformation a phase transition induced by the presence

of the analog of Cooper pair Bose-Einstein condensate (the mechanism would be the analog of stimulated emission). Could this be tested experimentally?

To sum up, the proposed hypothesis could unify three different hypothesis about the origin of macroscopic quantum coherence. The hypothesis that living matter is high T_c electronic superconductor, the hypothesis that negentropic entanglement is the basic characteristic of living matter, and the hypothesis that dark matter corresponds to a hierarchy of Planck constants realized in terms of effective multi-sheetedness of the imbedding space.

What is the exact role of the solar radiation?

Photons provide the energy in photosynthesis. Do photons also provide negentropic entanglement or only make possible to re-distribute negentropic entanglement? Since the negentropic entanglement is a non-local 2-particle property rather single particle property, the idea that photons would carry negentropic entanglement does not make sense. This would support the minimal assumption that solar photons provide the metabolic energy needed to re-distribute the entanglement: this indeed requires destruction and reconstruction of highly energetic valence bonds. Of course, this energy could be also realized as a mechanical work.

Large \hbar photons should in question. Are they generated by a phase transition increasing the value of \hbar at relevant magnetic body? What level in the onionlike hierarchy of magnetic bodies this magnetic body corresponds to? Is the magnetic body of the antenna proteins in question? Or is it some higher layer in the hierarchical structure of the magnetic body? Do the photons appear with several values of Planck constant?

How do dark protons and dark electrons relate?

One of the key observations leading to the identification of dark matter as a large \hbar phase was the effective chemical formula $H_{1.5}O$ for water in atto-second time scales [K27]. The explanation was that 1/4:th of protons are dark in this time scale. The portion of dark photons is expected to depend on temperature and pressure and would make water a two-phase system effectively. This could explain the numerous anomalies of water in the temperature range 0-100 C [K27]. In living matter the portion of dark protons could be even higher.

This hypothesis led later to the idea that dark protons form dark nuclei and to the completely unexpected observation that the quantum states of dark protons are in natural correspondence with DNA, RNA, tRNA, and aminoacid molecules and that vertebrate genetic code finds a natural realization [L7, K36]. The fundamental realization of genetic codes would be at the level of dark nuclei consisting of dark proton strings connected by color flux tubes just as ordinary nuclei in TGD inspired model of nuclei. Taking this seriously, one is forced to conclude that also dark protons play a crucial role in living matter. They indeed appear in key role in both photosynthesis and cellular respiration. The challenge is to understand the precise mechanisms involved.

1. The number of both protons and electrons participating to a typical process step is $n = 4$. The oxidation of two water molecules gives O_2 molecule and 4 protons and electrons. Is the reason for number four just this or could four protons form a dark nucleus serving as a counterpart of 4He , which has exceptionally high binding energy. This sequence corresponds to a sequence of four DNA codons. Do this kind of sequences have a special role?
2. One could counter-argue that the high binding energy of 4He like state would require additional binding energy requiring additional metabolic resources. A possible resolution of the problem would be negentropic entanglement allowing binding without binding energy. This would allow also longer dark nuclei proposed to accompany DNA, RNA, and amino-acids. If dark 4-proton nuclear strings are there, could they be associated with pairs of water molecules and could hydrogen bonds accompany them and serve as their signature? Could the appearance of 4 protons in $ADP + P_i \rightarrow ATP$ process involves a reconnection of the flux tube with hydrogen bond and transfer of 4-proton dark nucleus through the mitochondrial membrane?
3. A natural question is whether also dark nuclei give rise to magnetic flux tubes giving rise to macroscopic quantum coherence. DNA double strand has very high electronic charge of two units

per nucleotide assignable to the negatively charged phosphate groups. This creates problems with the stability.

- (a) Could this charge be stabilized by dark protons forming long dark nuclear strings? This would give unit positive charge per single nucleotide which is more favorable concerning stability. Could one have one dark proton per single nucleotide with a 1-1-correspondence between the state of the nucleotide and DNA so that genetic code would be realized? Nucleotides and their conjugates in DNA double strand are connected by hydrogen bonds. Could the long dark proton strings possibly accompanying DNA and its conjugate relate with these hydrogen bonds?
 - (b) Could the dark protons have spins parallel to the DNA strand and generate the magnetic flux tubes around which the DNA strands are formed? Are also other mRNA and amino-acids formed around magnetic flux tubes generated by dark proton string?
4. The condition that the Compton length of dark proton is of order the length of DNA associated with single nucleotide (about 1 nm) would fix the value of \hbar associated with the dark protons to be about 10^6 . For this value of the Planck constant electronic Compton length would be around 1 micrometer which is the size scale of cell nucleus. Is this a mere co-incidence? In fact, the condition that dark electrons and protons appear with Planck constants giving rise to approximately same Compton lengths gives rise to a hierarchy of Planck constants in powers of integer near to the mass ratio $m_p/m_e \sim 2^{11}$ postulated in the original version of dark matter hierarchy but given up latter.

Empirical evidence for quantum coherence

Since 2007 empirical evidence for the importance of macroscopic quantum phases and quantum entanglement in photosynthesis has been accumulating and provides support for electronic bio-superconductivity suggested already two decades ago.

1. The group led by Graham Fleming [I86] provided evidence for quantum coherence in light-harvesting proteins of green sulphur bacteria. The experiments were however carried out at 77 K so that one could not exclude the possibility that the effect is due to the low temperature.
2. The group led Graham Fleming 2010 has found evidence for quantum entanglement [I38] at room temperature and in much longer length scales than expected. This is against the prediction of the standard quantum theory that quantum entanglement is extremely fragile and destroyed by thermal fluctuations. The new physics explanation would be naturally as entanglement of large \hbar structures for which the length scale of entanglement would be scaled up and the energies associated with the bonds would be still above the thermal threshold. Photons with the energies of visible light and having wave lengths even in EEG range [K26, K62] are indeed basic building brick of TGD based view about living matter.
3. 2010 the group led by Elisabetta Collini [I36] found similar evidence in light-harvesting protein found in cryptophyte algae at physiological temperatures. The second finding was that the rate at which the the oscillations of a coherent superposition of two electron excitations with different energies lasted about 400 fs whereas the expectation was 100 fs. The naive guess would be that the value of Planck constant was by a factor 4 larger than its standard value.
4. Greg Scholes [I15] irradiated in his experiment the antenna proteins of marine algae at room temperature by two laser pulses lasting for about 10^{-12} seconds to induce single electron excitations with slightly different energies. This created effectively two oscillating dipoles whose electric fields were superposed. Immediately after laser beam was sent through the antenna protein system. The study of the changes in the laser beam due to the interference with the electric field generated by the electronic excitations demonstrated that the energy patterns of distant molecules fluctuated in a manner revealing correlation between them. The phenomenon observed was quantum beat [B1], a quantum version of the low frequency oscillation observed when two tuning forks with slightly different frequencies are hit simultaneously. Quantum beat demonstrated that the two electronic excitations generated by the laser pulses were non-local and superposed with each other.

These experiments provide the strongest support hitherto that the harvesting the photons in photosynthesis are macroscopically quantum coherent structures in electronic degrees of freedom. The measurements demonstrate the linear superposition for electronic excitations with different energies. Not only single molecule would be excited but a superposition of electronic excitations localized at different molecules would be generated. This would help to explain the extremely low losses of photon energy in the process. The energy would be routed from antenna proteins to nearby reaction-center proteins. Instead of choosing one classical path the electrons are transported simultaneously along all paths and every-time the shortest path will be chosen eventually.

A superposition of electronic excitations at different locations for the condensate by single photon would be in question. Visible photon wave length sets the scale in question to be at least of the order of micron (the size scale of cell nucleus). For a non-standard value of Planck constant the scale would be longer. The following picture applying quite generally rather than only in the case of antenna proteins suggests itself.

1. By their small mass electrons obey very fast dynamics and adapt to the conformational dynamics of molecules. Single electron cannot affect the conformational dynamics but acting quantum coherently together electron pairs can control the protein dynamics by collective phase transitions.
2. Magnetic flux tubes would accompany spin 1 electron pairs replacing valence electron pairs and would give rise to macroscopic quantum coherence and correlations at the level of molecules. This is more or less the original proposal made for almost two decades ago [K13, K14]. The new elements are the hierarchy of Planck constants and the identification of Cooper pair like states as valence electron pairs with spin 1. The dipole magnetic fields generated by spin 1 electron pairs make possible the web of magnetic flux tubes along which supra currents can run.
3. This could be also the mechanism of high T_c super-conductivity. Magnetic flux tubes are key players also in TGD inspired model for high T_c super-conductivity [K13] explaining the observed two critical temperatures in terms of percolation process: a phase transition in which relatively short flux tubes emerge below the first critical temperature but cannot give rise to a macroscopic super-conductivity. At lower critical temperature these flux tubes reconnect to form longer flux tubes and in this manner make possible macroscopic super-conductivity [K13]. Reconnection would be the fundamental mechanism also in high T_c super-conductivity. It should be possible to test the predicted spin 1 property of electron pairs and in the case of high T_c super-conductivity the spin 1 character has been established.
4. The interpretation in terms of a Bose-Einstein condensate of non-localized electron pairs would be a natural first guess. In this case all electron pairs would be in same state and quantum entanglement need not be present. A better guess is indeed entanglement between electron pairs at the ends of flux tubes. Whether this kind of entanglement plays a role also in high T_c super-conductivity is an interesting question.

8.4.2 Questions about metabolism

Adenosine-tri-phosphate (ATP) is usually seen as a universal energy currency molecule of cell (for excellent popular article see [I3]). ATP is critical for all forms of life. ATP is involved with transport work (e.g. the transport of molecules along micro-tubuli) and mechanical work (muscle contraction and movement of flagellae and chromosomes). The major role of ATP is usually believed to be related to chemical work. ATP serves also as a switch: by bonding to a protein and receiving or giving phosphate to a protein ATP molecule can induce a conformational change of protein leading to its activation or inactivation.

The basic processes involved are charging and discharging of the ADP molecule by phosphorylation and its reverse process (according to standard view: TGD view is somewhat different). Many aspects of the ATP functioning are far from being completely understood and there are real mysteries, if not paradoxes, involved. One of them is how the process inducing ATP mediated energy transfer is accompanied by momentum transfer giving rise to a coherent locomotion. This suggest strongly quantum coherence of the process.

The TGD inspired vision allows to see the basic purpose of metabolism as a redistribution of quantum information realized as negentropic entanglement between sender and receiver and this allows to see also ATP from a new viewpoint. Macroscopic quantum coherence is indeed the basic aspect of the process in this picture. In this framework energy metabolism might be seen as a pre-requisite for the re-distribution of bridges of negentropic entanglement.

ADP → ATP as a reconnection process?

The interpretation of $ADP + P_i \rightarrow ATP$ as a reconnection process is the genuinely new element in TGD view about metabolism. The reason is that this process is essentially non-local modifying the connectedness structure of the web formed by the magnetic flux tubes. As opposed to this, metabolism is purely local process in the standard view.

1. ADP → ATP could be regarded as a reconnection machine creating reconnections between various systems and in this manner re-organizing the connectedness structure of the magnetic flux tube web. Flux tubes from systems A and B going through ADP and P_i short-cut to water molecules a and b would reconnect with the mediation of ATP molecule creating connection between A and B.

O= would be in a special role since flux tubes connect at least these. Why? A possible explanation comes from the observation that the flux tube pair associated with O= gives rise to a representation of genetic codons by the total spins of two electron pairs associated with the flux tubes. Also the directions of magnetic fields associated with the flux tubes provide this kind of representation.

2. Suppose that hydrogen bonds are accompanied by flux tubes. Note that this flux tubes need not be short. Magnetic flux tubes can reconnect with the flux tubes associated with hydrogen bonds. In the initial situation: ADP is connected to system A by a flux tube and P_i to system B by a flux tube and in ATP state ATP fuses the two connections to single one.

There are two O=:s assignable to the ends of the flux tube. The flux tubes from A and B can short cut to water molecules and one obtains A-OH and B-OH connections and splitting of A-B connection. Formation of ATP is a reversal of this process. OH from water molecule a and H from water molecule b "eaten" and part of connection created between systems A and B. What remains is water molecule getting OH from and H from a.

3. What it means for the flux tube end to the water molecules? Is the negentropic entanglement present? This is possible since OH carries a dark electron pair located near OH. One could speak about macroscopic quantum phase formed by dark water molecules. If O= flux tube pairs are correlates for directed attention, one could say that water molecule is target of attention [K28].
4. Is an oxidation process involving two water molecules and producing 4 protons and electrons accompanied by the above described process involving flux tubes?
5. The communication of sensory data from the cell membrane to the magnetic body is a key element of TGD based model of living matter and EEG and its variants are involved with these communications [K26]? This communication would naturally involve negentropic entanglement. Can one have a negentropic entanglement between the ends of the flux tubes with length scales which is astrophysical? Do the flux tubes return back to some other organism or organism itself? Or could electron pairs at the ends of flux tubes located in distant magnetosphere outside Earth be important? I have indeed proposed that the magnetic body of entire Earth is relevant for consciousness and life and there is intriguing indications that this might be the case [K41].

Generalized form of second law and metabolism

The non-determinism of state function reduction gives automatically rise to the ensemble entropy so that NMP implies second law of the entanglement is ordinary entropic entanglement. What happens in the case of negentropic entanglement: does the notion of ensemble fail now?

Negentropic entanglement makes possible a generation of genuine negentropy locally. This is not possible in standard physics where the optimal situation means vanishing negentropy and entropy

when entanglement is reduced in state function reduction process. TGD based form of second law predicts that second law holds true for zero energy states only above the time scale characterizing the CD geometry defined by temporal distance between the tips of the CD .

How the second law generalizes? Could it be that negentropic entanglement breaks the second law? In any case, second law in time scales larger than the scale of CD would be natural since one must introduce ensemble to describe the situation but does it follow when also negentropic entanglement is allowed?

The pessimistic generalization of second law states that the generation of negentropic entanglement is always accompanied by a process generating a compensating entropic entanglement. There is no rigorous justification for this proposal and it might be wrong. On the other hand, if this generalization holds true, one should be able to identify the process generating the compensating entropy in metabolism.

Consider first what happens in the generation of ATP trying to think in terms of transfer of negentropic entanglement - its re-distribution - rather than in terms of metabolic energy.

1. Generation of ATP creates connection and negentropic entanglement between distant molecules and uses one molecule of water as a hydration process. One cannot say that the negentropy of water molecule is transferred to the high energy phosphate bond. Rather the entanglement in the final state is between two molecules A and B connected by flux tubes going through the ATP. Before the generation of ATP there were two flux tubes connecting A and B to water molecules. Metabolic energy would be basically used to realize re-distribution of negentropic entanglement? The reverse process can be regarded as dehydration and one molecule of H_2O is used.
2. In phosphorylation the splitting $ATP \rightarrow ADP + P_i$ producing intermediate P_i would not occur but ADP is produced. P_i and high energy negentropic bond would be transferred to the phosphorylated molecule. It could be enzyme which is activated in this manner so that the redistribution of negentropic entanglement would be essential for the bio-catalysis. The phosphate P_i would be attached to the second end of a flux tube. Reconnection process inducing the transfer of entanglement would take place so that negentropic A-B entanglement would transform to A-C entanglement.
3. $ATP \rightarrow ADP + P_i$ liberates energy.
 - (a) Is the negentropic entanglement lost and transformed to entropic entanglement as the connection splits or is the negentropic entanglement only transformed to a different form?
 - (b) In the splitting short-cut of flux tube connections to water molecules happens as their reconnect with hydrogen bond. This would split the connection A-B to A-water and water-A connection. Does it make sense to speak about negentropic entanglement between water molecule and molecules at the end of the connection?
 - (c) The valence electron pair associated with O-H valence bond would entangle negentropically with that of molecule A/B. This process reduces the connectedness of the web formed by magnetic flux tubes: does this mean generation of entropy?

Consider next how the second law in the pessimistic form could be realized in metabolism suggested by the fact that living matter seems to be very effective polluter of environment.

1. In cellular respiration CO_2 and H_2O are regarded as "wastes". Could this mean that the electron pairs possibly having large \hbar and spin 1 lose their flux tube connection to the organism? And could the lack of flux tube connection induce a transformation to ordinary spin 0 valence electron pair at least in the case of CO_2 ?
2. In photo-synthesis O_2 molecules are regarded as the "wastes". They have only one valence electron pair and several unpaired electrons. Same hold true for O_2^- super-oxide molecules. Both are free radicals and highly reactive causing oxidative stress [I31] inducing damage to DNA. This in turn correlates with degenerative diseases, cancer, and senescence. Could this be interpreted as an entropic effect? Is the damage to DNA caused by the transformation of high \hbar electrons to ordinary ones and their pairing with ordinary electrons so that super-conducting

phase suffers damage inducing a further damage at molecular level as the magnetic body loses negentropic entanglement and its controlling abilities weaken? Could it be possible to "heal" the damaged super-conducting phase?

If the second law in the pessimistic form is behind the effect it could be cured only by guiding the unavoidable entropy production to take place outside body.

TGD inspired questions about photosynthesis

The basic assumption is tht hiving matter is high T_c super-conductor [K13].

1. Spin 1 electron pairs with negentropic entanglement generate magnetic flux tube structures and long range coherence. These spin 1 pairs give rise to high T_c superconductivity by creating the magnetic flux tubes as the routes along which they propagate. If they have energy higher than spin 0 pairs they decay to these and magnetic flux tube structures disappear and therefore also super-conductivity.
2. Electrons and electron pairs control the conformations by their very fast adaptive dynamics. Macroscopic quantum coherence would induce macroscopic quantum coherence of this dynamics. The challenge is to preserve the macroscopic coherence for which a geometric correlate is defined by long magnetic flux tubes.
3. There is considerable evidence for quantum coherent electron transport [I86]? The electronic excitations are not local but superpositions of excitation located even in separate chromophores. This would suggest electronic excitations affecting the Cooper pairs of entire Bose-Einstein condensate. The decay of a Cooper pair defined by a spin 1 pair of valence electrons looks like a natural mechanism. A defect in super-conductor would be created. "Correlated protein environments" and "correlation between protein induced fluctuations in the transition energy of two neighboring chromophores" are the terms used. Magnetic flux tubes accompanying electron pairs with parallel spins along flux tubes would give rise to these environments and correlated fluctuations.
4. If one believes that a single electron process is in question, dark electron pair could be destroyed in the absorption of dark photon. This is consistent with non-locality of the electronic excitations since non-locality requires that dark electron pair absorbs the photon.

This rough picture raises further questions about the details of the photosynthesis.

1. Suppose that the photons from Sun are ordinary ones so that the presence of the dark magnetic body at some level of hierarchy induces the phase transition of solar photons to large \hbar photons. In the geometric picture this phase transition would correspond to a leakage of photon to a magnetic flux tube at the dark sector of the imbedding space. Does the leakage at the level of antenna proteins or already earlier? Or at the magnetic flux tube associated with the chlorophyll's electron kicked to a higher energy state? Does this kicking split valence electron pair.
2. At what step the dark excited electrons combine to form spin 1 pairs again? Does this take place in the formation of ATP and ADPH and in the generation of sugar molecule? The maximization of the number of valence bonds is an empirical fact and suggests that all valence electron pairs of bio-active molecules are dark spin 1 pairs.
3. Could denaturation [I12] of bio-polymers transform dark valence electron pairs to spin 0 pairs with standard value of Planck constant. Could something like this happen also for the possible dark protons assigned to the basic building bricks of the bio-polymer in denaturation process?
Could this proposal be tested experimentally?
 - (a) The parallel spins of pairs give rise to net spin compensated by opposite orbital angular momentum. Is this kind of angular momentum present in living DNA and protein molecules and does it disappear in denaturation?

- (b) Are also water molecules of cellular water dark? If this is not the case, the oxidation process splitting water molecules to O_2 , 4 protons, and 4 electrons should induce a phase transition producing dark electrons and protons. Could large \hbar characterize the valence electron pairs of the "living" portion of water and could the presence of this dark fraction relate directly to water memory and effective $H_{1.5}O$ formula in atto-second time scale?
- (c) How water memory for which evidence is accumulating [K36] relates to electronic and protonic negentropic entanglement?

There are also questions not directly related to the electron pairs.

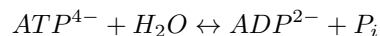
1. In photosystem II the 4 electrons are provided by the oxidation of water catalyzed by P680 molecule. What happens in this process? Do the 4 protons produced in the splitting of water form dark nucleus analogous to 4He but having charge 4, which the decays to 4 dark protons received by $NADP^-$. What would transform the protons to dark protons. How this phase transition is catalyzed by P680 molecule? Does it provide the presence of imbedding space sector with large \hbar to which protons leak and possibly also fuse to form a dark nucleus? Or is the sector present and P680 only provide the energy needed to jump over the potential wall for the ordinary protons.
2. At which step the transfer between different space-time sheets creating or liberating zero point kinetic energy takes place for electrons and protons? Oxidative process or $ADP + P_i \rightarrow ATP$ giving out one water molecule. The P-O-P bond should contains the surplus energy and electron pair should reside be at a smaller space-time sheet at this bond. The dropping of the pair to a larger space-time sheet would destroy the bond which is stabilized by the negative Coulomb energy due to the interaction of the pair with ionized atoms at the ends of the bond.

8.4.3 Hydrolysis of ATP in TGD universe

The generation of phosphate polymers and polymers in general occurs by dehydration which quite generally seems to involve dropping of a proton to larger space-time sheet and liberation of metabolic energy quantum. It is interesting to find how one could understand these processes in TGD framework. Since the notion of wormhole magnetic flux tube playing a central role in the model of DNA as topological quantum computer and in the model of bio-catalysis, it is natural to look whether the basic steps of these processes could be understood in this conceptual framework.

1. $ATP \rightarrow ADP$ process

AMP, ADP, ATP are phosphorylated RNA nucleosides [I3] and the hydrolysis of ATP to ADP [I4] plays a key role in the metabolism. Obviously also the molecules XMP, X=U,C,G are important biologically. Each PO_3 in ATP corresponds to one unit of negative charge except for the last one which carries two units of negative charge. According to the standard chemistry $ATP \leftrightarrow ADP$ corresponds to the hydrolysis



where P_i denotes orthophosphate HPO_4^{-2} . In ADP the last phosphate group is $HO-PO_2^{-2}$ rather than $O=PO_2^{-2}$ as in case of ATP.

The actual process is however much more complex than this.

1. The process involves several steps such that energy is liberated in two steps in which the change of Gibbs free energy is $\Delta G = .42$ eV and $\Delta G = .31$ eV making altogether .73 eV, which should closely relate to the liberated metabolic energy.
2. Three protons are accelerated in electric field during the generation of ATP. The interpretation would be in terms of driving of electrons from larger space-time sheet to $k = 137$ atomic space-time sheet. If the larger space-time sheet corresponds to $k = 139$, the increment of the zero point kinetic energy of proton is $(1 - 1/4) \times E_0(137) = .375$ eV for $E_0(137) = .5$ eV of metabolic energy quantum. Three protons would give net zero point kinetic energy increment of 1.125 eV which is higher than $\Delta G_{tot} = .73$ eV. The explanation of the discrepancy should relate to

Coulombic binding energy of protons with ATP and F_1 . This interpretation conforms with the observation that the liberated energy is higher for the third proton. It must be emphasized that one can imagine several alternative explanations.

Consider now a more detailed model for the process. The binding of ATP to the catalytic site involves several steps.

Step 1: The binding $ATP + F_1 \rightarrow ATP \cdot F_1$ to the catalyst site is a complex process involving the break-up of the hydrogen bonds between cellular water and ATP molecule and cell water and catalyst site and generation of hydrogen bonds between catalyst site and ATP molecule. In TGD framework this means that protons can be kicked to and dropped back from atomic space-time sheets. Only the net number of protons dropped however matters.

This process involves liberation of Gibbs free energy about $\Delta G_{ATP} = .42$ eV. It was earlier believed that this energy is liberated instantaneously but the findings about the behavior of the F_1 motor coupled to dissipative load, lead Oster and Wang to suggest that the process is more complex and starts from a loose binding and ending up to a strong binding [I109] .

Step 2 Hydrolysis: $F_1 \cdot ATP \rightarrow F_1 \cdot ADP \cdot P_i$. The change of free energy is small during this step: $\Delta G \sim 0$.

Step 3: Ortophosphate is released from the catalyst site: $F_1 \cdot ADP \cdot P_i \rightarrow F_1 \cdot ADP + P_i$. Free energy $\Delta G \sim .31$ eV is liberated at this step.

Step 4: ADP is released from the catalyst site: $F_1 \cdot ADP + P_i \rightarrow F_1 + ADP + P_i$. $\Delta G \sim 0$ holds true also for this process.

This picture suggests that the notion of the high energy phosphate bond is not quite correct as suggested also by some empirical findings [D34, D20] , [I102] . The metabolic energy would be stored as the zero point kinetic energy of protons rather than in phosphate bonds. Perhaps the fundamental function of phosphates would be to make DNA and RNA polymers charged in turn making possible the formation of wormhole magnetic flux tubes and braiding making possible a wide repertoire of catalytic actions.

2. Model of $ATP \rightarrow ADP$ based on wormhole magnetic flux tubes

Consider first the basic philosophy behind model.

1. In the model of DNA as topological quantum computer $XMPs$, $X = A, T, C, G$ can be connected to oxygen atoms by wormhole magnetic flux tubes having quark and antiquark at opposite throats of wormhole contact and charge conjugated quark-anti-quark pairs at the ends of the flux tubes. Dark u quark and its charge conjugate code for A, T and d quark and its conjugate for G, C so that the conjugation for nucleotides corresponds to charge conjugation for quarks and $A - G$ and $T - C$ symmetries of the third nucleotide of the codon to isospin symmetry.
2. Basic bio-catalytic processes are identified as a reconnection of the wormhole magnetic flux tubes and change of the length of the flux tube induced by the change of the value of Planck constant associated with it. It would not be too surprising if this kind of mechanism were involved also in $ATP \rightarrow ADP + P_i$. The reason for the special role of ATP among XTP might be that the positive charge $q(u) = 2/3$ of u -quark maximizes the attractive interaction between u quark and phosphate.
3. Flux tubes connect to oxygen atoms in the proposed model of bio-catalysis and protein folding [K4] . The model is relies on ideas inspired by the model of DNA as topological quantum computer [K28] . In this model hydrogen bonds are assumed to correspond or to be accompanied by (wormhole) magnetic flux tubes. Also flux tubes connecting acceptor atoms or molecules of hydrogen bonds are assumed to be connected long flux tubes and represent genuinely new physics. Examples of acceptors are $O =$ atoms in phosphates and amino-acids and aromatic rings in DNA and also in some amino-acids. The model for protein folding has tight connections with existing chemistry and leads to a very simple and successful criterion for the formation of hydrogen bond between $N - H$ and $O =$ in the constant part of amino-acid and to a successful proposal for the folding code.
4. DNA as tqc model gives further constraints. The structure of the phospholipids suggest that in the case DNA nucleotides long flux tubes connect the aromatic ring of the nucleotide to the $O =$

atom at the hydrophilic end of the lipid acting as a standard plug which in turn can be connected to another acceptor and eventually terminates to a donor of hydrogen bond. The detailed charge structure of the aromatic ring(s) should determine the quark-nucleotide correspondence. The connection line to the lipid could involve several intermediate $O =$ plugs and the first plug in the series would be the $O =$ atom of the monophosphate of the nucleotide. Not surprisingly, phosphorylation would be absolutely essential for the operation of DNA as topological quantum computer. $O = -O =$ flux tubes could also act as switches inducing a shortcut of the flux tube connection by reconnecting with a hydrogen bond connecting two water molecules. This is an essential step in the model for how DNA acts as topological quantum computer.

A possible model (perhaps the simplest one found hitherto) for the reaction $ATP \rightarrow ADP + P_i$ is based on the assumption that it splits a flux tube connection defining strand of a braid defining topological quantum computation. A change of the hardware of topological quantum computer would be therefore in question.

1. Suppose that ATP defines a standard plug in flux tube connections. This would mean that aromatic ring and the oxygen atoms $O =_1$, $O =_2$, and $O =_3$ of the phosphates are connected by magnetic flux tubes to a string and $O =_3$ in turn is connected to some (hydrogen bond) acceptor elsewhere, say $O =$ or aromatic ring. These flux tubes represent genuinely new physics in accordance with the fact that "high energy phosphate bonds" are not really understood in the standard chemistry.
2. The reconnection of $(O =_2) - (O =_3)$ flux tube with the hydrogen bond connecting two water molecules leads to the splitting of the flux tube so that the incoming and outgoing the flux tubes are shortcut by $(O =_2) - -H - (OH)$ resp. $(O =_3) - -H - (OH)$ hydrogen bonds (connection to ground is the analog in circuit theory). This corresponds in the usual terminology the liberation of the third phosphate: $ATP \rightarrow ADP + P_i$. P_i however remains at the end of flux tube to be attached later to another ADP.
3. The process involves also hydration. $(OH)^-$ ion joins to the third P to give P_i^{-3} and H^+ to $O - P$ in second P to give $H^+ - O$ in ADP^{-1} . The exchange of electron would lead to the final state $ADP^{-2} + P_i^{-2}$.

A possible model for the dropping of protons would be following.

1. It is absolutely essential to realize that F_1 is an open system and that naive thermodynamic considerations can lead to misunderstandings. In particular, the notion of high energy phosphate bond does not make sense. The source of metabolic energy is chemical energy used to drive protons to the atomic space-time sheets of F_1 . The function of the large negative charge of ATP is to increase the rate for the binding of ATP^{-4} to F_1 . In the classical picture the binding to F_1 is followed by the dropping of two protons to larger space-time sheet. The value of the metabolic quantum could be reduced from .5 eV to about .21 eV by the Coulombic interaction energy of proton with PO_4^- . The Coulombic binding energy of the remaining protons at F_1 with $ADP + P_i$ is smaller and the dropped proton liberates larger energy about .31 eV. In quantum picture the division of the process to this kind of sequence might not be a good approximation.
2. One function of the $ATP \rightarrow ADP$ would be to induce the dropping of the third proton from F_1 space-time sheet. Metabolic energy should make possible information processing. Second function might indeed relate to the topological quantum computation like process since the decay would correspond to a splitting of a braid strand coming to the aromatic ring of A and proceeding along string defined by the ring and three $O =$ s of phosphates and continuing further. This would make possible tqc as a braiding for both halves of the split flux tubes. After the reconnection the total braid structure would be different.
3. The reason for why P_i leaves the catalyst site and proton is dropped (step 2) should be the in-stabilization of the bound state of positively charged proton with $ADP^{-2} + P_i^{-2}$ which does not have so strong Coulomb interaction energy with proton as ATP^{-4} . As a consequence, proton can drop to the larger space-time sheet.

4. What remains open are the details of the transformation of the chemical energy to zero point kinetic energy of protons. Remote metabolism suggests that protons send negative energy phase conjugate photons to the direction of geometric past inducing a transition of an energy carrying molecule to a lower energy state. This would mean the failure of the standard description in terms of reaction kinetics. The catabolism of nutrients is the eventual provider of the metabolic energy and the coenzyme nicotinamid adenine dinucleotide NAD^+ [I26] receives electron and the energy liberated in the catabolic reaction. In the proposed framework it is not an surprising that NAD^+ is analogous to RNA dinucleotide (perhaps as remnant from RNA era when dinucleotides defined the 2-codon code) and consists of two phosphates and adenine and nicotinamide nucleosides. The oxidation reaction $NADH \rightarrow NAD^+$ in turn liberates this energy. Protons could gain their energy by sending negative energy photons to $NADH$. Negative energy photons would propagate along "topological light rays" parallel to the flux tubes connecting the system in a precisely targeted manner to NADH aromatic rings. Alfvén waves propagating along magnetic field lines would be the standard electrodynamics counterpart for these topological light rays.

Many details of the process remain open but it would seem that the key ideas of TGD based quantum vision about living matter are fused together in rather detailed manner in this picture.

8.4.4 Could high energy phosphate bond be negentropic bond with negative binding energy?

Most people assign the word "love" to the word "life" as their first association. There is a notable exception to this: scientists including biologists. Un-educated layman might however wonder whether one can understand life without identifying any physical counterpart for this notion (, which could be replaced with that of compassion, sex, or ability to act synergetically or just X if some of these notions sounds less un-scientific). Certainly the word "love" stimulates a deep feeling of disgust in a reductionistically conditioned scientist. But isn't the duty of scientist to win this kind of feelings and try to see whether this identification might be possible after all? The prize could be high: the understanding of what distinguishes between living and dead matter could change the entire culture. Who knows, maybe it could be possible to identify some poorly understood fundamental biological process allowing a quantitative model using a guess for what this physical correlate could be. The basic step of metabolism is at the core of life and indeed poorly understood, and I shall argue that the identification of the negentropic entanglement as the counterpart for the notion of love could allow to model quantitatively what happens in this process.

Basic ideas

Before continuing general motivating comments about implications of negentropic entanglement are in order.

1. Ordinary bound states are stable because they have positive binding energy. One can visualize this kind of binding as a jail: the second particle resides near the bottom of a potential well. Organized marriage is a social analogy for this situation. Negentropic entanglement makes possible bound states for which binding energy can have and perhaps even has always a wrong sign. The state is not prevented from decaying to free particles in state function reduction by energy conservation: Negentropy Maximization Principle (NMP) [K46] takes care that they remain correlated. The social analogy would be a voluntary marriage based on love. Partners are completely free to leave but want to stay together. One implication could be explanation for the stability of highly charged basic molecules of life such as DNA and ATP.
2. The presence of the negentropic entanglement implies the directedness of the biological processes since the outcome of the state function reduction would be far from random since the behavior of negentropic bonds could be almost deterministic. In the case of time-like entanglement this would select only particular initial final state pairs so that determinism would emerge also in this sense and could lead to almost deterministic irreversible cellular automaton behavior characteristic for the living matter very different from the reversible determinism of classical physics and very difficult to understand in quantum context.

3. The determinism would of course be only partial and would allow violation not spoiled by randomness of quantum jump. This would provide a general explanation for the ability of the living matter to overcome the second law basically implied by quantum randomness predicted by the standard quantum theory. This would happen in time scales shorter than the time scale of the appropriate causal diamond (CD) only but one would have hierarchy of CD meaning that in arbitrary long time scales there are levels of hierarchy at which second law is broken. The hierarchy of Planck constants would be also crucial since it would allow zooming up to arbitrarily long time scale. Non-equilibrium thermodynamics and cellular automaton models could be seen as phenomenological descriptions for the actual breaking of second law in the intersection of real and p-adic worlds.
4. High energy negentropic bonds need not be present only in phosphates. O=s are present in all important biomolecules. Phosphates are present in DNA. Each peptide bond in amino-acid polymer contains O=. Also sugars contain it. Maybe O= indeed acts as a universal plug defining then ends of negentropic flux tube bonds between biomolecules. For instance, protein folding for which a possible model is discussed in [K4] from different view point could be more or less deterministic cellular automaton like process if the bonds are negentropic. Negentropic entanglement would also guarantee the stability of the folding pattern. Certainly the assumption that the process is random -as standard quantum theory would suggest- leads to Levinthal paradox stating that the rate of the process is quite too slow. The simplest possibility is that the flux tube bonds are between O=s of subsequent amino-acids before folding and the folding process involves formation of reconnections possibly drawing by a reduction of Planck constant certain amino-acids near to each other. O=s could also act as plugs connecting protein to other biomolecules. One must however notice that many neurotransmitters, hallucinogens, and alcohol having strong effects on consciousness have O-H groups instead of O=s. This inspires the question what happens to the flux tube in $O=\leftrightarrow O-H$ process.

General formulation of the model

Consider now the model. High energy phosphate bond [I19] assigned with the two outer-most phosphates of ATP [I3] is fundamental for the basic processes in living matter. The $ATP \rightarrow ADP + P_i$ liberates metabolic energy loaded to ATP in the cellular respiration process [I7] or its equivalent and occurs again and again and defines a kind of Karma's cycle in living matter. The phosphate bond is assumed to have a high energy content liberated as ATP is hydrated to ADP [I2] and phosphate ion $P_i = PO_4^{3-}$ [I32]. The notion of high energy phosphate bond has been however challenged as being meaningless [D34, D20], [I102].

1. One can of course consider a high energy bond for which the interaction potential looks like a well at the top of mountain and spin glass degeneracy of quantum TGD would certainly allow to consider this kind of notion. I do not know whether models realizing this idea concretely have been really constructed.
2. My earlier proposal for $ATP \rightarrow ADP + P_i$ process is inspired by the notion of many-sheeted space-time and p-adic length scale hypothesis making sense in the intersection of real and p-adic worlds and involves the dropping of protons (or electrons) to larger space-time sheets and driven back in oxidative metabolism. The energy liberated in this process corresponds to the zero point kinetic energy of protons (or electrons), which is smaller at the larger space-time sheet. The maximum value of zero point kinetic energy is predicted to be $E_0 \simeq .5$ eV for $k = 137$ in the case of proton and for $k = 148$ in the case of electron (for electron the energy would be by a factor $2^{-11}m_p/m_e \simeq .94$ smaller).
3. With an inspiration coming from DNA as topological quantum computer model [K28] I have also proposed that the magnetic flux tubes connecting bio-molecules to each other define a kind of Indra's net plays a key role in the biological information processing. For instance, topological quantum computations could be realized in terms of braids formed by flux tubes [K28, K4]. O=s associated with phosphates would serve as universal plugs to which flux tubes could be connected connecting intronic nucleotides and lipid layers of nuclear or cell membrane. In particular, the innermost O= of ATP could be connected by a flux tube to any biomolecule

needing metabolic energy- say some catalyst or the F_1 machine central for energy metabolism. The reduction of Planck constant would bring ATP and biomolecule near each other and lead to a formation of a weakly bound state making catalytic processes possible. The outer O=:s of the ATP molecule could be connected by a flux tube to each other, which could be rather long loop. This flux tube could provide the new physics realization of the high energy phosphate bond.

4. $ATP (P_i)$ has 4 (3) units of negative charge and at least ordinary layman might wonder why this does not induce instability. Similar problem is encountered in the case of DNA, which contains two units of negative charge per nucleotide. This particular problem is regarded as completely real. The idea about life as something in the intersection of real and p-adic worlds [K69] raises the question whether these high energy states could be made possible by the presence of negentropic bonds- most naturally associated with the flux tubes with large \hbar . This love marriage would stabilize ATP , ADP , and DNA and other charged biomolecules. The presence of phosphates would be a clear-cut signature of this stabilization mechanism. Also proteins involve phosphates playing a key role in the bio-control: typically phosphorylation activates or de-activates the protein and is also involved with the generation of signal pathways. Why this happens would be easy to understand in Indra's net model.
5. In $ATP \rightarrow ADP + P_i$ transformation the energy carried by the negentropic bonds would be liberated but leave the flux tube bonds negentropic. Cell respiration would take care of the loading of the batteries with negentropic metabolic energy. This would involve also the kicking of protons back to the smaller space-time sheets. Also the molecular lovers ADP and P_i would find each other again as the Planck constant for the flux tube connecting them would be reduced during the cellular respiration transform ADP and P_i back to ATP .

Quantitative estimates

Consider now a more detailed model for $ATP \rightarrow ADP + P_i$. The binding of ATP to the catalytic site involves several steps. I have described them in the previous section and in the following add to this template the interpretation suggested by the proposed picture.

1. **Step 1:** The binding $ATP + F_1 \rightarrow ATP \cdot F_1$ to the catalyst site is a complex process involving the break-up of the hydrogen bonds between cellular water and ATP molecule and cell water and catalyst site and generation of hydrogen bonds between catalyst site and ATP molecule. In TGD framework this means that protons can be kicked to and dropped back from atomic space-time sheets. Only the net number of protons dropped however matters.

This process involves a liberation of Gibbs free energy per single attachment, which is about $\Delta g_{ATP} = .42$ eV. It was earlier believed that this energy is liberated instantaneously but the findings about the behavior of the F_1 motor coupled to dissipative load, lead Oster and Wang to suggest that the process is more complex and starts from a loose binding and ending up to a strong binding [I109].

Comment: One can question the assumption that strong binding is generated. Instead of binding proton or electron would be dropped to a larger space-time sheet and liberate zero point kinetic energy.

- (a) The simplest interpretation in the proposed picture is that the negentropic flux tube connecting ATP and F_1 molecule and behaving as high energy phosphate bond associated with the innermost O= is contracted via the reduction of Planck constant. Then proton is dropped from $k = 137$ space-time sheet to a much larger space-time sheet and liberates metabolic energy quantum $E(137) \simeq .5$ eV. Another possibility is that electron at $k = 148$ space-time sheet is dropped. This process would replace the instantaneous generation of binding energy and in zero energy ontology the time scale for this process would correspond to the time scale of appropriate causal diamond (CD).
- (b) Instead of single particle energy macroscopic Gibbs energy $G = E + PV - TS$ is the useful notion now since macroscopic quantities of matter are studied and pressures and temperature are typically constant in the situations considered ($dG = -SdT + VdP$). G is minimized for constant T and P prevailing in the situation considered.

- (c) In the attachment of ATP to catalyst S is reduced and a good guess is that volume is not affected so that PV term does not change. From this one can deduce that the liberated energy per catalyst particle -call it $\Delta e = e_i - e_f = \Delta g - T\Delta s$ (i and f refer to initial and final states) satisfies $\Delta e > \Delta g = .42$ eV.
- (d) One must estimate the value of Δe . The attachment reduces the kinetic energy of relative motion of catalyst and ATP to zero. If it makes sense to speak about thermal equilibrium for ATP a catalyst in translational degrees of freedom the reduction of kinetic energy is $\Delta e_K = 3T/2$, which is of order .045 eV at room temperature. Whether this energy remains in the catalyst-ATP system or is it liberated in the process is not clear. The energy liberated in the dropping of the proton or electron gives a contribution $\Delta e = E_0 = .5$ eV. This gives the condition

$$\Delta g_1 = E_0 + 3T/2 - T\Delta s = .42 \text{ eV} . \quad (8.4.1)$$

If the liberated kinetic energy remains in the system, the first guess is $\Delta e = E_0 = .5$ eV, where E_0 is the nominal value of zero point kinetic energy. This would give for $T\Delta s$ the estimate $T\Delta s = .08$ eV about 3 times thermal energy corresponding to three translational degrees of freedom. This looks rather reasonable order of magnitude estimate.

- (e) NMP suggests-maybe even requires- that the bond remains negentropic. The binding energy associated with ATP- catalyst binding could be small- of the order of thermal energy about .045 eV.
2. **Step 2** Hydrolysis: $F_1 \cdot ATP \rightarrow F_1 \cdot ADP \cdot P_i$. The change of free energy is small during this step: $\Delta G \sim 0$.

Comment: The simplest option explaining the fact that the change of energy is small is that hydrolysis leaves the flux tube between outer O=:s of ATP intact and removes only the P-O-P bond. This flux loop could have rather large \hbar .

3. **Step 3:** Ortophosphate is released from the catalyst site: $F_1 \cdot ADP \cdot P_i \rightarrow F_1 \cdot ADP + P_i$. Free energy $\Delta G \sim .31$ eV is liberated at this step.

Comment: The simplest option is that the negentropic flux tube liberates its energy but remains negentropic. The increase of Planck constant might be involved.

- (a) The value of Δe is now smaller than ΔG , which suggests that the metabolic energy quantum in the case of proton corresponds to $\Delta e = E(139) \simeq .25$ eV. The average change of kinetic energy can be assumed to be equal to thermal energy in final state and is same as above. This gives the condition

$$\Delta g_2 = E_0/2 - 3T/2 + T\Delta s = .32 \text{ eV} .$$

- (b) By adding this equation with the similar equation for Step 1 (see Eq. 8.4.1) one obtains the condition

$$\Delta g_1 + \Delta g_2 = 3E_0/2 = .74 \text{ eV} .$$

This gives $E_0 = .49$ eV so that the model seems to be internally consistent.

4. **Step 4:** ADP is released from the catalyst site: $F_1 \cdot ADP + P_i \rightarrow F_1 + ADP + P_i$. $\Delta G \sim 0$ holds true also for this process.

Comment: \hbar increases back to the original value for the innermost flux tube which could it still have small positive energy and be negentropic.

The model would predict that ADP and P_i and remain highly correlated (connected by flux tubes) as do also AXP and F_1 . These predictions should be testable by marking ADP and P_i of ATP with the same "color" (say radioactively) and finding whether the colors of ADP and P_i remain the same during the subsequent cycles or whether they mix immediately. These love affairs at molecular level could be modified only by reconnections of flux tubes as also in human relationships. For instance, two ADPs could exchange their P_i s or F_1 s. Negentropic entanglement could guarantee the highly organized and directed nature of basic bio-catalytic processes.

8.5 Many-sheeted model for photosynthesis

Photosynthesis is a fundamental metabolic function and a many-sheeted model allows to concretize the general ideas about quantum metabolism. What happens in photosynthesis at the level of energy balance seems to be relatively well-understood [I100, I35] but the detailed molecular mechanisms remain obscure. Several strange features, such as the appearance of electron pairs, suggest that superconductivity and atomic and molecular Bose-Einstein condensates are involved. p-Adic length scale hypothesis gives very strong quantitative guidelines in the attempt to understand photosynthesis in many-sheeted space-time, and one ends up to a general view about how Bose-Einstein condensates store metabolic energy as zero point kinetic energy and how this energy is utilized by remote metabolism by generating negative energy MEs. What is so remarkable is that the resulting extremely simple model of photosynthesis is successful both at qualitative and quantitative level.

8.5.1 A rough overall view about photosynthesis

The photosynthesis in eukaryotes occurs in chloroplasts, which are the counterparts of mitochondria in animal cells and contain photosynthetic pigment-protein complexes [I100, I35]. Prokaryotes do not possess chloroplasts and it is believed that chloroplasts are ancient prokaryotes captured by eukaryotic cells. In both cases the crucial structures are membranes.

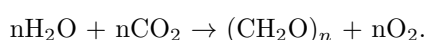
There is an antenna system harvesting photon energy. Antennae are photosensitive pigments sensitive to visible light (400-700 nm). In some bacteria pigments are also sensitive to infrared light in the wave length range 700-1000 nm. The energy is transmitted in electromagnetic form to the so called reaction center. Antenna pigments as well as reaction center pigments are bound to proteins. After the light is transmitted to chlorophylls it excites electron pairs in turn transferred between pigments.

Oxygen producing plants have two photo-systems, photo-system I present also in plants not producing [J35] [I100, I35]. These photo-systems have several tasks to perform.

1. To store the energy of photons permanently to various energy carrying molecules, in particular glucose. Photo-system I takes care of this. Besides hydrogen carbon dioxide serves as the basic raw material of these molecules. The covalent double bonds between carbon and oxygen are reduced in the process. The photons excite in the reaction center of photo-system I electron pairs transferred to NADP^+ to give NADPH which transfers electrons and metabolic energy to where they are needed. Photo-system II draws electron pairs from water and feeds them to the photo-system I to compensate the electrons lost in the generation of NADPH. As water molecules lose two electrons, oxidation happens which means the generation of O_2 molecules. The production of oxygen utilized also by plants themselves is a further basic function of plants.
2. To store photonic energy temporally by transforming ADP molecules to ATP molecules to be used for various purposes. In the photo-system I the electrons can also circulate energizing *one* ADP molecule to ATP per electron pair whereas photo-system II energizes *two* ADP molecules per electron pair to ATP molecule.

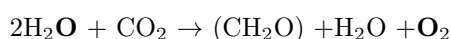
The overall reaction balance equations for photosynthesis deserve a consideration.

1. The overall reaction equation reads as

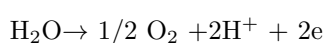


$n = 6$ corresponds to hexoses, in particular glucose, which are the basic products of molecular synthesis and carriers of the metabolic energy.

2. A more precise form of the reaction equation is

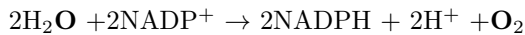


O means that free oxygen derives from water rather than from carbon monoxide which enters to the reaction much later than the oxidation of water. The oxidation of water



indeed happens in photo-system II and provides the electron pair to compensate the electron pair lost by the photo-system I.

3. Hill's equation



tells what happens in photo-system I before CO_2 enters the game. The equation tells that the oxidation of two water molecules providing two electrons and two hydrogen atoms for two NADP^+ ions happens first (for basic facts about NADP molecules see [I27]). NADPH carries then the electrons and hydrogen atoms to the process leading to the formation of say glucose.

8.5.2 A general model for energy storage and energy utilization by remote metabolism

It is good to formulate first a general model for energy storage and utilization based on remote metabolism.

1. Metabolic energy can be stored as zero point kinetic energy to various space-time sheets. The storing particles form Bose-Einstein condensates so that the energy storage is analogous to a population inversion in laser. Bose-Einstein condensates of electronic Cooper pairs, H atoms, H_2 atoms and protonic Cooper pairs, O and O_2 atoms,... are possible. The dropping of a particle to a larger space-time sheet liberates a standardized energy quantum. Since Bose-Einstein condensate is in question, this process can occur coherently which allows high metabolic power. Electronic Cooper pairs kicked to $k = k_{ex} < 151$ space-time sheet from $k = 151$ cell membrane space-time sheets are involved with photosynthesis.
2. Remote metabolism provides an elegant manner to utilize the stored energy. The user must only send negative energy ME at energy sufficiently near to the energy currency. This implies a highly economical use of the metabolic energy. For instance, when an enzyme needs energy, it generates negative energy ME activating ADP to ATP by kicking proton to the atomic $k = 137$ space-time sheet. In this case .5 eV plus possibly an additional energy .34 eV to kick phosphate ion to $k = 131$ space-time sheet is needed. As already found, the model for the $\text{ATP} \rightarrow \text{ADP}$ transformation favors a situation in which space-time sheets involved are linear structures with thickness $L(137)$ and $L(139)$ predicting that the kicking of single proton gives rise to energy .25 eV.
3. "Seesaw" mechanism minimizes the waste of metabolic energy since the same energy can be used repeatedly [K62] . In the simplest situation two users send repeatedly negative energy MEs for each other and dissipative losses are minimized.

Energy and momentum conservation deserve separate comments.

1. Momentum conservation requires that the kicked particles interact with the Bose-Einstein condensate so that it can receive the momentum of ME. The resulting energy transfer to the condensate is very small, a fraction p/M about the energy of ME.
2. It is of paramount importance to realize that the particles of the Bose Einstein condensate cannot be free. This assumption would lead to contradictions since atomic binding energies are more than order of magnitude larger than metabolic energy quantum. This means that Cooper pairs must possess a binding energy not too far from that possessed the spin-paired valence electrons of water molecule.

Hence the pairs of valence electrons form Bose-Einstein condensates at larger space-time sheets $k = k_{gr}$ are analogous to the delocalized valence electrons in metal. In the excitation of electrons $k_{gr}(i) \rightarrow k_{ex}(i)$, $i = I, II$ the binding energy of electron pair (electron) is not changed appreciably. Also electronic Cooper pairs have their binding energy with Opp system since the nuclear charge is still there, and are delocalized like electrons in metal. Hence there are two separate delocalizations involved and naturally allowed by the many-sheeted space-time. The system is nearest to water if oxygen appears in atomic form.

8.5.3 The general model for photosynthesis

The model for the energy storage and utilization by remote metabolism in living matter is stupendously simple and equally simple is the many-sheeted model for photosynthesis resulting as a by-product.

A more detailed model for photosynthesis

The existing ideas about remote metabolism and p-adic length scale hypothesis provide useful hints concerning what happens in the process.

1. The appearance of electrons as pairs is a hint about the presence of electronic super-conductivity.
2. The basic constraint is that single electronic Cooper pair gives rise to single ATP in the case of photo-system I and 2 ATPs for photo-system II. Accepting the proposed model predicting that dropping $k = 137 \rightarrow 139$ of single proton liberates .25 eV and 3 protons drops in single ATP \rightarrow ADP transition, one has that in photo-system I the increment of zero point energy for electronic Cooper pair should correspond to .75 eV at least and in photo-system II to 1.5 eV at least.
3. If the dropping of electron Cooper pairs is the mechanism liberating the zero point kinetic energy in both cases, this gives $k_{gr}(I) = k_{gr}(II) + 1$. Assuming $k_{ex}(i) = k_{gr}(i) - 2$ and the absence of energy losses the conditions $\Delta E_0(e, I) = 3\Delta E_0(p) = .75$ eV and $\Delta E_0(e, II) = 6\Delta E_0(p) = 1.5$ eV give

$$(k_{ex}, k_{gr})(I) = (147, 149) \quad , \quad (k_{ex}, k_{gr})(II) = (146, 148) \quad .$$

For larger values of $k_{gr}(I)$ the metabolic quanta approach to the limits 1 eV and 2 eV.

4. The objection against this model is that single Cooper pair cannot generate to ATP molecules in single stroke. This encourages to consider the option $(k_{ex}, k_{gr})(II) = (148, 151)$ assuming that electron Cooper pairs decay at $k = 148$ space-time sheet and then drop to $k = 151$ space-time sheet. Because one has $\Delta E_0(e, 148) = \Delta E_0(2e, 147)$ and the electrons drop separately, the energy yield is twice that for a Cooper pair. The decay of the Cooper pair would be induced by the absorption of photon naturally since photon energy would be about two times higher than in the case of photo-system I.
5. The most natural p-adic space-time sheets carrying permanent Cooper pair condensates would be $k_{gr}(I) = 151$ giving $\Delta E_{2e}.86$ eV consistent with the upper bound .84 eV liberated as single ATP molecule is used. Same result is obtain in photosystem II. That ground state space-time sheets correspond to different p-adic primes would guarantee that photo-systems I and II are separate even when they have (apparent) spatial overlap.

The model for the effective axonal super-conductivity [K14] supports the view that the BE-condensate residing at $k = 151$ cell membrane space-time sheet is a fundamental electronic Cooper pair BE condensate since the p-adic prime characterizing the fundamental condensate is that for which thermal kicking of Cooper pairs to space-time sheets with smaller p-adic prime are not possible.

A model for the functioning of photo-systems

The previous considerations lead to the following model for the functioning of the photo-systems.

1. The function of the antenna system is to collect energy and store it to chlorophyll molecules by kicking electronic Cooper pairs from $k = k_{gr}(i)$ space-time sheet to $k = k_{ex}(i) < 1$, $i = I, II$ space-time sheets. Antenna pigments could generate MEs transferring the photonic energy to the reaction center as Bose-Einstein condensed photons.
2. Photo-systems II and I act in series. Photo-system II creates oxygen and generates 2 ATP molecules per electron pair whereas photo-system I is responsible for electron transfer and generates NADPH molecules. In the absence of photo-system II it generates only single ATP molecule per electron pair.
3. For both photo-systems chlorophyll acts as a population inverted many-sheeted laser receiving radiation, which inverts the electronic Cooper pair population. Energy storage reduces to the kicking of electrons to $k = k_{ex}(i)$, $i = I, II$, space-time sheet so that they get energy of 1 eV per electron.

4. The primary energy quanta absorbed from the solar radiation differ from the 2 eV and 1 eV energy currencies defined by Cooper pairs and electrons, and one can wonder how the transformation to standardized quanta occurs. Chlorophyll transition is certainly responsible for the absorption of quantum and the whole spectrum of visible light is involved. The question is how the absorbed energy of the chlorophyll is transformed to 2 eV or 1 eV quanta in the population inversion for electronic Cooper pairs. One could guess that the excited chlorophyll system generates ME bridges with energy 2 eV allowing the Cooper pairs to flow from $k = k_{gr}(i)$ to $k = k_{ex}(i)$ space-time sheet, $i = I, II$. In consistency with the seesaw mechanism, this emission would most naturally result from the dropping of electronic Cooper pairs from $k = k_{ex}(i)$ to $k = k_{gr}(i)$ space-time sheets induced by the absorption of photonic energy by chlorophyll.

What happens in the oxidation of the water molecules?

The oxidation of water is perhaps the most mysterious aspect of photosynthesis. The equation $H_2O \rightarrow 1/2 O_2 + 2p + 2e$ serves only book-keeping purposes and serious consideration of what might happen generates doubts about whether standard chemistry allows to understand what is involved. Since it is O_2 molecules which are produced, at least two water molecules are needed for the equation to make sense.

This observation suggests that collective effects are of importance, and one is almost unavoidably led to ask whether Bose-Einstein condensates of H, protonic and electronic Cooper pairs, H_2 , O, and O_2 at larger space-time sheets might be involved. If the Bose-Einstein condensates of O_2 and electronic Cooper pairs are involved, situation simplifies dramatically. The model for sol-gel phase transition already led to the tentative idea that Bose-Einstein condensates of hydrogen atoms could be present in the cellular water. Only a small fraction of O_2 , H_2 , H, 2p and 2e would reside at larger space-time sheets. O-, O_2 - and protonic Bose-Einstein condensates might perhaps make water some kind of liquid crystal structure for which electronic Cooper pairs are delocalized like electrons in metal and thus experience the Coulombic force. Also H atoms forming local bound states with O atoms could be delocalized just like valence electrons in the metal lattice.

In this framework oxygen production in photosynthesis could be seen as automatic side product due to the leakage of the O_2 molecules from the system. The sucking of electronic Cooper pairs from the Bose-Einstein condensate associated with water perturbs the critical system and O_2 molecules can be evaporated unless they are utilized by the system itself. The evaporation of O_2 molecules would correspond to the dropping of O_2 molecules to some larger space-time sheet giving at the same time a recoil momentum for the electronic Cooper pair so that it can enter to the reaction center to compensate the excited Cooper pair. The energy in question would be about .0039 eV.

8.5.4 Applying the general model of energy storage and utilization to ionic pumps

The general model allows also to understand the value of the cell membrane resting potential.

1. The $k = 139$ Bose-Einstein condensate of hydrogen atoms would be responsible for .125 eV energy quantum crucial for sol-gel phase transitions controlled by micro-wave MEs. Also electronic Cooper pairs at $k = 147 = 3 \times 49$ space-time sheet liberate same energy when dropping to larger space-time sheets.
2. H_2 and/or Cooper pairs of protons correspond to energy of .0625 eV (recall that there is small numerical uncertainty involved). Also electrons dropping from $k = 149$ lipid layer space-time sheet liberate this energy. Since the resting potential is .065 eV, this energy is very near to the energy needed/gained by singly charged particle when it traverses cell membrane. The zero point kinetic energy .125 eV of H atoms in turn correspond to the energy needed to carry doubly charged ion such as Mg^{2+} or Ca^{++} through the cell membrane. This leads to the hypothesis that the TGD counterparts of ionic pumps are based on remote metabolism, that is sending of negative energy MEs inducing the dropping of H, H_2 and possibly 2p from $k = 169$ space-time sheet or dropping of electronic Cooper pair from $k = 149$ and electron from $k = 151$ space-time sheet.

8.5.5 Quantum coherence and photosynthesis

During years the experimentation to test the presence of quantum effects in living matter has begun. And the positive evidence is accumulating. In Discover magazine there is an article titled *Is Quantum Mechanics Controlling Your Thoughts?* [I49] telling among other things about the latest direct evidence of quantum effects provided by experiments related to photosynthesis.

The article summarizes in popular terms the contents of the paper *Evidence for wavelike energy transfer through quantum coherence in photosynthetic systems* by Fleming and collaborators [I65] reporting evidence for quantum coherence in photosynthesis. The absorption of photon induces electron current from the point of capture- chlorosome- to the reaction centers. The semiclassical theory predicts the dissipation of the electronic energy to be about 20 per cent whereas the observed dissipation is only about 5 per cent. This suggests quantum coherence. The following abstract of the original article summarizes the essentials.

Photosynthetic complexes are exquisitely tuned to capture solar light efficiently, and then transmit the excitation energy to reaction centres, where long term energy storage is initiated. The energy transfer mechanism is often described by semiclassical models that invoke 'hopping' of excited-state populations along discrete energy levels. Two-dimensional Fourier transform electronic spectroscopy has mapped these energy levels and their coupling in the FennaMatthewsOlson (FMO) bacteriochlorophyll complex, which is found in green sulphur bacteria and acts as an energy 'wire' connecting a large peripheral light-harvesting antenna, the chlorosome, to the reaction centre. The spectroscopic data clearly document the dependence of the dominant energy transport pathways on the spatial properties of the excited-state wavefunctions of the whole bacteriochlorophyll complex. But the intricate dynamics of quantum coherence, which has no classical analogue, was largely neglected in the analyses even though electronic energy transfer involving oscillatory populations of donors and acceptors was first discussed more than 70 years ago¹¹, and electronic quantum beats arising from quantum coherence in photosynthetic complexes have been predicted and indirectly observed. Here we extend previous two-dimensional electronic spectroscopy investigations of the FMO bacteriochlorophyll complex, and obtain direct evidence for remarkably long-lived electronic quantum coherence playing an important part in energy transfer processes within this system. The quantum coherence manifests itself in characteristic, directly observable quantum beating signals among the excitons within the Chlorobium tepidum FMO complex at 77 K. This wavelike characteristic of the energy transfer within the photosynthetic complex can explain its extreme efficiency, in that it allows the complexes to sample vast areas of phase space to find the most efficient path.

The popular article translates the article to the following piece of text.

To unearth the bacteria's inner workings, the researchers zapped the connective proteins with multiple ultra-fast laser pulses. Over a span of femto seconds, they followed the light energy through the scaffolding to the cellular reaction centers where energy conversion takes place. Then came the revelation: Instead of haphazardly moving from one connective channel to the next, as might be seen in classical physics, energy traveled in several directions at the same time. The researchers theorized that only when the energy had reached the end of the series of connections could an efficient pathway retroactively be found. At that point, the quantum process collapsed, and the electron's energy followed that single, most effective path.

My own interpretation would be following.

1. *Remarkably long lived electronic quantum coherence* is claimed to be present. Authors propose that quantum computation like process -quantum random walk [I10] - could be in question. If I have understood correctly, the proposed process can halt only by a state function reduction localizing the electron at the reaction center. Completely standard Schrödinger evolution in the network would be otherwise in question. The good news is that the average time to find from the entrance to exit in this kind of process is exponentially shorter than in the classical random walk. One can say that exit plus all other points are always reached after some minimum time and it is enough to perform the state function reduction localizing the electron to the exit.
2. Somewhat confusingly, the popularizers claim that the authors argue (I do not have access to the original article) that the quantum random walk selects the shortest path from the chlorosome to the reaction center is in question. Quantum collapse is a non-deterministic process and if it selects the path in this particular case it can select any path with some probability, not always the shortest one. The selection of the shortest path is not necessarily needed since the quantum

random walk with fixed entrance and exit is by its inherent nature exponentially faster than its classical counterpart. The proposed interpretation makes sense only if the state function reduction takes place immediately after the electron's state function at the exit becomes non-vanishing. Does it? I cannot say.

If one accepts this view, the sole problem is to understand how macroscopic quantum coherence is possible in the length scales considered. There are good arguments supporting the view that this is not the case for the ordinary quantum mechanics. In TGD framework the hierarchy of Planck constants [K29] suggests that both macroscopic quantum coherence and very low dissipation rate are due to the large value of \hbar for electrons. For instance, for $\hbar = 5 \times \hbar_0$ the naive estimate is that dissipation rate should reduce by a factor 1/5 and coherence times and lengths should increase by a factor 5. I have proposed much larger values of \hbar in the model of living system.

Chapter 9

Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part II

9.1 Introduction

This chapter was originally a part of the chapter devoted to TGD inspired ideas about metabolism. It however turned out a good idea to divide the chapter to two parts. The basic topics of this chapter are TGD inspired view about brain metabolism and molecular machines in many-sheeted space-time. I have also included the rather nutty sounding idea about understanding super-luminal velocities observed in photon tunnelling in terms of remote metabolism as an example about how weird ideas theoretician can take seriously - at least for some time.

9.1.1 Quantum view about energy economy in brain

The application of these ideas results in a rather detailed model for the energy economy of brain (I will use the word metabolism in the sequel in the meaning energy economy). As a byproduct more detailed models for the generation of projector MEs to the magnetic sensory canvases and for the realization of motor control from the sensory canvas emerge.

Magnetic bodies as key participants of metabolic activities?

As already explained, dark matter hierarchy forces to consider the possibility that magnetic bodies are majors users of metabolic energy, and that magnetic bodies suck metabolic energy from the biological body as they realize intentional actions using time mirror mechanism by sending negative energy dark photons at cyclotron frequencies to the biological body.

This might relate to the paradoxical findings that much more oxygen rushes to coherently firing neuron groups than needed to satisfy the metabolic needs but that neurons actually utilize only a small fraction of this oxygen. Could it be that blood provides the metabolic energy and magnetic bodies are the users the metabolic energy rather than neurons? Could glial cells communicate the EEG signal to the magnetic body. Could the usual $\text{ADP} \rightarrow \text{ATP}$ transformation provide the metabolic energy in this case?

Or is time mirror mechanism involved meaning that magnetic body sends negative energy signals to the biological body. Also in this case it could be that positive metabolic energy is generated by $\text{ADP} \rightarrow \text{ATP}$ transformation provide the metabolic energy.

'Holy trinity' of red blood cells, astrocytes, and neurons

The model for the quantum metabolism of brain is based on the trinity of red blood cells, astrocytes, and neurons.

1. The hypothesis is that red blood cell colony represents the state of the internal milieu ('how it feels') in corresponding magnetic body. Neurons in turn generate the representations corresponding to the sensory input from the external world or body as seen by an outsider ('how it looks'). Both red blood cells and pyramidal neurons are magnetic and the ability to act as compass needles makes them excellent candidates for magneto-receptors. This would make them able to represent information about the orientation of body with respect to the reference frame defined by the direction of the gravitational and magnetic fields of Earth. Even honeybees are known to utilize magneto-receptors for navigation purposes.
2. Blood-brain barrier could be seen as a counterpart for the body-environment boundary. One of the almost-predictions is that during sleep a delegation of the responsibilities from the cortical level to the lower levels occurs and these lower level structures, including red blood cells and probably also ordinary cells, generate sensory and motor representations. The cellular representations should be accompanied by a radio frequency counterpart of EEG corresponding to lower levels of dark matter hierarchy. This kind of radio static has been indeed identified as I learned when building a model for taos hum [K65] .
3. Ca^{++} waves form a hierarchy with frequencies for their generation varying in enormous range. The interpretation as analogs of nerve pulse communications at $k \geq 3$ of dark matter hierarchy is attractive. Astrocytes serving as metabolic resources take a key role in quantum control based on the control of metabolic resources. Magnetic body would communicate its desires to the astrocyte synticia via synchronously firing neuron groups using Ca^{++} waves propagating along synticia. The frequency for the generation of Ca^{++} waves is few/minute, which suggests that they relate to quantum motor control at $k_d = 54$ level of dark hierarchy for two minute period. This and the fact that also short term memory corresponds to in this range encourages the interpretation that natural language and internal speech corresponds to signals communicated from magnetic body to synticia as Ca^{++} waves.
4. Sound waves are known to couple directly to Ca^{++} waves. Astrocyte synticia have endfeet to blood vessels. Blood vessels can mediate endogenous sound waves to synticia, where they give rise to Ca^{++} waves propagating along gap junction connected astrocyte structures (synticia). There are reasons to believe that physiophonic sounds and taos hum relate very closely to this kind of endogenous sounds. Dark matter hierarchy suggests that there is an entire hierarchy of 'internal speeches' effectively giving rise to a Fourier analysis of the control signals from the magnetic body and transformed in turn to mechanical, chemical, and electrical control signals representing concretely the Fourier components.
5. The general vision about realization of intentions are using time mirror mechanism and remote metabolism provides also concrete ideas about how the coherent locomotion is realized. The basic problem is to understand how coherent momentum generation in macroscopic length scales is possible and the proposed solution to this problem is based on the notion of many-sheeted space-time. Interestingly, the same mechanism explains a bundle of anomalies related to the over-unity energy production and strange facts about electrolysis of water discovered already a century ago by the nobelist Irving Langmuir. Therefore, somewhat surprisingly, a direct connection with the new energy technologies and quantum biology emerges.

9.1.2 Molecular machines in many-sheeted space-time

Molecular motors have become the hot topics of biology. The so called Brownian motors are the dominating theoretical paradigm but there are some empirical findings challenging the concept. TGD suggests an alternative approach based on the notion of quantum motor. The basic idea is that all moving parts of the quantum motor move on the non-atomic space-time sheets so that momentum dissipation is minimal. It turns out that this picture might work but that TGD allows both quantum and classical modes for the molecular motors and it is quite possible that both modes are present. The

phase transitions changing Planck constant and inducing shortening or lengthening of the magnetic flux tubes connecting molecules could be the basic mechanism behind various motor activities.

The model allows a new view about the real function of ATP leading to precisely correct quantitative predictions.

1. ATP molecules are certainly in a key role in the energetics of life but one might argue that the notion of high energy phosphate bond is not theoretically sound. In TGD framework the dropping of protons from atomic space-time sheets to super-conducting space-time sheets liberating zero point kinetic energy .49 eV is the fundamental mechanism generating usable energy. This leads to a new view about the role of ATP forcing to give up the notion of the high energy phosphate bond.
2. In quantum mode molecular motor receives its energy as a single photon with energy .49 eV emitted when a proton drops to the super-conducting space-time sheet. In classical mode the dropping of the proton to high n cyclotron state generates a cascade of ELF photons with frequencies equal to multiples of the cyclotron frequency of proton giving rise to a radiation pressure forcing the motion of the motor molecule.
3. The model explains the homeopathic $f_h/f_{ELF} = 2 \times 10^{11}$ scaling law: the ratio in question could correspond to the ratio of the zero point kinetic energy and cyclotron energy of ion. Quantum model for molecular motors predicts correctly the order of magnitude for the velocities of these motors and the general time scale of molecular motors is predicted correctly as the time scale defined by the proton cyclotron frequency $f_c \simeq 300$ Hz. The phase transition $\hbar_0 \rightarrow 2 \times 10^{11} \hbar_0$ could transform photons with cyclotron frequency and extremely small frequency to photons possessing zero point kinetic energy which is above thermal threshold.
4. The model allows to understand cell membrane as a barrier preventing the leakage of proton Cooper pairs from $k = 139$ super-conducting space-time sheets to the magnetic flux tubes of Earth's magnetic field and a new view about nerve pulse and EEG results. Besides proton also electron and heavier ions can in principle serve as providers of energy and the latter could make possible more refined bio-energetics.

What looks really mysterious in the conceptual framework of the standard bio-chemistry, where proteins are nothing but inanimate molecules, is that nano-motors are able to co-operate and behave like an advanced society rather than a collection of dead and autistic robots colliding continually with each other. Dark matter hierarchy makes it easier to understand what is involved. Dark matter hierarchy leads to the notion super-genome and hyper-genome [K26] : these generalizations could make sense also in the case of nucleus and cell. Super-genome integrates the genomes of individual nuclei to sequences analogous to lines of written text: the page of the book corresponds to a magnetic flux sheet traversing through DNA strands of several nuclei. Super-genome would make possible to interpret organs and societies of nano-motors as motor instruments of magnetic bodies.

I have been forced to learn a lot of new things about the metabolism of brain and molecular motors and do not pretend of being more than a novice in the field. Despite this I dare hope that the power of the general vision compensates the lag of professional rigor as far as biological knowledge is considered.

9.1.3 Could super-luminality be understood in terms of remote metabolism?

This section can be regarded as a curiosity. The idea of explaining super-luminality observed in photon tunnelling experiments in terms of remote metabolism is one of those weird ideas which look brilliant when they come and after few years make the proud father of the idea to blush. I have however included it in purpose of showing that all ideas are not here to stay. As a matter fact, sub-manifold gravity allows also simpler explanation for effective super-luminality as being due to the fact that maximal signal velocity in sub-manifold geometry defined operationally depends on the pair of points of space-time surface and is in general smaller than the maximal signal velocity assignable to the light-like geodesics of M^4 .

I have included to the end of the chapter also other miscellaneous topics such as an old proposal for the possible role of four-wave interactions in the construction of conscious holograms.

9.2 A model for brain metabolism

Oxygen and glucose are absolutely essential for consciousness. Thus I find it somewhat astonishing that quantum consciousness theorists (with myself included!) have paid only a minor attention to the exceptional role of oxygen and glucose. The realization that the liberation of a usable energy and the generation of bound states giving rise to macroscopic coherence and binding mental images to larger mental images are two sides of the same coin encourages the hopes that one might understand why metabolism is so crucial for consciousness.

In the most conservative scenario the ordinary metabolism corresponds to a purely local liberation of energy whereas the generation of macroscopic bound states means a nonlocal liberation of usable energy and represents a new kind of metabolism involving time mirror mechanism and generalized four-wave interaction with the ensuing time non-locality and instantaneous generation of usable energy. Also ordinary metabolism might involve generation of macroscopic bound states and a non-local liberation of a usable energy as some paradoxical findings about energetics of neural activity suggest. Nanobiology has during last years demonstrated that existing Newtonian thinking does not be of much help in the understanding of the phenomena involved and might provide fascinating applications for the notion of bound state entanglement.

At the concrete level of models the TGD view about metabolism and consciousness would look like follows.

1. There are at least three important participants involved in the generation of conscious experience: the colony of red blood cells, the gap junction connected structures formed by astrocytes, and neurons: all these structures and their components can form bound state entanglement with each other.
2. Astrocytes serve as energy reserves of the brain and bound state entanglement allows a non-local liberation of the metabolic energy at the neuronal level. Part of this energy must go to the build-up of MEs serving as projectors to the sensory magnetic canvases at various levels of the hierarchy. The mysteriously low rate of the oxidative neuronal metabolism during a heightened neuronal activity might be partially due to the fact that the dissipation is very low, partially due to the fact that bound states are generated and binding energy is also liberated. Many-sheeted ionic flow equilibrium (supported by the findings challenging the notions of ionic channels and pumps [I113]) with non-dissipating supra currents generating evoked and invoked potentials might reduce dramatically the postsynaptic energy costs. Further support for this picture comes from a detailed model for the generation of MEs defining projectors to the sensory canvas explaining also the strange properties of the so called Brown gas obtained by electrolysis from water as well as from the explanation of the anomalies found already century ago by nobelist Irving Langmuir.
3. Astrocytes are coupled by notile 'endfeet' to neurons and are known to be in intense communications with them. There are reasons to believe that neuronal data are transmitted to the gap junction connected structures of astrocytes, synticiums [J18, J49] . Astrocytes have also 'endfeet' to blood cells. Blood cells rush where the neuronal action but as already noticed, oxidative metabolism is very low during heightened neuronal activity. Blood cells are magnetic structures and blood records the direction of the gravitational force. Hence thus blood cell sub-colonies are ideal candidates for generating the projector MEs to the sensory magnetic canvases. The pyramidal cells which also contain magnetic crystals are second candidate for the projectors and now cellular water takes the role of blood. These two sensory representations are good candidates for the representations of 'internal milieu' (what it feels) and external world and body as seen by outsider (what it looks).
4. A general vision about how generalized motor control is performed from sensory canvas emerges as a by-product. The proposed realization is based on the generation of sound waves on blood vessels by MEs from the sensory canvas. These sound waves interact with astrocytes generating Ca^{++} waves and induce 'internal speech' serving as high level symbolic language in turn transformed into nerve pulse patterns by the memetic code. As a matter fact, entire hierarchy of 'internal speeches' is predicted and correspond effectively the Fourier decomposition of MEs to frequency components by various parts of brain and body at various length scales. The scaling

law from homeopathy serves as a guideline leading to the identification of detailed mechanisms for how this Fourier analysis happens.

9.2.1 Metabolism in brain

In order to detail the general vision about the relationship between metabolism and consciousness, it is good to learn the basic facts about the energetics of brain. At the level of biological body there are three interacting systems: blood flow, astrocytes, and neurons. In the sequel I provide the view of an innocent novice about these three systems and their interactions and try to identify anomalies serving as signatures for the presence of nonlocal energy liberation mechanisms. I hope that the power of the general vision to unify might compensate the un-precision at the level of details.

In the classical world the understanding of the energy and information currents between these three systems would be enough. In TGD framework the presence of the dark matter hierarchy of magnetic bodies changes the situation profoundly since magnetic bodies become key participants of the energy metabolism. Time mirror mechanism provides a tool of both remote metabolism, long term memory, and quantum control. The reduction of the charged entanglement induced by W MEs affects local charge densities, which induces ordinary currents. This quantum control mechanism would rely to the exotic ionization of dark bosonic ions, in particular Ca^{++} ions, and the appearance of Ca^{++} waves in a very wide velocity range suggests the universality of this mechanism. W entanglement provides also a mechanism making possible sharing of mental images: this mechanism could be realized during nerve pulse propagation, and could make also possible also quantum parallel superpositions of nerve pulse patterns and hence quantum computation like activities [K91, K62].

Magnetic bodies as key participants brain of metabolism

Dark matter hierarchy leads to a new view about neuronal metabolism where communications to and control by the magnetic bodies are key utilizers of the metabolic energy.

1. Many-sheeted ionic flow equilibrium

The prevailing view about neuronal metabolism is that in the resting situation most of the metabolic energy goes to the maintaining of the concentration gradients by pumping ions between cell interior and exterior. There is however empirical evidence challenging the notion of ionic pumps and channels and there are also theoretical objections against them [I113].

The notion of the many-sheeted ionic flow equilibrium relies on these observations. The basic idea is that cell interior and exterior correspond to disjoint space-time sheets and that the join along bonds connecting them appear and disappear by a quantum mechanism. Join along boundaries bonds allow the ionic currents to flow as non-dissipative quantal currents. This explains why ionic currents can flow during metabolic deprivation, the observed quantum character of these currents, and completely unexpected independence of the ionic currents on the details of the membrane in question [K14, K62].

Channels and pumps are identified as sensory receptors detecting ions and also membrane voltage allowing neuronal and cell membrane to perceive the nearby environment chemically. Only a negligible amount of ionic currents would flow through them. Synaptic contacts would play same role but now the primary sensory input would arrive from the external world. Note that also supra currents could provide metabolic energy as well as momentum when it leaks to the atomic space-time sheet and in the model of ATP this mechanism is assumed to be behind coherent locomotion.

2. The new view about neuronal metabolism

If this picture is correct, the view about the neuronal and also cellular metabolism changes profoundly.

1. The concentration of cytochrome oxidase measures the local metabolic activity and correlates with the number of synapses rather than with the number of neurons. This suggests that postsynaptic activity, whatever it is, is responsible for the use of metabolic energy.
2. In the usual book-keeping the ionic currents associated with the action potentials and postsynaptic activity would be main users of the metabolic energy. Cation fluxes increase by a factor of 100-1000 during action potential but they last for only 1 millisecond. Evoked and invoked

postsynaptic potentials are accompanied by cationic fluxes which are 10 per cent of the range for action potentials but last for 10-1000 longer. If these ionic currents flow almost without dissipation the situation changes profoundly.

3. The cell membrane Josephson junctions generating coherent IR photons and the scaled up dark variants of this Josephson junction (in particular ordinary EEG) generating photons with the same energy scale would become main utilizers of the metabolic energy. This metabolic energy would be needed to the communication of sensory input to the hierarchy of magnetic bodies using dark photons with energies above the thermal threshold and the the motor response of the magnetic body utilizing negative energy photons in same energy range would also require metabolic energy.
4. Metabolism is needed also for the synthesis, transport and recycling of the neurotransmitters. If these activities are control by neuronal magnetic body, they could proceed by a sequence in which neuronal magnetic body sucks energy from the motor instrument and this sucks energy from mitochondria or directly from from glial cells. This "repeated stealing" of energy does not look very attractive ethically but the monstrosities that we see in nature documents are in spirit with this hypothesis.

The three metabolic pools in brain

Brain metabolism [J89, J94, J34] forms 20 per cent of the total metabolism during wake-up state. There are three interacting systems: neurons, glial cells (astrocytes) and red blood cells. There are three metabolic pools corresponding to glutamate- and GABA-ergic neurons and glutamine-ergic astrocytes (X-ergic means that neuron uses neural transmitter X in synaptic transmission). The oxidative metabolism of the glutamate-ergic neurons is estimated to be roughly 70-80 per cent of the brain metabolism. The rate of the oxidative metabolism correlates with the glutamate production rate which could also mean that oxidative metabolism corresponds only to what happens in axons. The metabolism of the GABA-ergic neurons and glutamine-ergic astrocytes contribute both 10 per cent to the total brain metabolism.

Astrocytes signal glutamate-ergic neurons using glutamine as a transmitter: in neurons it is transformed to glutamate used in turn to generate depolarization of astrocytes followed by Ca^{++} waves serving as a signalling mechanism inside astrocytes. Glutamate is in turn utilize glutamine by astrocytes. This gives rise to glutamate-glutamine cycle. The rate for the transformation of glutamine to glutamate as well as the rate of the anaerobic metabolism of the astrocytes in this glutamine-glutamate cycle correlate with the rate of the metabolism of glutamate-ergic neurons.

Glutamine part of the cycle could be identified as a motor control of neuron group performed by magnetic body with the mediation of astrocyte synticia whereas glutamate part could correspond to a sensory input from neuron groups to astrocyte synticia to magnetic body.

Metabolic anomalies

There exists actually no consensus view about neuronal metabolism and there are many poorly understood and even mysterious looking aspects. The paradoxical finding is that much more oxygen rushes to coherently firing neuron groups than needed to satisfy the metabolic [J89]. What doubles the paradox is that the recent MRI studies show that the heightened neural activity uses only a very small amount of the extra oxygen [J35]. This would suggest that oxygen has some other function than providing metabolic energy in the standard manner.

That the cyclotron frequency of O_2^- radical is 9.4 Hz in Earth's magnetic field forces the question whether oxygen radicals could provide partially the metabolic energy used by $k_{em} = 4$ magnetic body as it performs bio-control by sending negative energy $k_{em} = 4$ dark photons in alpha band to the firing neuron group. The mechanism providing the metabolic energy would be the dropping from excited cyclotron states to lower cyclotron states. Free oxygen radicals would not be a mere nuisance in this framework.

Resolving the mystery of the ionic channels and pumps

The dark matter inspired view about metabolism is that ionic pumps and channels serve only as various kinds of ionic and voltage receptors of the magnetic body allowing it to receive information about the

cellular environment. Only a minor fraction of ionic currents would flow through them. The main sink of the metabolic energy would be the photons and weak bosons associated with the generalized hierarchy of EEGs serving communication and control purposes of the hierarchy of magnetic bodies. The energy per ELF photon at $k = 4$ level of the dark matter hierarchy would be indeed above the thermal threshold so that already ordinary EEG would require a considerable expenditure of the metabolic energy.

The metabolic energy needed to build magnetic bodies

It is interesting to find what the the proposed vision allows to conclude about the metabolism related to the construction of magnetic bodies.

1. The flux tube of Earth's magnetic field of length $L(167) = 2.52 \mu\text{m}$ with quantized magnetic flux has rest energy L/S and if the area is $S = L(167)^2$ the rest energy is $E(167) = .4844$ eV, which is the energy released when single ATP molecule transforms back to ADP. The first question is whether the metabolism might take care about the regeneration of the magnetic flux tube structures, including also those associated with the magnetic sensory canvas. This does not seem to be the case: the reason is that magnetic flux tubes are expected to be rather stable structures and their continual generation would mean that the system would get drowned to magnetic flux tubes.

Part of the magnetic flux tube structure might however be generated during the growth period of the system. A rough estimate for the power needed to generate the magnetic canvas during this period is in order. The total rate of metabolism in a normal situation is about 10^4 kJ/day translating to $10^{12}m_p/\text{second}$, where $m_p \simeq 10^9$ eV is proton mass. Magnetic flux tube with a length of one Earth's circumference could thus be produced in 10 nanoseconds.

This estimate corresponds to the $k = 0$ level of dark matter hierarchy. For higher levels of dark matter hierarchy flux tubes are expected to define r -fold coverings of ordinary flux tube and have r -fold energy, $2 = 2^{k_a}$ for Mersenne hypothesis. Time scales are scaled up by r which would suggest that the buildup of magnetic bodies is a process occurring in the same time scale as the evolution of biological body and requires considerable metabolic resources.

2. MEs represent classical radiation escaping from the system and have a finite duration at a given space-time point. Therefore MEs can and must be generated continually. Buy now-pay later mechanism at DNA and possibly other levels could and probably does generate MEs at least in alarm situation without metabolic costs. This corresponds to generation of bound states and the assumption that the energy costs must be paid later would mean that thermal noise sooner or later destroys the bound states. The classical estimate for the power involved with EEG gives an order of magnitude estimate about the metabolic energy involved.

Does brain delegate?

During wake-up state motor control from the magnetic body affects directly neuronal level. During sleep neurons the connection between astrocytes and neurons is off. This would suggest that during sleep red blood cells and astrocytes are involved in conscious processing of information using sensory representations about internal milieu generated mostly by red blood cells and feedback to the astrocytes. Also visual representations besides auditory ones are possible since red blood cells are also able to 'see' bio-photons.

During wake-up period cortex takes care of a large amount of conscious information processing and the experience from what happens in human organizations suggests that during sleep this processing is delegated to the lower levels of the self hierarchy, in particular blood cell colony, while cortex is reserved for the purposes of the higher levels selves communicating and controlling at theta and delta EEG frequencies. Blood cells colonies of the entire body could be wake-up when we sleep. Of course, also other than blood cells could be in wake-up during sleep.

The bodily consciousness possibly activated during sleep would process the information from environment and wake-up cortex if needed. Red blood cells are indeed able to 'see' at visible wave lengths and could provide for the body eyes allowing to perceive the radiation emitted by other living organisms (say predators). Also sounds could be transformed to em waves and amplified by the liquid

crystals [D3] of the body acting as piezoelectrics. Blind sight and the strange feats of sleepwalkers might be due to the body vision and the role of red blood cells sensitive to visible light might be decisive.

One expects that red blood cells correspond to rather low level of dark matter hierarchy and thus rather high Josephson frequencies. One possibility are microwave frequencies assignable to the dynamics of protein conformations. Microwaves would serve as a correlate for the wake-up state of the red cell colony and cells in general.

While constructing a model for taos hum [K65] , [I125] I learned that after sunset there appears a radio static which has a biological origin and correlates strongly with taos hum [I125] . I identified this static as the analog of EEG for the sensory canvases associated with cells and proposed that the emergence of this radio static means wake-up at cellular level. The painful experience of taos hum presumably related to microwave hearing and inducing fatigue could be understood as a failure of the electromagnetic immune system to prevent the sucking of metabolic energy by other organisms using phase conjugate $k_{em} = 1$ radio waves. The radio noise generated by computers and other sources of radio waves need not cause troubles since these radio waves are expected to correspond to $k_{em} = 0$ and positive energy photons. To test this hypothesis, one could look whether a radio static analogous to EEG sets on after sunset and disappears after sunrise as the observations about taos hum suggest.

9.2.2 Astrocytes and quantum control of brain

Astrocytes

Astrocytes form 50 per cent of the total number of brain cells whereas neurons make only 10 per cent. The view about the function of astrocytes has changed dramatically during the last half decade thanks to the progress in the experimental side. The earlier view was that astrocytes have only two roles: they are kind of a motile skeleton of brain keeping neurons on place and serve as energy stores of brain. The new view is that astrocytes support, monitor, integrate and regulate neuronal activity [J49] .

The existing understanding about astrocytes combined with TGD views encourages to think that astrocytes, neurons and red blood cells form kind of a 'holy trinity' in which astrocytes allow the magnetic bodies to perform motor control in very general sense. In computer metaphor according to which me is computer sitting at its own terminal astrocytes correspond to the computer keyboard used by magnetic body corresponding to $k_{em} = 5$ level from the frequency of Ca^{++} waves. Red blood cells *resp.* neurons in turn project somatosensory sensory input *resp.* sensory input from external world to the magnetic body with blood brain barrier representing the boundary between body and external world. Blood cells would represent somatosensory information about body including the orientation of the body whereas external world and third person view about body would be represented by neurons.

1. Basic facts about astrocytes

Astrocyte have typically a stellar shape with size of at least 10 micro-meters. Astrocytes form gap junction connected structures, synticiums, consisting of several millions of astrocytes and having sizes of order millimeter which is also the size of the coherently firing neuron groups in cortex. Astrocytes have processes or 'endfeet' which envelope either groups or neuronal synapses or blood vessels. The neuronal endfeet make possible bi-directional communication between neurons and astrocytes and extended control of neuronal activity and modulation of neuronal synchronization. Also in case of capillaries control activity is possible and there is no good reason of not believing that also now bi-directional communications are possible.

The endfeet of astrocytes are motile and tend to move to the direction of the most active neurons. Astrocytes can also swell and the resulting change of the intercellular volume probably plays a control role since it changes both ion and transmitter concentrations.

Astrocytes and neurons communicate by neural transmitters. Astrocytes have large number of various receptors [J49] and there are good reasons to believe that astrocytes have complex chemical communications with neurons. For instance, glutamate-glutamine cycle involves reception of glutamate from neuronal synapses and chemical signalling by glutamine received by neurons. Glutamate induces depolarization in the synticium of astrocytes propagating through it and accompanied by Ca^{++} wave . Ca^{++} is known to excite synaptic transmission, the dependence of transmission efficiency being proportional to the fourth power of Ca^{++} concentration. The sucking of Ca^{++} by Ca^{++} waves from synaptic regions near endfoot has thus inhibitory effect on them. The resulting Ca^{++}

sooner or later returns Ca^{++} with opposite effect on synaptic efficiency. Now however the effect occurs simultaneously to a large number of neurons and this is believed to support and modulate neuronal synchronization.

The typical frequency for inhibitory-excitatory action is few times per minute, which suggests that Ca^{++} waves relate to the quantum control by $k_{em} = 5$ level of dark matter hierarchy for with Josephson period is about 3.6 minutes (.2 seconds for $k_{em} = 4$). Also short term memory relates to this level in the proposed vision [K26]. The scaling law $v = Lf$, with v taken to be the velocity of Calcium waves, L the size of synticism, and f the frequency of wave, deserves a testing. The law would give very small velocity of order mm/minute for $L = 1$ mm.

It has been proposed that a control circuit neurons-astrocytes-blood exists and that neurons could communicate for blood circuit the desire about increased blood flow. NO diffusion activated by a signal from neurons and in turn affecting blood circuitry via endfeet is one possibility. In TGD framework the control hierarchies magnetic body-astrocytes-neurons-blood flow and magnetic body-astrocytes-blood flow and sensory hierarchies resulting as their reversals seem natural.

2. *The role of the astrocytes as metabolic reserves*

Astrocytes act as the energy reserves of brain [J49] and should therefore act as metabolic censors limiting the intensity of conscious experiences expected to correlate directly with the amount of the binding energy liberated in the experience. The astrocyte-to-neuron ratio increases in the brains of the higher animals. The narrowest interpretation is that this reflects the increasing metabolic needs as higher levels of dark matter hierarchy emerge for each of which energies of dark EEG photons are above thermal threshold.

Astrocytes both synthesize, store and catabolize glycogen molecules. An obvious question is how this fuel is transferred from astrocytes to neurons. According to [J49] "It is very likely that there is astrocytic export of fuel substrates such as lactate to neurons". The oxygen consumption in the activated neurons is very low [J35]. Is there *any* transport mechanism? Brain has probably not taken the risk of not getting fuel in case that the quantal transport mechanism based on the generation of negative energy bio-photons by neuron groups and received by astrocyte synticiums fail.

3. *Astrocytes as an instrument of motor control*

The known role of astrocytes as metabolic controllers and the gardener metaphor vision about control as a selection of existing activities is consistent with the identification of the astrocytes as mediators of generalized motor control performed by magnetic $k_{em} = 5$ magnetic bodies.

This motor control would be high level control involving presumably symbolic representations: instead of detailed commands only names of complex motor activities are given. A reference wave generating a complex hologram is basic example of this kind of quantum control. This would suggest that the frequency of the carrier wave generation is rather low. Ca^{++} waves indeed appear with low frequencies of order few/minute. This frequency would be analogous to the kHz frequency associated of neural synchrony.

According to the TGD based models of EEG [K26] and nerve pulse [K62], gap junction connected structures can carry standing EEG waves and their scaled up variants. Also W MEs inducing charge entanglement are possible and would induce deviations from charge equilibrium and currents tending to compensate them. Ca^{++} would represent basic example of this and could be also seen as higher level variants of nerve pulses. In case of astrocytes $k_{em} = 5$ level suggests itself. Perhaps $k_{em} = 5$ magnetic body controls via synchronically firing neuron groups the metabolic activities of astrocyte groups. The scaled up variant of memetic code with the durations of memetic codon about $T = \lambda \times .1 \simeq 200$ s and single bit of codon about $T/127 \simeq 1.6$ seconds suggests itself.

If astrocytes are involved with the generalized motor control in the proposed manner, the astrocyte-neuron coupling should be on only during wake-up and turn off during sleep and relaxed states. This is indeed what has been observed according to [I41]. During sleep astrocytes would control mostly blood flow and receive sensory information also from blood flow through endfeet. This picture suggests that neuronal level delegates the responsibilities to the lower levels of the self hierarchy during sleep. This means that lower level magnetic bodies take care of bodily functions. The prediction is that astrocyte-neuron connection should be active during verbal dreams.

4. *The role of astrocytes in information processing*

During the last years it has become clear that astrocytes express most neurotransmitters and

receptors expressed by neurons so that complex communications between astrocytes and neurons are expected to occur. The already mentioned glutamine-glutamate cycle involving the generation of Ca^{++} waves represents one example of astrocyte-neuron communications.

For instance, according to [J18] astrocytes have an active role in the information processing in the association areas, which have been identified as $k_{em} = 5$ levels of dark matter hierarchy in [K26], and the neuronal sensory information is represented at the level of astrocytes by patterns that activate Ca^{++} waves and that astrocytes in turn infotropically encode the information with resulting synchronously firing synaptic domains. The role of astrocytes associated with associative regions in the generalized motor control in TGD based model is as an interface transforming high level symbolic control signals (internal speech) from $k_{em} = 5$ level to lower level signals modulating nerve pulse activity via metabolic control.

Astrocytes also receive and gather information about blood flow through the endfeet in blood vessels and very probably also control the blood flow metabolically. One can ask whether sound waves in blood vessels or capillaries could allow the magnetic bodies associated with blood flow to communicate with astrocytes. Sound waves would be generated by MEs projecting to brain from sensory canvas coding the generalized motor commands as internal speech.

The holy trinity of blood, astrocytes, and neurons

The foregoing observations conflicting with the standard beliefs about how reductionistic and materialistic brain should function can be understood in the framework of TGD inspired theory of consciousness. I have already introduced the basic ideas of the model piece by piece but it is worth to develop it more systematically.

The computer sitting at its own terminal metaphor, the gardener metaphor, puppet on string mechanism, hologrammic control by reference waves, identification of features as synchronously firing neuron groups are the notions which lead to view that neurons, astrocytes, and blood form a 'holy trinity' with sensory canvas representing the subjective me identifying itself with the physical body; astrocytes representing the computer terminal mediating motor control from the level of sensory canvas to brain level; neurons representing the processors of computer; and blood and pyramidal cells (at least) generating the projector MEs to our sensory canvas. Of course, blood allows an entire hierarchy of sensory canvases.

Calcium waves as a tool of generalized motor control

The basic facts about Calcium waves are summarized in [J66]. Ca^{++} waves appear at all control levels in living matter and there are both mechanical, chemical, and electric mechanisms for the propagation. This suggests that the motor control mechanism based on MEs generating various kinds of waves at resonant frequencies is utilized by living matter in a very wide range of time and length scales. For a given mechanism of conduction the value of the velocity varies in rather narrow limits. The spectrum of the possible conduction velocities however spans nine orders of magnitude from few nm/s to about one m/s. The velocities of the ultraslow waves vary in the range 1-30 nm/s and they accompany developmental processes. Slow waves move with velocities 1-3 μ m/s. Fast waves move with velocities 10-30 μ m/s and move by reaction diffusion mechanism. Ultrafast waves move with velocities of about 15-40 cm/s and propagate electrically. In accordance with fractality, the ratio of the upper and lower limits for the velocities equals to 3 in all these cases.

If the entire astrocyte synticum is excited, the frequency f is smallest and should be of order few/minute: this together with the size estimate $L \sim 1$ mm for the size of the astrocyte gives estimate for the velocity v as $v \sim 16 \mu\text{m/s}$. This velocity belongs to the range of the fast Ca^{++} waves propagated by reaction diffusion mechanism. If only single astrocyte with size about 20 micro-ns responds, the frequency is of order $f \sim .8$ Hz. This would mean that the frequency interval to which astrocytes respond via Ca^{++} waves would be below the EEG range. Of course, it is highly plausible that there is entire hierarchy of responses in various frequency ranges and this would mean that the signal sent by ME would be effectively Fourier analyzed to various responses in various frequency ranges.

For ultrafast waves the frequency spectrum would vary roughly between .5 kHz and 50 kHz. The resonant kHz frequency involved with the synchronous firing of nerve pulse patters belongs to this frequency range. Slow and ultraslow waves would correspond to frequency scales of order few/10

minutes and 1/month and interpretation in terms of biorhythms is suggestive. Interestingly, EEG range remains outside the frequency bands associated with Ca^{++} waves. This could mean a sharing of the frequency bands such that the frequency bands used for the generalized motor control do not have overlap with the frequency bands involved with the em MEs and responsible for projecting information to the sensory canvases.

Are astrocytes above neurons in the hierarchy?

The question is whether magnetic body uses astrocytes to control neurons or whether it uses neurons to control astrocytes. Or more precisely: does magnetic body use synchronously firing neuron groups to induce Ca^{++} waves in astrocyte synticia or use Ca^{++} waves to modulate neuronal firing? Astrocytes have "endfeet" on neurons and red blood cells and there are good reasons to believe that that the end feet act as switches to control and integrate information. Astrocytes are present already in invertebrates so that there is not obvious answer to the question.

That astrocytes are above neurons in the hierarchy is suggested by following observations.

1. Since astrocytes are metabolic resources it would be very natural for magnetic body to suck energy directly from astrocytes. Also the fact that the frequency for the generation of Ca^{++} is few/minute, $k_{em} = 5$ is a natural identification for the dark matter level involved so that astrocytes seem to correspond to a higher level in dark matter hierarchy whereas nerve pulse activity would correspond to $k_{em} = 3$.
2. Astrocytes are known to "behave" (morphological change, motility, myelination, mitosis), which suggest a role that they are at higher level of hierarchy than neurons. The fraction of astrocytes in vertebrate brain increases at higher levels of the evolutionary hierarchy.
3. Microtubules were regarded as passive support structures for a long time. Astrocytes play a role analogous to micro-tubuli, which give rise to cytoskeleton playing a role of CNS of cell, take care of logistic functions, and also declarative memory in TGD framework [K62]. This encourages the view that astrocytes act as motor instruments of the magnetic body to control the behavior of neurons and are involved with short term memories as the frequency of Ca^{++} wave generations suggests.
4. According to [I41], in deep relaxation states the switches from neurons to astrocytes are off whereas those from red blood cells are on. This would suggest that both neurons and red blood cells are at a lower level in the hierarchy. This would TGD based view suggests that astrocytes feet are essential link in the control of brain by magnetic body at $k_{em} = 5$ level of hierarchy. It is possible to assign to astrocytes also circadian rhythms that also $k_{em} = 6$ level is involved.
5. Since astrocytes are the metabolic stores of brain they naturally have a filtering role proposed also in [I41]. During altered states of consciousness this censorship temporally loosens and very intense euphoric moods can result. These 'highs' however deplete sooner or later the metabolic reserves of astrocytes and are followed by 'lows' as happens periodically in the manic-depressive disease. Quite generally, mental disorders could be accompanied by metabolic disorders at the level of astrocytes and due to the abnormalities in the blood flow.

Do higher levels of dark matter hierarchy use brain during sleep?

The absence of higher than delta bands in EEG spectrum during deep sleep is consistent with the assumption that dark photons in other than delta bands are absent. The frequencies around 1 Hz correspond to DNA cyclotron frequencies which suggests that quantum control of DNA activities occurs during deep sleep.

The metabolic energy spent by the brain to sensory and motor activities in the day-time would be used by magnetic bodies at $k_d > 46$ levels of dark matter hierarchy during sleep ($k_d = 46$ corresponds to 10 Hz region). For instance, $k_d = 54$ corresponds to the time scale of few minutes assignable to short term memory and to astrocyte-neuron interaction which is absent during deep sleep.

Structures responsible for circadian rhythms should involve $k_d = 65$ level. The master circadian pacemaker in mammals is considered to be the suprachiasmatic nucleus (SCN) of the hypothalamus

containing heterogenous population of neurons and glial cells: both express genes with circadian period [J74].

This would suggest that brains would be literally in a shared use. Higher level selves would use the brains of the average citizen mostly during night time whereas the brains of the people endowed with creative and meditative practices would be available to the higher level conscious entities also during daytime.

9.2.3 The effects of endogenous sound waves as a support for the scenario

The effects of endogenous sound waves on consciousness provide some support for the suggested role of astrocytes as buffer between neurons and $k_{em} = 5$ magnetic body.

How the signals from magnetic body are transformed to control signals?

If the entire head of body receives the internal speech from $k_{em} = 5$ magnetic body, several amplification mechanisms are possible.

If this picture is correct, astrocyte synticia act as an interface between higher level symbolic and linguistic representation and neuronal representations. This would explain why the astrocyte/neuron ratio increases in higher organisms.

An interesting question relates to what differentiates between the natural sounds and spoken language. One might wonder whether hearing involves also the generation of internal speech involving the propagation of the speech sounds in blood vessels or some other cavities. Since body is liquid crystal it is also possible that muscles and collagen structures act as amplifiers of the weak sounds generated by MEs near vacuum extremals and carrying both em and Z^0 fields proportional to each other.

The size L of the excited part of the astrocyte synticium, which can be assumed to vary, and the propagation velocity v for the Ca^{++} waves, presumably controlled by the metabolic conditions, determine the ELF frequency which can interact resonantly with the astrocyte and generate high frequency oscillations in it (MEs with frequencies at multiples of $f_h = c/L > 3 \times 10^{11}$ Hz and directly controlling the molecular level). Each astrocyte synticium could respond to a characteristic ELF or ULF frequency determined by its internal state and metabolism. It is conceivable that astrocytes can control also the Ca^{++} wave conductances of the gap junctions and thus the size and shape of the Ca^{++} conducting regions and the the ELF or ULF frequency that they respond to. The increase of the metabolic rate presumably increases the velocity of propagation for Ca^{++} waves.

Are sounds transformed to endogenous sounds to Ca^{++} waves?

The following considerations force to consider seriously the possibility that endogenous sounds transmitted from blood vessels to astrocytes are involved with hearing and create the sensation of hearing.

Various structures of biological tissue form collagen networks which are liquid crystals [I93] and thus piezoelectrics [D3] and allow the transformation of classical em and Z^0 waves to sound waves and vice versa. The weak sound waves might be amplified also by the walls of the blood vessels and capillaries and also by other muscles. This amplification mechanism is expected to work in entire length scale range ranging from body size to atomic length scales. For instance, if the carrier wave has kHz frequency, the wave giving rise to the neuronal synchrony, it has wave length of order head size, and the blood vessels and collagen networks inside head could serve as acoustic wave cavities.

There is empirical support for the endogenous amplification of sounds. Physiophonic sounds result in an electrical stimulation of the skin and speech represented in this manner is subjectively understood as speech: this could be due to the propagation of the sound signals through body. Note that meaningful signals coming from environment (created by say predator) can be transferred from skin directly to the astrocytes and stimulate wake-up. In light of this it would seem that deaf persons could learn to hear by feeding the sound signals directly to the body.

The sound waves could be mediated by blood to the endfeet of the astrocytes to blood vessels. Sound waves are indeed known to induce Ca^{++} waves [J18], which suggests that the mechanism explaining physiophonic hearing involves the transformation of endogenous sounds to Ca^{++} waves. Instead of magnetic body communicating internal speech as metabolic control signals to the astrocyte synticiums, the sound mediated from external world as physiophonic sound does the same. Also

ordinary hearing could involve the transfer of sound waves of sounds as endogenous sounds to the synticiums such that spoken language would be transformed to Ca^{++} waves defining a representation experienced by the $k_{em} = 5$ magnetic body as speech.

That acoustic signalling could be present conforms with the fact the acoustic vibrations are indeed transformed to Ca^{++} waves. For instance, a very light blow in head generates acoustic waves which induce Ca^{++} wave patterns and can induce a loss of consciousness. The 1/minute frequency scale for Ca^{++} waves indeed suggests that the high level control using high level symbolic representation is in question.

Taos hum and endogenous sound waves

The victims of taos hum [I125] hear an intolerable humming sound with no identifiable external source containing also components reflecting the structure of acoustic environment could also involve the generation of physiophonic sounds. The most plausible identification of taos hum in terms of microwave hearing (amplitude modulation represents the sound) explains the failure of the attempts to identify the source for taos hum. The modulation of microwaves at audible frequencies would induce endogenous sounds which induce the sensation of hearing by generation Ca^{++} waves in astrocytes.

Taos hum starts immediately after sunrise and stops after sunset and seems to have biological origin. A possible explanation is that the magnetic bodies of (say) plant cells send $k_{em} = 1$ dark negative energy photons at microwave frequencies to satisfy their metabolic needs. An explanation for why the hum is intolerable and for extreme fatigue caused by it might be simple: the microwaves suck energy from its victim whose electro-immune system fails to insulate the body against this radiation.

Minor head trauma, epilepsy and endogenous sound waves

Minor head trauma and epilepsy provide a testing ground for the identification of endogenous sound waves as inducers of Ca^{++} waves in astrocytes. Minor head trauma does not cause any injury but is accompanied by a loss of consciousness. A possible explanation is that the endogenous sound waves contain the resonance frequency of head with high amplitude and induce a phase transition replacing $k_{em} = 5$ level with $k_{em} = 4$ level or even lower level so that consciousness at $k_{em} = 5$ level is lost.

One could try to understand also epileptic seizures in this framework. Hyperventilation increasing the oxygen content of blood is known to induce a petit mal in children. Petit mal is accompanied by the characteristic 3 Hz EEG rhythm in delta band. If motor control is mediated via the blood vessels as sound waves, the anomalously high concentration of oxygen in blood could somehow cause the petit mal.

1. In [J18] it is proposed that the mechanism involves the generation of Ca^{++} waves with 3 Hz frequency instead of few/minute frequency. Too much oxygen might induce a phase transition $k_{em} = 5 \rightarrow 4$ in which the frequency of Ca^{++} waves increases by a factor λ to about 3 Hz. This would also imply the increase of the velocity of propagation for Ca^{++} waves if scaling law $v = Lf$ is taken seriously. The resulting spatial and temporal incoherence would mean loss of consciousness at $k_{em} = 5$ level of the hierarchy.
2. This model for epilepsy is consistent with my own simultaneously frightening and fascinating night-time experiences in which the subjectively experienced volume of the sound of the refrigerator begins to get gradually amplified and I have a strong conviction that I am very near the border of an epileptic seizure and must wake-up fully as soon as possible. If theta and delta waves represent the frequency bands through which higher levels selves control our brain and receive sensory information, the amplification of the delta and theta waves above critical threshold could imply that these conscious entities take the cortex to their "possession" as also during sleep. Perhaps it is not an accident that prophets were often epileptics: trance could be an example of a situation in which higher level self operating at very low EEG frequencies uses brain to send motor commands and even communicate.

'Great experiences' and 'blood consciousness'

I apologize for not saving the reader from the obligatory reference to my own strange visual experiences about complex hydrodynamics flow having usually a sink ('third eye') in the middle of the visual when

I close my eyes in a highly relaxed state. Perhaps this flow could relate to blood flow or magnetic flux tubes structures associated with the blood flow represented at 'my' magnetic sensory canvas and represent also visually the state of the internal milieu. Also representation in other modalities are possible. A possible interpretation is that this flow somehow represents the state of the central nervous system with the sink ('third eye') having identification as spine. An alternative possibility is that it represents directly the structure of the sensory magnetic canvas. The vortical structure of this flow could reflect the helical structure of the magnetic flux tubes associated with the sensory canvas and the canvas would be dynamical if this is the case.

The state of whole body consciousness accompanying sometimes this experience is characterized by the disappearance of the unpleasant noise usually present in the body and the generation of the thrill-in-spine sensation generated by good music and spreading over the entire body. Perhaps in this state both neuron and blood and possibly entire body are in a wake-up state simultaneously and use common sensory canvases at various levels. Maybe the entanglement with the higher levels of the self hierarchy makes possible the feed of the metabolic energy also from the external world in the form of electromagnetic energy carried by positive energy MEs during this kind of state.

I have also personal experiences about strange doubling of sound of breathing outwards just after wake-up or having run. What might happen is that the externally heard sound of breathing is heard as a copy slightly later. Perhaps the copy is nothing but the sound of breathing heard physiophonically. Another amusing (but not pleasant!) effect is to hear one's own snoring when body still sleeps. The subjectively experienced intensity of the sound is much stronger than usually and experienced as an outsider: body is indeed effectively outsider when decoupled from the motor system. Also this sound could be interpreted as a physiophonic sound.

The well-known correlation of the skin conductivity with the mental state is consistent with the idea of body consciousness. Skin is an important factor in paranormal abilities such as telepathy (I have a personal experience in which I experienced what I believe to be a remote event as happening at my skin as a miniature version!), healing by touch, and psychokinetic abilities in which PK-able person holds some object in her hands and gradually releases it so that it remains 'hanging' in the air.

9.3 Molecular machines in many-sheeted space-time

Biophysics in nano scale looks like a miniature society populated by molecular citizens in their many duties. The basic problem is to understand how these molecular creatures are able to fight against thermal fluctuations so that their motion does not degenerate into mere Brownian randomness and how they can so effectively transform metabolic energy to a usable energy. The existing models rely on the so called ratchet principle: Brownian motors [I50, I119, I63] rectify Brownian motion and pick up from it only the thermal momentum which is in the desired direction.

The idea of Brownian motor is ingenious but many-sheeted space-time concept suggests even cooler idea: why not move on the non-atomic space-time sheets where there is no thermal motion so that the dissipation is practically nil and the only energy needed is basically the difference of the zero point kinetic energies needed to kick the molecular ant or its leg back to the atomic space-time sheet. Or expressing it in engineering terms: all moving parts of the quantum motors move at the non-atomic space-time sheets where the dissipation is minimal.

TGD provides also a new view about the energetics of molecular motors. The energetics of the living matter can be understood as being based on the ions flowing in an ohmic circuitry on the atomic space-time sheets (DC currents of Becker [J23]) and in a supra-current circuitry formed by the magnetic flux tubes. Energy is liberated in the dropping of protons and possibly other ions from atomic to super-conducting space-time sheets: the difference of the zero point kinetic energies is liberated as a usable energy. For chemical purposes this energy is emitted as a single photon whereas for mechanical purposes it could be liberated both as a single photon or as a cascade of ELF photons generated when high n cyclotron state of proton decays.

Amazingly, the velocities predicted by single photon mechanism for the motor enzymes turn out to be of correct order of magnitude! The zero point energy allows also ordinary dissipative motion if the proton drops to high n cyclotron state and decays by generating ELF MEs in turn building up a radiation pressure forcing the motion of the motor molecule. Thus one has two options, classical and quantum, for the molecular motors in TGD framework and both might be utilized depending on situation. The difference with respect to thermal ratchets in both cases is that the energy is liberated

as a directed energy rather than mere heat energy rectified to a directed energy by ratchet.

The theory resolves several paradoxes, makes quantitatively correct predictions, and yields several pleasant surprises.

1. As far as molecular motors are considered both quantum and classical options seem to work. Quantum option is extremely predictive and easily killed by checking whether the velocities of motion for motor molecules scaling like $1/m$, m mass of the motor molecule, are what the theory predicts their precise values to be.
2. A new view about the real function of ATP molecule emerges: the questionable notion of the high energy phosphate bond is definitely wrong in TGD framework and the $F_0 - F_1$ machine generating ATP actually kicks up protons from super-conducting space-time sheets to atomic space-time sheets thus energizing them. Also other ions can serve as energy carriers and the DC currents of Becker [J23] would act as power lines.
3. The energy liberated in the dropping of a single proton from the atomic space-time sheet equals to energy about .5 eV liberated when single ATP molecule is consumed. On basis of the data about reaction kinematics [I109] it however seems that also second proton drops down so that the liberated energy would be ~ 1 eV and too large by a factor of two. A possible explanation for the discrepancy is that the energy is liberated with equal probability as a single quantum and as a cascade of ELF photons and that the cascade of ELF photons are not taken into account in the usual book-keeping.

One can understand the duration of the ATP production step and the time scale for a single step of motion for molecular machines as being determined by proton's cyclotron frequency f_c about 300 Hz. The ratio $\Delta E/E_c$ of the zero point kinetic energy ΔE of proton at atomic space-time sheet to the proton cyclotron energy E_c equals precisely with the ratio $f_h/f_{ELF} = 2 \times 10^{11}$ of high and low frequencies appearing in the homeopathic scaling law stating that high and low frequencies implicating each other's presence [K36]. This supports the idea that both quantum and classical modes for the molecular motors are possible.

4. Ionic pumps and channels allow ions to run from atomic space-time sheets to magnetic flux tubes and vice versa: this resolves the paradox created by the empirical facts both supporting and challenging the existence of the ionic channels and pumps.
5. The TGD based vision about quantum neuron deepens considerably. The resting potential of the cell membrane (-63 meV) has an interpretation as a barrier preventing the flow of proton Cooper pairs from the $k = 139$ super-conducting space-time sheets in the cell interior to the magnetic flux tubes in the cell exterior. Nerve pulse is generated when the membrane potential drops below the critical value so that proton Cooper pairs start to flow from $k = 139$ super-conducting space-time sheet to the magnetic flux tubes of Earth's magnetic field. This induces the flow of various ionic currents, perhaps along same join along boundary contacts along which proton Cooper pairs flow in case of K^+ and Cl^- ions. EEG waves accompanying the propagation of the nerve pulse result when the high n cyclotron states of these ions decay. Also a novel view about the function of Ca_{++} waves emerges.

Already on basis of these examples, it seems to me that the understanding of what it is to be a proton in the many-sheeted space-time points out the Golden Road to the physics of the living matter. My hope is that these miracle like quantitative successes could help to break the reductionistic resistance against the new view about space-time and make possible collective effort to develop TGD based quantum theory of bio-systems.

9.3.1 TGD inspired questions and ideas relating to coherent locomotion

Does it make sense to store momentum?

An important aspect of doing work, not usually considered, is to generate or transfer momentum besides energy. An interesting question is whether also momentum could be stored just as energy is stored.

Chemi-osmotic phosphorylation involves the acceleration of the hydrogen ions in an electric field associated with an appropriate membrane structure. Part of the protonic momentum could be stored in a phosphate group related structure or directly to ohmic protonic currents perhaps identifiable as the DC currents of Becker [J23]. In photophosphorylation the storage of both photonic energy and momentum might be possible and the maximal momentum stored would be $p = E/c$ and by a factor $\sqrt{E/m_p} \sim 10^{-5}$ smaller than the maximal momentum $\sqrt{2m_p E}$ transfer in the chemi-osmotic phosphorylation.

If molecular storage mechanism of the momentum is same in both cases, the dominant fraction of the momentum must be absorbed by some larger structure, say by the catalyst site or the appropriate membrane, in the chemi-osmotic phosphorylation. The rotation of the rotating shaft of the $F_0 - F_1$ machine [I108] generating ATP could dissipate large fraction of the protonic momentum. Thus photosynthesis would be dominantly an energy transfer process whereas the hydrogen ion flow occurring in the chemi-osmotic phosphorylation is also a candidate for a momentum transfer or -generation process involved with locomotion and various transport processes.

An order of magnitude estimate for the maximal momentum transfer rate (acceleration) is obtained by assuming that the whole mass 50 g of the ATP of human body is recycled in 20 seconds and that phosphorylation of each molecule is accompanied by a generation of parallel momentum equal to $p = 3\sqrt{2E/m_p}$ when it receives the momentum of about 3 protons. In this manner one finds that the acceleration of the body with mass of 50 kg would be roughly $5 \times 10^{-2}g$, where $g = 10 \text{ m/s}^2$ is the acceleration of gravitation at the surface of Earth under average conditions. This value is certainly too low but this is for average conditions only: the acceleration can certainly be much higher. One must consider also the possibility that locomotion involves also protonic currents in which ATP is not produced.

Possible mechanisms of momentum, angular momentum, and energy transfer

One could try to understand the function of ATP by assuming that the usage of ATP involves generation of a photon with the energy .5 eV giving momentum to a motor molecule such as myosin or actin. The amount of momentum transferred to a motor molecule is $p = .5 \text{ eV}/c$. The corresponding velocity $v = p/M \sim 10^{-14}c$ is of order one $\mu\text{m}/\text{sec}$ and of the same order of magnitude as the velocities of the motor molecules like myosin and kinesin having masses $M \sim 10^5 m_p$. Therefore it seems that photon with energy $E = .5 \text{ eV}$ could indeed mediate the momentum to the motor molecules in the presence of ATP complex. The importance of this observation is that molecular motors could be genuine quantum motors moving without momentum dissipation and obviously at non-atomic space-time sheets where dissipation is indeed practically absent.

This observation leaves a lot of freedom to imagine various mechanisms.

1. Energy is stored as the zero point kinetic energy of ions and atoms at the atomic space-time sheets: this energy would be liberated when an ion or atom drops on a super-conducting space-time sheet. The photon carrying the energy .5 eV would also carry corresponding momentum. If the user sends a negative energy photon to the energy storage in precisely defined direction, the momentum is indeed generated in a coherent manner. The transfer of a beam circularly polarized photons along ME in the direction of rotation axis would generate torque in the direction of ME. If photons have large value of \hbar the unit of angular momentum would be large and large value of standard angular momentum currency would become possible. MEs are not however the best possible solution energetically. The target with mass m would receive the kinetic energy $\Delta E = E^2/2mc^2 < E$ and momentum $E = E/c$ so that most of energy would go to the internal degrees of freedom. Somehow the energy dissipation should be avoided and the seesaw mechanism to be discussed later could allow this.
2. There is a second manner to avoid energy dissipation and to avoid much larger momentum transfer. The mechanism is based on the induction of join along boundaries bonds making possible the flow of say electrons from the space-time sheet of the target to a larger space-time sheet generating the motion as a recoil effect. Also a phase transition of (say) electrons to their dark variants involves leakage to different page of the book like structure representing generalized imbedding space and would lead to similar recoil effect. There is experimental support for this kind of mechanism. This mechanism would differ from the first in that the energy of photon would go to energy of the receiver and the leakage of the particles would give rise to much larger

momentum transfer $\Delta p = \sqrt{2mE}$. For instance, the system moving could send negative energy photon to the energy storage (say "many-sheeted laser") and the constraint forces would force the resulting momentum to be given by the previous formula. The moving system would act like rocket.

Modanese and Podkletnov [H7] discovered that dielectric breakdown of a capacitor made of super-conducting and non-super-conducting electrodes induces unknown radiation inducing an oscillatory motion of penduli at large distances and that the effect does not weaken with distance as would happen if the penduli absorb the radiation. It was also found that absorption hypothesis would required the quanta of the radiation to be tachyonic. The explanation in terms of the proposed mechanism [K83] would mean that the MEs generated in dielectric breakdown would act as switches inducing the JABs needed for the leakage of matter to larger space-time sheets and making the target to behave like rocket using its own fuel.

It turns out that in the case of molecular motors this mechanism implies too high momentum transfers whereas the first mechanism predicts correct order of magnitude.

3. Parallel supra currents of massive charge particles at magnetic flux tubes as carriers of momentum are more promising energetically since the momentum to energy ratio behaves as $\sqrt{2m/E}$ for them and the transfer of energy to internal degrees of freedom of the target would be much smaller. The supra currents associated with Bose-Einstein condensate of ions moving with constant velocity and possessing constant value of angular momentum in the direction of magnetic flux tube could make possible angular momentum transfer. This would require a mechanism transferring the momentum and angular momentum from the sender to the beam.

Constraints on the model for a coherent momentum transfer

Consider now the constraints on the model of the coherent momentum transfer.

1. The coherence of the momentum transfer results if the protonic current results from a leakage of the protonic supra-current to the atomic space-time sheet and is induced by the generation of join along boundaries bonds acting as Josephson junctions between magnetic flux tubes and atomic space-time sheets. The TGD based model for auroras [K14] suggests that this process is quite generally the mechanism destroying super-conductivity locally. A priori the magnetic flux tubes involved could correspond to the magnetic circuitry associated with the body or to much larger magnetic flux tube structure. This option does *not* require that the momentum of the ions of the protonic supra current is stored: the mere control of the process from this level is enough to guarantee coherence.
2. The extreme synchrony and coherence of the biological locomotion would be made possible by the fact that magnetic flux tubes and hence also electronic and protonic supra currents entering to the organism/organ/organelle/macro-molecule are parallel and are in the same phase. This allows simultaneous generation of the supra current leakage induced by the nerve pulse pattern in case of muscle cells. Since protonic supra currents have parallel momenta ATP molecules can transfer parallel momentum increment to about billion ATP molecules in billions of cells.
3. Magnetic flux tube structures with sizes of body seem to be enough to guarantee the coherence of the locomotion. The time scale of 1/200 seconds for the duration of single ADP-ATP-ADP process is of the same order of magnitude as protonic cyclotron frequency $f_c = 300$ Hz. If magnetic mirrors are involved also now, the wave length associated with the protonic cyclotron frequency 300 Hz in Earth's magnetic field suggests itself as the length of the magnetic flux tubes carrying the hydrogen ions and would thus be of order $L_p = 2\pi R/30$, where R is Earth's radius. The generation of the electronic charge attracting the protonic charge to the region between membranes is essential part of the process and now the leakage of the electronic supra currents to atomic space-time sheets should be involved. In case of electrons the lengths of MEs, if given by the wave lengths associated with the electronic cyclotron frequency, would be of order $L_e = 10^{-3}L_p/2 \sim 1.5$ km and corresponds to a time scale of 1.7 micro-seconds.

To sum up, if the proposed view has some seed of truth in it, super-conductivity in body length scale would be a central element of the functioning of organisms. Super-conductivity even in geophysical

length scales could be crucial, not only for the realization of the sensory representations and motor actions, but also for the basic metabolic processes of life and for the coherent motion of living matter.

The phase transitions changing Planck constant as a basic mechanism

The phase transitions changing Planck constant induce change of the length of magnetic flux tube and this mechanism could serve, not only as the basic mechanism of bio-catalysis, but also as mechanism generating gel phase phase transitions typically inducing a change of the volume of the cytoplasm. These phase transitions could be one mechanism involved with locomotion. Also the reconnection of flux tubes making possible to modify the hardware of topological quantum computer defining also tqc program, is an attractive mechanism inducing this kind of phase transitions.

1. Quantum criticality suggests that the phase transitions for the gel phase are induced by quantum phase transitions changing the value of Planck constant for magnetic flux tubes and inducing the change of the length of the flux tube. Macroscopic quantum coherence would explain the observed co-operativity aspect of the phase transitions. Concerning locomotion and transport mountain climbing using pickaxe and rope inspires a guess for a general mechanism. For instance, a packet of molecules moving along actin molecule or a molecule carrying a cargo along micro-tubule could repeat a simple basic step in which a magnetic flux tube with large \hbar is shot along the direction of the electric field along micro-tubule and stuck to a ratchet followed by a phase transition reducing the value of \hbar and shortening the flux tube and forcing the cargo to move forward. The metabolic energy might be provided by the micro-tubule rather than molecular motor.
2. The reconnection of flux tubes would be a second phase transition of this kind. This phase transition could lead from a phase in phase proteins are unfolded with flux tubes connecting aminoacids to water molecules and thus possessing a large volume of layered water around them to a phase in which they become folded and flux tubes connect aminoacids to each other in the interior of protein. The phase transition could be associated with the contraction of connecting filaments of muscle cell. The phase transitions are also seen in "artificial protein" gels used for drug delivery applications, and are built from polymers arranged in alpha helices, beta sheets and common protein motifs [I113]. If wormhole magnetic flux are taken are taken as a basic prerequisite of life, one must ask whether these "artificial proteins" represent artificial life.

9.3.2 Some facts about molecular and cellular motors

Molecular motors are enzymes having typical size about 10 nm and mass about $10^5 m_p$ moving along DNA strand, micro-tubules, actin filaments, through cell membranes, etc. Of course, the terms 'motor' and 'machine' must be taken with a big grain of salt in TGD Universe, where bio-molecules are conscious and intelligent selves and more like molecular counterparts of ants rather than dead nanoscale robots.

During the last years it has become possible to monitor the activities of a single molecule by using laser traps and optical tweezers: also the the responses of the molecules to external forces can be studied routinely [I77]. With the advance of the experimental techniques molecular motors have become a hot research topic during last years [I50, I119, I63].

Molecular motors transform chemical energy with the mediation of ATP molecules to mechanical work, transport work, energy of electromagnetic fields, and various types of chemical work.

1. The functioning of the skeletal muscle is based on the sliding of the myosin molecules along actin filaments. Kinesin molecules are two-headed molecules moving along micro-tubuli and carrying molecular cargo.
2. Molecular motors can transport molecules along DNA, transport various molecules such as neurotransmitters through the cell membrane or along axon. There is a vast kit of motors enzymes affecting the topology of DNA: for instance, these enzymes can zip or unzip DNA double strand, past, unwind, translate, replicate, unknot and repair DNA.
3. There is evidence that ionic channels are transformed to ionic pumps by a mediation of single ATP molecule [I51]. In light of the experiments challenging the notions of ionic pumps and

channels, one is forced to ask what is really occurring in this process and what its real function is. In TGD framework ATP molecules is a plug connecting two magnetic flux tubes and $ATP \rightarrow ADP + P_i$ would induce shortcut of this flux tube. This flux tube could effectively act as ionic channel.

4. Molecular motors transform chemical work to various other forms of chemical work. Consider only the assembly and breakdown of proteins and DNA replication as examples.
5. The machines producing the energy needed by the other machines are obviously exceptional and thus especially interesting. The generation of ATP, usually believed to serve as a universal energy currency (this view is challenged by TGD approach), involves a protein machine known as $F_0 - F_1$ machine [I108, I109] .

Consider now general features of these machines.

1. A common denominator of all these activities (the F_0 machine producing ATP molecules forms an obvious exception) is that ATP complexes somehow provide the energy needed by the process and this energy is quantized. The time scales involved are very long, for instance 1/100 seconds for a single step of the kinesin along the micro-tubule or 1/20 seconds for the addition of a single amino-acid to a protein in the translation of mRNA. These time scales represent almost an eternity as compared to the time scale of the dissipative effects: for instance, for a protein in water the time scale τ defined by the frictional force $F_d = mv/\tau$ is of order $\tau \sim 10^{-13}$ seconds [I77] .
2. If space-time is single-sheeted, the macroscopic time scales for these processes imply that classical mechanics based description relying on conservative force fields combined with Brownian and dissipative forces should be an excellent approximation. The chemical aspects of these processes should in turn be modelable by statistical models relying on thermal arguments. In the many-sheeted space-time and for a hierarchy of Planck constants the situation need not be this since molecular motors could move along cold space-time sheets and the constant velocity for this motion could be erratically interpreted as resulting from frictional forces.
3. Also definitely quantal aspects are present. The motion of the molecular motors is quantized to steps. For instance, the motion of the kinesin along micro-tubule is quantized with the length of single step being 8 nm. Kinesin uses always the same energy of about .5 eV provided by single ATP complex [I121] . Since the energy needed to perform a single step in the process is quite generally provided by the ATP complex and thus constant and independent of the properties of the fluid (viscosity, ionic concentrations,..) which can be varied, one must conclude that the energy given by ATP complex is considerably larger than the energy needed by the process. The energy could be however used to kicking the molecule from the local potential well. Rather intriguingly, if kinesin molecule receives momentum of photon with energy of .5 eV, it gets velocity which is of correct order of magnitude. Thus quantum motor option might work!
4. Thermal ratchets for which the ATP molecule induces local heating with heat energy being rectified to directed kinetic energy, predict deterministic motion. The motion of a myosin molecule along the actin filament the motion is however effectively non-deterministic consisting of one to five steps and sometimes occurs also backwards but that always single ATP molecule is used [I78] . The average number of steps is three and the length of single step is 5.3 nm.

9.3.3 Molecular motors in single-sheeted space-time

The experimental advances have generated vigorous theoretical activity involved with molecular motors. The basic challenge is to understand how the molecular motors are able to fight against the thermal motion.

To get some idea about the challenge provided by the thermal noise, it is good to have some order of magnitude view about the forces involved. A typical protein has mass $m \sim 10^6$ proton masses. In water it experiences friction force $F_d = mv/\tau$, $\tau = 10^{-13}$ seconds. The Brownian force experienced by protein, say kinesin, is of the order of magnitude

$$f_B \sim mv_T/\tau ,$$

where $v_T \sim \sqrt{kT/m}$ is the thermal velocity. The resulting typical Brownian force is of order one nN (nanoNewton). Let us compare this random force to the force associated with organized motion. Kinesin moves a distance $L = 8$ nm along micro-tubule during .01 seconds by using an energy of about $\Delta E = .5$ eV provided by a single ATP molecule. The average force is $F = \Delta E/L \sim 10^{-2}$ nN and by two orders of magnitude weaker than the typical Brownian force. This is like driving car pushed and pulled by random forces varying their direction in a time scale of 10^{-11} seconds and which are of same order of magnitude that the force usually needed to give the car a velocity of order 100 m/s!

From this estimate it is clear that the theoretical understanding of how molecular motors can cope with the thermal noise cannot be achieved by a routine application of the existing methodology. Something more is needed. The attempts to meet the theoretical challenge are based on the notion of ratchet rectifying thermal energy to a coherent motion. One school believes that various classical ratchets, which are actually more or less must in a single-sheeted space-time, are enough to explain everything. There are also those who believe that quantum ratchets might be needed but here the needed extremely low temperatures are the stumbling block in a single-sheeted space-time. The notion of many-sheeted space-time however suggests a simple solution to this problem: put all moving parts of a quantum motor to the cold space-time sheets.

Brownian ratchets

The standard thermodynamical approach is based on free energy diagrams telling only what is impossible. One can go however further and try to build models for the molecular motors. Hard-boiled reductionism, together with the observation that the relevant time scales are measured using a fraction of second as a natural unit, implies that molecular motors must be purely Newtonian mechanical motors using chemical energy. The basic challenge is to understand how these motors are able to fight against or rather, utilize, thermal motion which in the molecular length scales is dominating in the framework of standard quantum theory.

1. Basic framework and questions

The premises above lead to the following picture.

1. Molecules obey Newtonian mechanics and quantum effects manifest themselves only statistically and are buried in the parameters characterizing effective model (such as effective chemical kinetics). Besides conservative forces used to describe the interaction of the motor with the medium and the presence of the load, there is friction and randomly fluctuating forces characterizing the Brownian motion caused by the thermal effects. Fluctuation-dissipation theorem is used to relate dissipation constant to friction.
2. Basic question is how chemical energy is transformed to mechanical energy.
3. The questions related to how the motors are controlled and how macroscopic synchronous motion is achieved are not pondered in this approach, to say nothing about the possibility of macroscopic quantum states.

2. The notion of ratchet

The basic challenge is to understand how the thermal perturbations in the molecular length scales, which are of the same order of magnitude or even stronger than the amplitude of the ordered motion, can be tamed, circumvented, or utilized. The ingenious idea is the notion of Brownian motor rectifying Brownian motion (for material about Brownian motors see [I50, I119, I63]).

Ratchet is essentially a rectifier that picks up the component of motion that is in the desired direction. The asymmetric periodic saw tooth like structure characterizes ratchet. Screw-driver and the transformation of the motion of the clock pendulum to the motion of the hands of the clock rely on the ratchet principle.

One might naively think that thermal perturbations of a ratchet could be quite generally rectified and thus generate a macroscopic motion. This would obviously mean failure of the second law of thermodynamics and perpetuum mobile of the second kind. This is not possible as shown for the first

time by Smoluchowsky in 1912 and also demonstrated by Feynmann later in his Lectures in Physics. The situation however changes in case of far from thermal equilibrium systems.

One can invent myriads of ratchets once a sufficiently abstract definition of a ratchet is available. The asymmetric periodic structure of the cogwheel is abstracted to a potential which is periodic such that the potential well has the characteristic asymmetric shape.

1. In case of a thermal ratchet periodic heating (which requires energy so that one cannot circumvent the second law) causes the motion in case that the average distance diffused by a particle during the higher temperature period is shorter than the width of the asymmetric sawtooth like potential well. During the low temperature period particle ends up to the right, deeper end of the potential well. If the particle diffuses to the left during high temperature phase, it remains in the original potential well. If it diffuses to the right, it ends up to the next well before next heating. Thus there is a net motion to the right.
2. Also the ratchet potential might vary with time (note that this requires energy feed to the system so that the second law is respected also now). In an idealized situation potential varies from asymmetric saw tooth to constant potential and back. During the period of constant potential particle diffuses freely and if the length traveled in this manner is shorter than the width of the potential well, particle moves to the right.
3. Also oscillatory electromagnetic field containing higher harmonics of the fundamental frequency and coupled to a Brownian motor in a non-linear manner can induce the rectification of Brownian motion.

The ratchet mechanism is so general that one can invent practically endless number of Brownian motors. The basic signature of the ratchet mechanism is extremely loose coupling between the asymmetric periodicity of the potential function and the presence of a time varying external perturbation. This loose coupling is what makes the mechanism so rigid and universal and also testable. In fact, the experiments of Steven Block about the motion of kinesin along micro-tubule suggest that the coupling is *not* loose [I121] .

In the case of molecular motors chemical energy liberated with the mediation of ATP molecule is the basic driving force. For a thermal ratchet the liberated chemical binding energy would induce local heating of the system and this in turn would lead to the ordered motion of the motor enzyme. One can imagine that also the ratchet potential, say the asymmetric periodic potential along micro-tubule or actin filament, could be modified by the chemical energy liberated by ATP molecule.

4. *Mathematical modeling of Brownian motors*

Material about the mathematical modeling of Brownian motors can be found [I50, I119, I63] .

1. Newton's equations are used to model the motion of the motor molecule. The interaction with the medium in which molecule moves is characterized with an asymmetric periodic potential function. The load (second molecule carried by the molecule) is described by an additional term in potential function giving rise to constant opposing force. Friction is characterized typically by a force proportional to the velocity of motion and thermal perturbations are described by a randomly fluctuating force. In equilibrium situation in which the average acceleration of the particle vanishes, particle drifts with an average velocity proportional to the net force. Fluctuation-dissipation theorem relates friction coefficient to the diffusion constant D characterizing the Brownian motion and to temperature.
2. Probabilistic description using time dependent probability distribution for the position of the particle is used for practical purposes. The basic equation states the the probability for a given chemical compound to exist in a given infinitesimal volume element is affected by diffusion, by the flow caused by the drift force and by chemical reactions.
3. Chemical reactions, typically binding of ATP or some other energy carrier molecule and its hydrolysis, are modelled in a very rough manner in terms of effective reaction kinetics using effective rate constants. Thermodynamical arguments based on Gibbs free energy are central. The increment of Gibbs free energy $\Delta G = \Delta H - \Delta(TS)$, which determines to which direction the reaction proceeds and the ratio of the initial and final state concentrations in equilibrium

situation. In constant temperature the increment ΔH of the enthalpy representing typically change of the electrostatic energy and $T\Delta S$ term representing entropy increment are competing factors.

4. In biological systems water is a crucial partipator: before a charged ion can bind to, say aminoacid, both reactants must get rid of the waters of hydration surrounding them. Binding itself reduces entropy in the translational degrees of freedom whereas the liberation of molecules from hydration waters increases the entropy and more than compensates the reduction of entropy. Obviously the situation in question is very complex and only rough phenomenological parametrizations are possible.

In TGD view about functioning of ATP the coupling to water is especially non-trivial: ATP does *not* serve as energy currency but acts as a catalyst making possible to transform the zero point kinetic energy of proton of the hydration waters to a usable energy.

5. Criticism

One can criticize the approach for several reasons.

1. The use of the potential to describe the force is quite a strong idealization and breaks momentum conservation. A more explicit manner to model also the momentum economy would be highly desirable but not possible in the simple Newtonian framework.
2. Biological systems are extremely ordered and purposefully behaving systems: consider only the translation of DNA to proteins as an example. Their modeling using the approach originally developed for the description of dead matter, seems highly questionable.
3. The models for the molecular motors do not discuss control aspects at all. The actual presence of meso- and macroscopic coherence making possible macroscopic organized motion is neglected completely in the reductionistic approach in which everything is assumed to allow modeling at atomic and molecular physics level and believed to reduce to effective theories. In TGD framework these aspects are sides of the same coin and neglecting the presence of correlations in mesoscopic and macroscopic length scales might mean the neglect of something absolutely essential. Of course, it might be that with good luck the model for the motion of the motor enzyme along micro-tubule might be separated completely from its control but this is by no means obvious.
4. There exists empirical evidence against the notion of the thermal ratchet. Thermal ratchet seems to be the most realistic approach for the modeling of the motion of motor enzymes along micro-tubule and actin filament [I119]. In this model the energy liberated in the binding of the ATP molecule is used to increase the local temperature in turn allowing the particle to diffuse along the asymmetric and periodic ratchet potential. The basic qualitative predictions are that the motion occurs only single step at time and deterministically, and that the energy needed to carry out single step should depend on the state of the liquid unless the energy liberated with the mediation of ATP molecule is much higher than the energy needed.

However, the motion of the myosin along the actin filament involves one to five steps and can occur sometimes also backwards [I78]. This is not easy to understand if thermal ratchet is in question. The non-determinism can be understood classically as an apparent non-determinism if ATP gives also coherent momentum to the myosin (say via radiation pressure) and if the direction of momentum depends on the relative orientation of the ATP molecule and actin filament. The more radical option is that a genuine quantum motor is in question: in this case the motion would continue until it is stopped.

In the case of kinesin the energy liberated by single ATP molecule gives always rise to a single step of motion and the energy used per step does not depend on the state of the fluid [I121]. This can be understood if the energy liberated by the ATP complex is much higher than the actual energy needed: this seems indeed to be the case. According to [I119] the thermal ratchet fails also at quantitative level being unable to explain the speed of the motion.

Quantum ratchets

Classical ratchets rectify the Brownian motion. A simplest quantum variant of classical ratchet studied by Hänggi and Reimann [190] is a spatially periodic lopsided potential in which electrons move. If one modulates this potential periodically, the electrons move inside the lopsided wells to either direction and this also modifies the shape of the wells. When the potential well is lowered, highest energy electrons can spill to the well on the right and are localized to the bottom of the well as potential well gets deeper. Thus one can make electrons to move up-hill.

Genuine quantum ratchets are however much weirder. They rectify quantum fluctuations and rely on quantum tunneling. Also now the motion occurs in a ratchet potential with the characteristic asymmetric periodic structure and modulated by oscillating potential difference between the sequence of lopsided potential wells. Now however temperature is very low and the tunneling of the electron is what leads from potential well to another one. Since tunneling probability decreases rapidly when the tunneling length increases, the tunneling should occur when the well is deeper and electrons are at the left hand side of the well. Thus the electron current should flow to the left rather than right in this case.

Heiner Linke tested experimentally this effect by constructing a string of triangular shaped quantum dots [167]. Linke saw the predicted effect but at much lower temperatures the direction of the current became very sensitive to the strength the potential signal and effect became essentially unpredictable. The explanation is in terms of interference of electron waves. The occurrence of the tunneling requires also that there is something which can tunnel. Thus a destructive interference can inhibit the tunneling which could occur otherwise. Thus interference effects obviously provide an optimal control mechanism and the possibility of wireless electronic circuits has been suggested as a possible technological application. In TGD framework the interference effects caused by MEs provide a very attractive control mechanism of supra currents.

9.3.4 Molecular machines in TGD framework

Steven Block, one of the top researchers in the field of the molecular motors, summarizes the recent theoretical situation by saying 'Everything you know about biophysics... is wrong!'. Thus there seems to be some room for new physics and chemistry. TGD indeed brings in several new elements: the notion of many-sheeted ionic flow equilibrium and quantum control based on MEs and supra currents; hierarchy of Planck constants; buy now-pay later mechanism based on the generation of bound states and allowing effective over-unity energy production accompanied by automatic generation of meso- and even macroscopic quantum coherence; and finally but very importantly, the molecular motion along dark and non-atomic space-time sheets in principle allowing to dramatically reduce dissipative effects. Note that the second law is respected since (very!) far from thermal equilibrium systems are in question.

Questions

TGD approach stimulates several critical questions about the fundamental notions involved with the motor enzymes. The first group questions relate to the basic philosophy and fundamental working principles of molecular motors.

1. Is the highly mechanistic notion of the molecular motor really appropriate in TGD framework or should one regard motor enzymes as tiny but conscious and intelligent creatures forming a society able to co-operate and solve problems. In the following the notion of molecular motor is used but without the usual robotic coloring. Equally well one might call a highly specialized professional a robot.
2. How the living matter manages to cope with the thermal motion? Could molecular motors be able to minimize friction by using \hbar increasing phase transitions.
3. How the quantum control is realized? How many-sheeted ionic flow equilibrium is involved with the control of the motion: in particular, how it determines the direction of the movement of a molecular motor around DNA strand, micro-tubule, or actin filament? Could it be that the direction of the supra current breaks the symmetry and fixes the direction of the motion? What is the role of Ohmic currents on atomic space-time sheets?

Second group of questions relates to the energy economy.

1. Is ATP indeed the universal energy currency or does it only connect the user of energy to its provider? The notion of high energy phosphate bond is indeed unconvincing and suggests that the understanding of ATP is far from complete. Is the ATP related energy source the only energy source or could the generation of macroscopic bound state entanglement make possible effective over unity energy production as suggested by the strange findings about neuronal metabolism [J22] ?
2. No consensus exists about how the chemical energy is transformed to mechanical energy or other forms of chemical energy. Is the energy per single step of a molecular motor always the same and provided by the ATP complex as in the case of the kinesin motion? What does the independence of the energy used per single step on the state of the cellular water mean and why the variation in the rate of dissipation does not change the amount of the energy needed? How so high an efficiency is possible in extremely dissipative circumstances: molecular motors have a better efficiency than ordinary motors although the situation should be just the opposite. In particular, $F_0 - F_1$ motor generating ATP molecules has essentially unit thermal and Stokes efficiencies [I109] .
3. ATP complex should liberate energy used to perform chemical work as single quantum. If molecular motors behave classically the energy should be liberated in very small increments in order that the process is reliable and controllable. Could one think the possibility that chemical machines operate quantally whereas molecular motors are effectively classical machines? Or are both quantum and classical modes possible for molecular motors?

The third group of questions relates to the properties cell membrane.

1. What this the real function of the ionic channels and pumps? There is evidence both supporting [I51] and challenging these notions [I113] and somehow one might hope that the notion of many-sheeted space-time could resolve this apparent paradox. In [K62] the TGD inspired solution is discussed in detail.
2. What is the real function of the cell membrane resting potential? What is the real role of the ionic currents associated with nerve pulse activity? How the ionic currents generate EEG waves? The facts that resting potential is -63 mV and the zero point kinetic energy of proton Cooper pair at $k = 139$ super-conducting space-time sheet is 61.5 meV suggests that the real function of the resting potential is to prevent the leakage of the protonic Cooper pairs from $k = 139$ space-time sheets to the super-conducting space-time sheet.

Many-sheeted molecular machines

The TGD based solution to the problem of coping with the thermal noise is simple: increase the value of Planck constant. This means essentially zooming up of the quantal scales to longer ones, even macroscopic. There are however several options whose realism can be judged by using simple order of magnitude estimates. Basically one must choose between whether momentum or energy is used as a fuel. If momentum of exchanged photons is used as a fuel, one must invent a mechanism to avoid large dissipation of energy. If energy is used as a non-dissipative fuel the problem is how to avoid too large momentum transfer and this seems to require large friction forces.

1. Mountain climber mechanism

A rather plausible sounding option is based on the mountain climber mechanism in which the motor action of magnetic body induces the motion of of molecule. The moving system induces an \hbar increasing phase transition of flux tube. The flux tube attaches to the substrate along which the molecule is moving and after this a phase transition reducing the value of Planck constant and forcing the molecule to move takes place. The attachment of the rope could mean attachment of ATP molecule appearing as a plug in flux tube to F_1 and subsequent $ATP \rightarrow ADP + P_i$ cutting the flux tube. The energy would come from dropping of three protons to a larger space-time sheet and the direction of motion would be dictated by the direction of the flux tube along the linear structure. This direction could be statistically determined for single step but there would be a preferred direction determined

most naturally by the electric field along the linear structure. The momentum gained by the moving system would be dictated by the proposed rocket mechanism and there would be the dissipation of energy would be minimal.

2. Seesaw mechanism

Assume that the molecule gets the momentum $p = \Delta E/c = .5 \text{ eV}/c$ from ATP. In this case the velocity of the molecule is $v = p/M$ and for $M \sim 10^5 m_p$ the velocity is of order $\mu\text{m}/\text{sec}$ which is of correct order of magnitude! Thus motor molecules could also act as quantum motors and their constant velocity would reflect the absence of dissipation rather than presence of it!

The velocity of the quantum motor is fixed completely to $v = p/M$ for this option. This is obviously very strong prediction and makes it easy to kill the model. The second testable prediction is that the ratio for the velocities of two quantum motor molecules is given by the inverse of the mass ratio.

Large dissipation can be avoided by using seesaw mechanism. The ADP molecule in the moving system sends negative energy photon transferring a proton in energy storage system to a larger space-time sheet and induces $ATP \rightarrow ADP + P_i$, and then energy storage system sends the negative energy photon back to the moving system inducing $ATP \rightarrow ADP + P_i$. At each step the moving system receives momentum $p = E/c$ but its net energy does not increase. This process could correspond to $ATP \rightarrow ADP \rightarrow ATP\dots$ for both systems involved. Obviously this mechanism can be combined with the mountain climber mechanism.

The seesaw mechanism applies in the case of quantum rotor. In the ideal case the angular momentum is not dissipated and only an exchange of few negative energy photons between ATP:s and polarized in the direction of the rotation axis is enough to gain the needed angular momentum. In the presence of dissipation continual exchange is required. The rotation of the shaft of F_1 machine could be due to this mechanism.

4. Quantum motor mode is required to perform chemical work

ATP complex is involved also with the performance of chemical work. In this case the zero point kinetic energy of the proton *must* be liberated as a single quantum (this actually supports the view that molecular motors indeed act also in quantum mode). Thus ATP complex must act both in effectively classical and genuinely quantal manner. Enzymes are the most important molecular machines and their poorly understood action could involve the notion of many-sheeted space-time in an essential manner. For instance, ions could avoid Coulomb walls by approaching other reactants at atomic space-time sheets along larger space-time sheets. Perhaps even chemical reactions could occur at cold space-time sheets: this would mean that the dropping of the chemicals to cold space-time sheets rather than heat could excite intermediate states.

4. Could classical motor run with the energy provided by ATP complex?

Assume that the energy .5 eV goes to the kinetic energy of the motor molecule rather than to the environment of the molecule. The average velocity of a typical motor molecule like kinesin during single step is $v = s/t$, where $s \sim 10 \text{ nm}$ the length of single step and $t \sim 10^{-2} \text{ sec}$ the duration of single step. The movement with dissipation requires energy feed

$$\Delta E_d = F_d s = \frac{mvL}{\tau} = 2E_{nd} \frac{t}{\tau} ,$$

where $\tau \sim 10^{-13} \text{ sec}$ characterizes time scale of friction and E_{nd} is the energy needed in the absence of dissipation. This energy is by a factor $t/\tau \sim 10^{11}$ larger than the energy when the movement occurs without friction. Thus quantum motor option does not make sense if motor molecule receives the entire energy .5 eV from ATP complex.

New view about $F_0 - F_1$ machine

$F_0 - F_1$ is in certain sense a universal machine. It acts as a ionic channel for protons and in the reverse mode as a protonic pump. It generates also ATP and in reverse mode uses it. Besides this $F_0 - F_1$ acts as a rotary motor. The model for $F_0 - F_1$ machine allows to resolve the paradoxical situation raised by the experiments challenging the notions of ionic pumps and channels [K14] .

$F_0 - F_1$ motor is certainly an extremely complex structure [I108, I109] and I confess of being deeply ignorant of its intricate chemistry and functioning. Despite this I cannot avoid the temptation

to understand the basic purpose and working principles of this machine. My only excuse is that this kind of exercise could promote the understanding of the basic principles of the many-sheeted molecular engineering.

1. $F_0 - F_1$ machine as ATP synthesizer

As mentioned the machine producing ATP is different from other machines since it cannot use ATP as an energy currency (except in the reverse mode!). This machine works somewhat like a hydroelectric generator or actually pair of them turning the shaft to opposite directions [I3, I108, I109, I77]. The proton flow induced by F_0 subunit rotates the shaft and this induces the stator like subunit F_1 to synthesize ATP whereas ATP hydrolysis in F_1 causes a reverse rotation of the shaft and reverses the flow of protons.

Protons are accelerated in an electric field generated by electrons and, according to the standard view, the machine transforms the energy produced by the oxidative metabolism to the energy of the high energy phosphate bonds of the ATP molecule. TGD view however suggests that ATP molecule does not carry energy but acts as a switch allowing the liberation of energy when protons drop from atomic space-time sheet the super-conducting space-time sheets. Thus F_0 machine would generate usable energy by kicking up protons to the atomic space-time sheet.

2. $F_0 - F_1$ machine as a rotary machine

$F_0 - F_1$ acts also as rotary motor rotating the so called γ shaft [I108, I109] and thus transferring the momentum of the supra currents at super-conducting space-time sheets. The accelerated super-conducting protons flowing through the space-time bridges through the region defined by the inner membrane of the mitochondria obviously provide momentum rotating the shaft. There are reasons to believe that this mechanism is very general and behind various rotary machines in the living matter. The beauty of this mechanism is that the generation of coherent momentum becomes possible since supra currents form a coherent macroscopic quantum systems.

3. Does the coupling $F_0 - F_1$ machine to actin filament make it classical machine

$F_0 - F_1$ machine can work also in reverse direction and a lot has been learned about the functioning of this machine. In this mode the machine becomes a proton pump. By attaching an actin filament to the shaft of the machine it has been found that both the thermal efficiency and so called 'Stokes efficiency' are very near to one for F_1 motor acting as proton pump [I109]. According to the analysis of [I109] this implies that the torque generated by the binding of ATP molecule to the catalyst and the liberation of the phosphate group cannot liberate the Gibbs free energy instantaneously but with a constant rate. This argument is based on a simple model of F_1 pump with the friction losses caused by the actin filament attached to the shaft modeled as a linear friction. This result is obviously a theoretical challenge.

1. If the protons provide their energy instantaneously, the hydrodynamic efficiency becomes effectively zero: ΔG is concentrated to a single moment of time and the angle of the shafts changes instantaneously by angle $\Delta\theta = 2\pi/3$. According to the formula of [I109] this would give vanishing rather than maximal 'Stokes efficiency'. Or putting it otherwise: the torque would be instantaneous rather than constant as also direct experimental data suggest.

There is however an important caveat involved here: constant torque corresponds experimentally to a constant rotation velocity and constant rotation velocity characterizes also non-dissipative quantum motion. The classical rotation velocity $\omega = L/I$ (I denotes the moment of inertia and $L = \hbar$ angular momentum) is indeed of correct order of magnitude $10^2/s$ for $I \sim MR^2$, $M \sim 10^7 m_p$ and $R \sim 10$ nm.

2. That Stokes efficiency equal to unity came as a surprise in the standard chemical model where one also expected that the Gibbs free energy is liberated essentially instantaneously. The explanation for the phenomenon proposed in [I109] is based on the tight coupling between mechanical and chemical degrees of freedom (should be loose for Brownian machines in general) predicting nearly unit thermal efficiency and a continual liberation of the Gibbs energy with a constant rate. The latter was assumed to be due to a gradual generation of the Gibbs free energies associated with the hydrogen bonds binding ATP to the catalyst site. In case of phosphate molecule one must assume that the energy liberated when the phosphate molecule is released from $F_1 \cdot ATP \cdot P_i$

complex remains to $F_1 \cdot ATP$ and is liberated at constant rate. Mechanism would be similar to that in case of ATP. One can criticize this view: the time scale of 1/200 seconds for the buildup of hydrogen bonds instead of the time scale of 10^{-13} seconds suggested by Uncertainty Principle looks unrealistic.

As found, in TGD framework the problem disappears since molecular motors would be almost dissipation free quantum machines.

Examples of many-sheeted molecular motors

TGD by no means excludes the thermal ratchet model but suggests the radiation pressure based classical motor and quantum motor options as a more plausible alternatives. Myosin moving along an actin filament and kinesin moving along a micro-tubule provide two basic examples of molecular motors and they could serve as a testing ground selecting between these models. Rather remarkably, quantum option predicts correctly orders of magnitude for the velocities of the molecules. Perhaps both quantum and classical modes are possible and which mode is chosen depends on whether the molecule moves along atomic space-time sheet or larger space-time sheet.

1. The motion of a myosin molecule along actin filament

The motion of the myosin molecule along actin filament involves one to five steps each of length about 5.3 nm (this length scale is somewhat longer than the p-adic length scale $L(149)$). This is not consistent with the thermal ratchet paradigm. As already found quantum motor option based on mountain climber mechanism and seesaw mechanism using $ATP \rightarrow ADP \rightarrow ATP\dots$ is most plausible in TGD framework. The following provides a simplified sketch about how the motion could take place.

1. Suppose for definiteness that the motion is to the right with "right" defined as the direction of electric field along actinin molecule. At each step flux tube containing ATP would be thrown like a rope along actinin filament to the right and get attached to it after which the myosin molecule would follow. This process would be essentially tunneling between two potential energy wells. The direction of electric field along actinin molecule would select "right" as the more probable direction. This is to be expected if myosin molecule is charged.
2. At the first step ADP_1 attached with the myosin molecule would send negative energy to ATP_2 at left and get the recoil energy inducing $ADP_2 + P_i \rightarrow ATP_1$ allowing ATP_1 to attach with the flux tube to tunnel from the potential well and move to the right as a result of recoil momentum. This would induce the decay $ATP_2 \rightarrow ADP_2 + P_i$.
3. At the next step ADP_2 would complete itself to ATP_2 by sending negative energy and momentum to the ATP_1 and inducing $ADP_1 + P_i \rightarrow ATP_1$. At this step the myosin molecule itself should move to the next potential well to the right.

2. The motion of a kinesin molecule along micro-tubule

It is known that the motion of the kinesin molecule occurs in steps of total length of 8 nm and that single step lasts for 1/100 seconds. Kinesin molecule has two heads and the motion resembles the movement of a molecular Tarzan along a horizontal rope by alternately placing one hand over the other. According to [I81], head 2 leapfrogs over the firmly fixed head 1 a distance of 8+5 nm and begins to rock back and forth. Then ATP molecule liberates the energy causing head 1 to wobble un-controllably and head 2 proceeds additional 3 nm and is firmly fixed at the surface of the micro-tubule. Then head 1 repeats the same and each step means progress of 8 nm giving velocity of 800 nm per second which, by the way, is rather near to the velocity of slow Ca^{++} waves in astrocytes. The more ATP there is around, the harder it is to stop the motion of the kinesin [I121]. It is of some interest to notice that the numbers 3, 5, 8 and 13 are Fibonacci numbers appearing almost everywhere in living matter.

The mechanism should be a generalization of the mechanism discussed. The simplest idea would be that the heads exchange a negative energy metabolic quanta back and forth. This is however not quite enough: also a third ATP molecule outside the kinesin molecule is needed to perform the basic step. The necessary presence of ADP_3 explains why it is hard to stop the motion when ATP is present. One manner to fill in the details could be following.

1. ADP_2 at head 2 attached to the flux tube sends a negative energy photon to ATP_1 and transforms to ATP_2 molecule. Recoil momentum kicks ATP_2 attached at flux tube a distance $8 + 5$ nm to the right. The recoil energy received by ATP_2 puts it in rocking motion in local potential well. $ATP_1 \rightarrow ADP_1 + P_i$ in turn puts head 1 in wobbling motion.
2. ADP_3 to the left of kinesin molecule transforms to ATP_3 by sending a negative energy photon to ATP_2 inducing $ATP_2 \rightarrow ADP_2 + P_i$. The received momentum pushes it 3 nm to right and negative energy stops rocking motion and fixes head 2 to the surface of the microtubule.
3. Head 1 repeats the same process.
4. The velocity $v \sim \mu\text{m}/\text{sec}$ is predicted if the mass of the kinesin molecule is of order $10^5 m_p$.

A decisive test for the quantum motor option is to look whether the motion of the molecular motor could be induced by irradiating it with coherent light with photon energies around .5 eV. By the universality of the ATP mechanism irradiation at this frequency could have several kinds of effects on living matter.

Flagellar motors

Bacterial motors operate in much longer length scales than molecular motors and the principles might differ from those utilized by the latter. In particular, quantum motor mode might be impossible now. The motion of bacteria, say Escherichia Coli, is based on flagellar motors involving a rotating helical propeller. When the spin is in anticlockwise direction, flagella come together and the motion the motion propels the cell through the fluid. When the spin is in clockwise direction, the flagella fly apart and a tumbling motion results. The binding of a phosphorylated CheY protein to the portion of the motor located in cytoplasm induces promotes counterclockwise rotation by inducing a conformational change of flagella.

The friction between water and bacterium making impossible slipping makes possible the propelling motion. A rotating helical propeller induces in the general case a motion of the fluid. This motion is minimal when the helical propeller as an abstract surface remains locally stationary during the motion so that the energy dissipation is only due to the frictional losses implied by the fact that the fluid near the propeller must co-move with it. For a helical curve $z = a\phi$ describing idealized flagellum this means that the motion is a combination of a translational motion in the direction of the axis of the motor and rotational motion with rotation and thus of the form $z = vt, \phi = \omega t, v = a\omega$ implying that the motion is along the curve $z = a\phi$.

$F_0 - F_1$ motor in the reverse mode induces the rotation of $F_0 - F_1$ shaft in reverse direction and thus acts as a rotary motor. The functioning of flagellar motor might be based on the same principles as $F_0 - F_1$ motor.

A possible quantum mechanism generating the torque of quantum rotor is inspired by the work in attempts to understand the claimed strange effects in rotating magnetic systems [H10] in TGD framework [K7]. The mechanism might apply to both molecular and bacterial motors [I16].

1. Consider a molecular rotor attached to the cell membrane and having its rotation axis orthogonal to the cell membrane. Assume that there is a magnetic field along the axis of the rotating shaft and that the system can also generate a pulse of line charge along the axis of the shaft. The pulse of line charge creates a pulse of radial electric field inducing a Josephson current along radial flux tubes assumed to be present. The oscillating Josephson current continues as a DC current after the disappearance of the line charge. The lines of Lorentz force experienced by (possibly dark) charge carriers at flux tube rotate along the axis of shaft and the result is a torque in the direction of the axis of the shaft.
2. The control parameters are the amplitude and duration of the charge pulse. These parameters determine the sign and the magnitude of the DC Josephson current proportional to the factor $\sin(\int 2eV dt)$ but do not affect its maximum value. Using this kind of pulses the system can control the direction and magnitude of the torque.
3. The mechanism generating the line charge could be following. There is a strong electric field defined by membrane potential along the axis of the shaft and Josephson currents are running

along the axis. The period of these currents depends on the magnitude of Planck constant for the flux tubes carrying the currents and the period can correspond even EEG time scale. The net charge density associated with the Josephson currents is expected to vanish. Suppose that the system is able to generate a resistance. The resistance experienced by various charge carriers are different so that the net effect would be a temporal generation of charge density on the axis creating the desired charge pulse. One can even consider effective cutting of the flux tubes at either side of the membrane so that charge begins to accumulate at the flux tubes.

4. In the model of DNA as topological quantum computer this kind of shortcut of flux tubes initiates topological quantum computation and the mechanism is the reconnection of the flux tube with the flux tube representing hydrogen bond between water molecules so that currents through flux tube goes effectively to ground. $ATP \rightarrow ADP + P_i$ would be the basic example of this kind of shortcut and should be involved also now. ATP can be regarded as a plug in flux tube connecting two molecules. The flux tube coming to adenosine aromatic ring from the first molecule continues via $O =$ atoms of phosphates to the target molecule. The shortcut splits the flux tube between second and third $O =$ atoms of ATP and induces $ATP \rightarrow ADP + P_i$. In the ideal situation this shortcut would be the only source of dissipation.

Transforming ionic channels to pumps

Just like the notion of high energy phosphate bond, also the concepts of ionic pumps and channels are both supported and challenged by empirical facts. As already explained, the paradoxes disappear in TGD framework. For supra currents running along super-conducting space-time sheets, no metabolic energy is needed to move through the cell membrane. Cell must however transport also ions from atomic space-time sheets to atomic or from atomic to super-conducting space-time sheet. In atomic-atomic case the intelligent solution is to drop the ions to the super-conducting space-time sheet and kick them back at the second side of the cell membrane (this might occur also spontaneously) if ions have enough energy. The ions indeed receive energy when they drop to the magnetic flux tubes from the atomic space-time sheets. The identification of the super-conducting space-time sheet would be as a magnetic flux tube having large value of Planck constant. ATP molecule would be attached to this flux tube and the splitting $ATP \rightarrow ADP + P_i$ would cut the flux tube and change ion channel to ion pump.

A test for this picture comes from a mechanism transforming channel to pump [I51]. Channel is a funnel like channel protein with a tip at outer membrane and mouth opening to the cell interior. When the mouth is open to the inside of the cell, there is a strong interaction of ions with interior. When the mouth is closed, the ions in the channel are released to outside. ATP binding favors the opening of the mouth and the release of the hydrolysis products favors the closing of mouth (in other words, the decay $ATP \rightarrow ADP + P_i$ splits the flux tube). It is found that alternating electric field induces pumping even without ATP [I51].

Previous considerations suggests that the two protons dropping in ATP binding opens the mouth and the proton dropping in the breaking of the phosphate bond closes it. One could also interpret the mouth as a system inhibiting the spontaneous flow of ions to the super-conducting space-time sheets. The fact that also single step of kinesin motion has a similar two-step structure encourages to generalize: perhaps all processes involving ATP could have this characteristic two step structure.

9.4 Explanation of super-luminal velocities in terms of remote metabolism

After the pioneering experiments of Nimtz and his collaborators 1992 [D7] a lot of evidence for effective super-luminal signal velocities has been accumulating [D30, D31]. These findings provide not only a challenge for TGD but also a means of developing the new views about time and energy to a more quantitative level. The simplest model for the super-luminality and related effects is in terms of remote metabolism associated with detectors and other instruments. Thus these experiments would give a firm grasp on phenomena at the border of dead and living matter.

9.4.1 General explanations for effective super-luminal velocities

Several explanations for the effective super-luminal velocities have been proposed. Quite generally, the explanations are marginally consistent with Maxwell's equations.

The explanation of super-luminality in terms of photon tunneling

The explanation of Nimtz [D30, D31] for effective super-luminal velocities involves the notion of evanescent wave for which the component of the wave vector in the direction of propagation is by definition imaginary: $k = i\kappa$ so that the wave is exponentially attenuated. For one-dimensional evanescent em waves dielectric constant ϵ as a function of frequency must be negative so that also the energy density becomes negative and Nimtz suggests that this holds true generally. For 3-dimensional waves in waveguide, which are not constant in the transversal degrees of freedom, evanescent waves in vacuum are possible below cutoff frequency ω_c and are generated in a wave guide containing a narrowed portion in the original experiments of Nimtz.

The analogy with the Schrödinger equation allows the interpretation of evanescent waves in terms of photon tunneling. The semiclassical model relies on the wave equation for non-allowed frequencies not propagating in the waveguide. The model predicts that asymptotically the time τ taken by the evanescent wave of mean frequency f to propagate through a narrowed section of length L of a waveguide does not depend on L and is $\tau \simeq 1/f$ so that arbitrary high effective signal velocities become possible in principle: note however that the exponential attenuation poses strong limitations. This effect is known as Hartman's effect, and generalizes to other geometries and also to electron tunneling. The prediction is consistent with experiments [D7, D30, D31] so that the model provides a reasonable looking phenomenological approach to the situation. The objection is that the solutions describe stationary photon states rather than the process creating them so that the the proposed interpretation of evanescent wave is correct only if the stationary solution codes in itself the process leading to it.

It has been proposed that the effective super-luminal velocities could relate to the breaking of local Lorentz invariance (LLI) [D30, D16] involving also quantum non-locality. The breaking of LLI at space-time level is possible in TGD since Poincare invariance is a symmetry of the 8-dimensional imbedding space. The induced metric of space-time surface can have even Euclidian signature, which might serve as the space-time correlate for the negative value of the dielectric constant.

Also the notion of anomalous interference and the notion of hollow wave analogous to the pilot wave of Bohm have been introduced by Cardone and collaborators [D16] . The phenomenological notion of hollow wave might allow precise formulation using the notion of many-sheeted space-time.

The explanation of effective super-luminality in terms of remote metabolism

TGD suggests a microscopic description in terms of many-sheeted space-time by utilizing the new energy concept allowing negative inertial energies. The explanation relies on time mirror mechanism realized in terms of the generalized four-wave mechanism and making possible remote metabolism by sending negative energy phase conjugate photons to the geometric past.

Remote metabolism can explain not only the effective super-luminality but also the effects interpreted in terms of anomalous interference effects [D16] . Detector could be seen as a self-organizing system able to suck energy by radiating phase conjugate negative energy photons to some other part of system absorbing them. This is also TGD proposal for the fundamental mechanism behind the ordinary metabolism in living systems and the model predicts that the detectors in the experiments considered behave to some extent like living systems. One can even imagine that a competition for resources occurs and that two systems do their best to suck energy from each other. The general catastrophe theoretic model of remote metabolism developed to explain the behavior of Searl device [K83] provides a starting point for the attempts to model the situation quantitatively.

In the case of the pioneering experiments of Nimtz involving a narrowed portion of wave guide the model would look as follows. When the photons in the wave cavity encounter the narrowed portion they are partially absorbed and excite higher energy states of the atoms and electrons at the walls of the cavity. As the detector has received sufficiently many photons, which have travelled through the narrowed portion of the cavity with light velocity, the detector starts to emit negative energy photons absorbed by the excited atoms which thus return to ground states. The shape of the signal received by detector is changed and the signal peak is shifted to earlier time and this gives rise to

effective super-luminal light velocity. According to the figure 4 of [D30] the tunneled signal is not obtained as a time shift of ordinary reference signal but has slightly different shape. In accordance with observations the energy received by the detector is predicted to be larger than expected.

9.4.2 Experiments involving super-luminal velocities

The pioneering experiments on super-luminal velocities were done by Nimtz and collaborators in Cologne 1992 [D7] using microwaves. The configuration used was a wave guide containing a narrowed portion with cross section less than one half of wavelength in both transversal directions. The finding was that the tunneling time is asymptotically equal to $\tau \simeq 1/f$, where f is the frequency of the microwave. More generally, photon tunneling can be realized in wave guides containing a narrowed portion, in the forbidden frequency bands of dielectric hetero-structures analogous to one-dimensional lattices, and also as the frustrated total internal reflection of a double prism, where the total reflection takes place at the boundary from a denser to a rarer dielectric medium [D31].

Standard theoretical description of the findings

The interpretation proposed by Nimtz for super-luminal propagation is in terms evanescent waves representing semiclassically photon tunneling. The quantum tunneling of photons was first discussed by Wigner and later by Hartman who deduced the independence of the tunneling time on barrier thickness [D22]. The article of [D36] [D36] summarizes the model.

Evanescent modes correspond to waves with imaginary wave number not satisfying the dispersion relation of free massless photon. The dispersion relation $\omega^2 - k^2 - \omega_c^2 = 0$ satisfied for free propagation in the waveguide is replaced by $\omega^2 + \kappa^2 - \omega_{c,1}^2 = 0$ in the narrowed portion of the waveguide. The photons satisfying $\omega_c < \omega < \omega_{c,1}$ can propagate in the narrowed portion but are attenuated exponentially. The narrowing of the waveguide by a factor x means $\omega_c \rightarrow \omega_c/x$ so that evanescent modes appear, when x satisfies the constraint $x < \omega_c/\omega$.

In Maxwell's theory a system allowing *one-dimensional* evanescent waves must have negative dielectric constant ϵ ($c^2 = \epsilon_0\mu_0 \rightarrow \epsilon\mu < 0$) for the frequencies involved so that d'Alembert type wave equation changes to Laplacian and tunneling cannot be regarded as a genuine propagation. A possible interpretation is in terms of breaking of Lorentz invariance. According to Nimtz, the evanescent modes seem to represent non-local fields. For one-dimensional propagation the energy density $\varepsilon = \epsilon E^2/2$ by $\epsilon < 0$ would be indeed negative. On the other hand, for 3-dimensional waveguide $\varepsilon < 0$ need not hold true. Evanescent have not been measured directly and they might represent fictitious quantities.

The so called phase time approach identifies the tunneling time as $\tau = d\phi/d\omega$, where ϕ is the phase change over the barrier. In the examples listed above phase change is vanishing since the wave number is imaginary implying $\phi = 0$. Experimentally it has been found $\tau \simeq 1/f$ and this is believed to be due to what happens at the barrier front boundary. A quantum mechanical model for photon tunneling originally developed by Wigner and by Hartman predicts phase-time correctly. A semiclassical description is in question since electromagnetic field does not allow interpretation as a probability amplitude.

The tunneling occurs only below certain length scale L . An interpretation as the size of the region inside which the breaking of Lorentz invariance at space-time level takes place, has been suggested. In the experiments of Nimtz and collaborators L corresponds to the 8.8 – 9.30 cm variation range for the penetration length of evanescent wave [D7]. Second scale corresponds to an energy threshold of $E_{0,e.m.} = 4.5 \mu V$ representing the difference of voltages induced in photodiodes in two experiments in which tunneling occurs/does not occur. In [D16] the threshold is interpreted as an energy threshold for the breaking of local Lorentz invariance.

TGD based explanation of effective super-luminality in terms of remote metabolism

The general TGD based description of the effective super-luminal propagation is based on time mirror mechanism realized in terms of a generalization of the four-wave interaction involving standing wave composed of two waves propagating in opposite directions and waves representing incoming wave and phase conjugate wave. Phase conjugate negative energy photons would propagate inside negative energy massless extremals (MEs, topological light rays). Time mirror mechanism makes possible remote metabolism, and it is assumed that detector is able to remotely metabolize by sending negative

energy photons to the walls of the wave guide whose atoms have been excited by the photons which have been excited.

In the following the consideration is restricted to the experiment [D7] of Nimtz in which waveguide contains a narrowed portion.

1. When the photons with frequencies below the cutoff frequency of the narrowed portion of the waveguide encounter the narrowed portion they are partially absorbed and excite higher energy states of the atoms and electrons at the walls of the cavity. When the detector has received sufficiently many photons, which have travelled through the narrowed portion of the cavity with the normal light velocity, the detector starts to emit negative energy photons absorbed by the excited atoms which thus return to ground state. The shape of the detector signal changes and the peak of the signal received by the detector is shifted to an earlier time. According to the figure 4 of [D30] the shape of the signal indeed changes. The outcome is an effective super-luminality.

If the change of the shape is such that it corresponds in the frequency domain to the phase shift induced by the translation $t \rightarrow t - \Delta\tau$ in the argument of the Fourier component $\exp(i\omega t)$, with $\Delta\tau$ given as the difference

$$\Delta\tau(\omega) = \tau_R - \tau = \frac{L}{c} - \frac{2\pi}{\omega} \quad (9.4.1)$$

of the real time τ_R taken to propagate through the barrier and of the semiclassical tunneling time $\tau(\omega)$, the theory makes same predictions as the semiclassical approach.

2. The prediction is that the detected signal is somewhat stronger than predicted by the standard theory. This has indeed been observed and is formulated in [D16] in terms of the effective energy threshold, which corresponds to the voltage difference $E_{0,e.m} = E_B - E_A \simeq 4.5 \mu V$, where A (B) corresponds to the situation in super-luminal propagation occurs (does not occur). Why this should be the case, is not obvious in the semiclassical model.

Could strong breaking of local Lorentz invariance occur at the space-time level?

The quantum-classical correspondence states that many-sheeted space-time realizes also the phenomenological smoothed out descriptions of the physical system using a hierarchy of larger space-time sheets: many-sheeted physics performs self-mimicry. This philosophy might apply also to the description of photon tunneling.

In TGD Poincare invariance corresponds to the symmetries of the imbedding space and TGD predicts the possibility of space-time sheets with Euclidian signature of metric and thus a dramatic breaking of local Lorentz invariance at space-time level. The physical interpretation of these space-time sheets has remained open. In spirit of quantum classical correspondence one can wonder whether the induced metric could have Euclidian signature for the standing microwave space-time sheet so that the negative value of dielectric constant $\epsilon(\omega)$ necessary for one-dimensional evanescent waves would have a direct space-time correlate in TGD framework. Even the effectively one-dimensional approximate description of the situation with length scale resolution larger than the transversal size of the narrowed portion of the waveguide could have this kind of space-time correlate.

If the standing microwave space-time sheets with Euclidian signature of the induced metric are vacuum extremals, the resulting flexibility gives good hopes about the correspondence with the tunneling interpretation of the evanescent waves. Of course, TGD description remains a bundle of ideas and precise quantitative model is not yet possible.

Alternative explanation in terms of drift of negative energy MEs does not work

A second explanation imaginable in TGD framework would rely on the drift of the negative energy MEs generated at the end B of narrowed portion and send to the end A and to the direction of the geometric past quantum jump by quantum jump so that the field pattern inside MEs would shift towards geometric past and effectively move with super-luminal velocity. This would imply effective

super luminal group velocity for the classical fields inside ME and also for the pattern of coherent photons. In this case the effective super-luminal light velocity would be most naturally constant irrespective of the length of the narrowed region. This is not consistent with the experimental findings. Note that the variant of this mechanism for positive energy MEs could provide the space-time correlate for the reduction of light velocity in dielectrics.

9.4.3 Experiments believed to involve anomalous interference

The experiments of Cardone and coworkers [D16] stimulated my own interest in the super-luminal propagation, a possible breaking of LLI, and non-locality. The experiments of Cardone were motivated by the notion of hollow wave analogous to the notion of pilot wave of Bohm. Hollow wave would not carry energy but would represent a deformation of Minkowski metric and its interaction with photons would somehow induce anomalous interference effects.

The experimental arrangement

The experimental arrangement discussed in more detail [D16] (see Fig. 9.4.3) is following.

- The geometry of the experimental arrangement can be described in terms of a configuration of vertical lines $V_1, V_2,$ and V_3 order from left to right and horizontal lines H_1, H_2, H_3 ordered from top to bottom. There are two identical sources S_1 and S_2 of IR photons, three identical slits F_1, F_2, F_3 and three identical detectors A, B, C (photodiodes sensitive to IR light).
 - S_2, F_3, C was in the intersection of $V_i, i = 1, 2, 3$ with the line H_3 in this order. C was in front of F_3 and detected photons from S_2 .
 - F_2, B was at the intersection of $V_i, i = 2, 3$ with H_2 in this order.
 - S_1, F_1 and A was at the intersection of $V_i, i = 1, 2, 3$ with H_1 in this order. The vertical line V_3 containing the detectors A and B could be moved in horizontal direction to five different positions.
- F_2 was outside the cone of maximal intensity for the radiation from S_1 and in geometric optics approximation no photons was predicted to go through F_2 . The expectation was however that the "hollow waves" accompanying photons emitted by S_2 could propagate through F_2 and induce anomalous interference effects.
- The geometric arrangement was such that B was predicted to detect nothing in the geometric optics approximation and this was found to be the case. Detector A was expected to detect only photons from S_1 : indeed, when S_1 was off and S_2 on, no signal was detected.

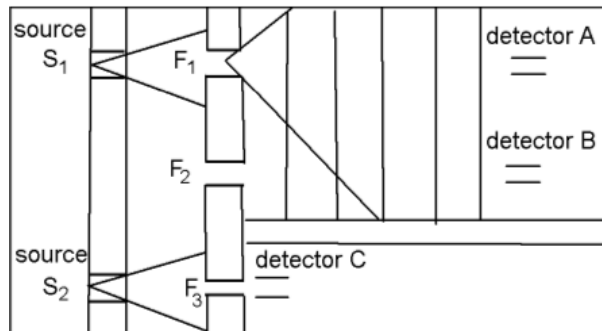


Figure 9.1: Schematic representation of the experimental arrangement of Cardone and collaborators.

Findings

Standard Maxwell's theory would predict that detector A should give same signal in the following situations:

- i) S_1 on and S_2 off
- ii) S_1 on and S_2 on.

What was found that when the distance d of the detector A from S_1 (on the same line parallel to x-axis) satisfied $d < 4$ cm, the two situations were different. The energy threshold defined as the difference of voltages in the detector A in situation i) and ii) was $\Delta_A(1 - 3) = 2.3 \mu V$ for $d < 4$ cm. The proposed interpretation was in terms of anomalous interference effects caused by "hollow waves" accompanying photons and diffracting through the slit F_2 .

TGD based model of remote metabolism as explanation of the effects

The general model of remote metabolism would look like follows.

1. The basic building blocks are negative and positive energy MEs containing phase conjugate IR photons. Although not separately mentioned in [D16], there are reasons to believe that the presence of the slit F_2 is necessary for the effect to occur. The interpretation would be that the standing microwave space-time sheet diffracts through F_2 . Also negative energy IR photons would tunnel through F_2 . Previous considerations allow to consider the possibility that hollow waves correspond to space-time sheets with an Euclidian signature of the induced metric so that physics itself would provide description of the situation with length scale resolution of the order of beam width. What is highly interesting that the critical distance d corresponds to the p-adic length scale $L(k) = 2^{(k-151)/2}L(151)$, $L(151) = 10$ nm for $k = 195$.
2. In order to develop the model further, a rough picture about the functioning of the detector A is necessary. When a photon is detected by A , it creates an electron hole pair in the active region of the photodiode. Conduction electron starts to move towards the n layer of the diode (cathode) whereas hole moves towards the p layer (anode).
3. Detector A emits negative energy phase conjugate IR photons absorbed by S_2 . The emission of negative energy photon from A means that electron becomes a conduction electron so that electron-hole pair is generated and a positive contribution to the voltage of the photodiode is generated. The absorption of photon by S_2 induce a transition of some atomic system in S_2 to a lower energy state without an emission of positive energy IR photon.
4. The "energy threshold" characterizes how efficiently photodiode at A generates negative energy photons and how effectively they are absorbed by S_2 and is a property of photodiode and photon source rather than of possible exotic interactions such as anomalous interference.
5. The model makes several predictions. Negative energy photons can be absorbed when their energies are sub-thermal so that mechanism might not work for photons with sub-thermal energies. The prediction is that the presence of the detector C is not necessary for the mechanism to work. The number of photons detected by the C should be changed by the negative of the amount that the energy detected by A is changed.

9.4.4 The experiments involving crossed photon beams

In [D16] the privately communicated preliminary experimental results of Ranfagni and coworkers are analyzed. The experimental arrangement is illustrated in figure 9.4.4. The primary microwave photon beam A_1 generated by a microwave antenna antenna splits into two beams A_{11} and A_2 . A_{11} is amplified by a second microwave antenna. A_2 , the secondary beam, propagates inside a waveguide, is modulated at 1500 Hz frequency by a chopper and passes to the detector. Either A_1 or A_2 is attenuated.

A_{11} and A_2 cross each other orthogonally and apart from very small interference predicted by QED (photon photon scattering), the effect of A_{11} to the detector should vanish.

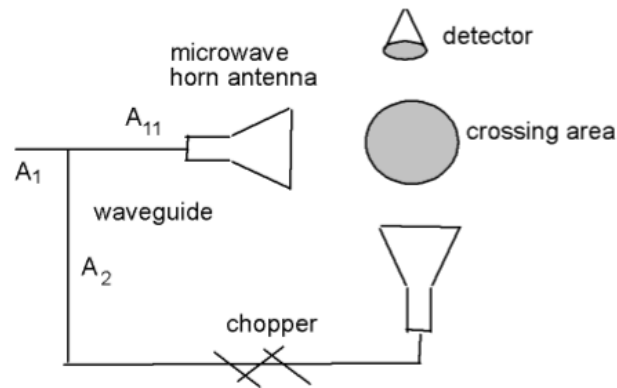


Figure 9.2: Schematic representation of the experimental arrangement of Ranfagni and collaborators discussed in [D16] .

Findings

The experiment demonstrates that the signal generated by photons in detector A depends on whether A_1 or A_2 is attenuated. The experimenters interpret the finding in terms of an anomalous interference involving "hollow waves".

Figure 7 of [D16] depicts the voltage of detector A as function of attenuation and polarization for A_1 and A_2 attenuation. If A_2 is attenuated, the voltage of the photodiode as a function of attenuation stays positive. If A_1 is attenuated, signal changes sign somewhat below 10 dB but approaches in both cases asymptotic value of $5 \mu V$ above 30 dB if the size of the crossing beam region is less than 8-9 cm *resp.* 4 cm for microwave *resp.* IR photons. Asymptotic situation corresponds to a single photon condition. There is no detectable dependence on beam energy but photon polarization affects somewhat the situation.

The laser variant of the experiment performed by Meucci and coworkers uses IR light without modulation and a similar effect is detected.

An overview of the TGD based model

The picture behind the TGD based model is following.

1. The propagation of the microwave through a resistor in microwave circuit is the simplest manner to achieve attenuation. Electrons absorb the microwave energy and dissipate it. Attenuation is a process analogous to a detection since photon is absorbed also now.
2. There is a competition between detector D and attenuator A about energy. In the case of A_2 attenuation D wins and sucks more energy from A_2 than A_2 from D : photodiode voltage is positive. For A_1 the situation is opposite in a critical range [8, 30] dB of attenuation strength A so that the voltage of the photodiode becomes negative. Conduction electrons in the photodiode annihilate with holes and a negative voltage contribution is generated. Asymptotically detector wins in both cases and this explains positive $5 \mu V$ voltage at large values of attenuation A .
3. Generalized four-wave interaction occurs most naturally in the detector and in the attenuator. Standing microwave space-time sheet and IR MEs with negative energy correspond to the four waves involved. The size of the region in which four wave interaction occurs is determined by the size of the crossing region. The wavelength and width of the standing waves between detector and attenuator corresponds to the critical length parameter L , which corresponds to a microwave wavelength in both variants of the experiment. Negative energy IR photons propagate between attenuator and detector along the wave guide A_2 . The branching of the A_1 induces also a branching of the beam of negative energy photons.

4. These length scales L corresponds to the p-adic length scale $L(197)$ for microwave photons and $L(195)$ for IR photons. This suggests that the microwave frequencies involve correspond to p-adic length scales. p-Adic frequencies are indeed expected to define "miracle frequencies" in TGD Universe and I have already proposed that these frequencies and corresponding p-adic codes might be used by more advanced civilizations of the geometric future to communicate with the civilizations of the geometric past (including ourselves). What is interesting that the attenuation need not make possible this kind of communications since time reflection of the signal back from geometric past instead of time transmission does involve attenuation.
5. The catastrophe theoretic model is inspired by the general model for Searl effect based on remote metabolism. Qualitatively the model is characterized by the numbers of state and control parameters. The voltage of photodiode of the detector is in the role of the state variable so that cusp, swallowtail, and butterfly are the candidates for the elementary catastrophes involved. At least $V = 0$ and $V \neq 0$ at the one photon limit represent steady states so that cusp catastrophe and less probably, the dual of butterfly catastrophe having both two steady states provide a possible model of the situation. Note that butterfly reduces to cusp in subregion of the parameter space.

The identification of the control variables

Consider now the possible control variables.

1. The attenuation of the beam A_1 or A_2 , denote it by A , is certainly a relevant dimensionless control parameter. From figure 7 of [D16] one finds that the sign of V changes rapidly as a function of attenuation A below 10 dB and stays negative in certain range of values of A for F_1 attenuation. For A_2 attenuation V preserves its sign. This suggests an idealization in terms of a discontinuous dropping from the upper sheet of cusp to the lower sheet so that A would be identifiable as the normal factor of the cusp.
2. The index $i = 1, 2$ telling whether the primary or secondary beam is attenuated is also a natural control variable. The naive expectation is that some fraction of the beam of negative energy photons from A_1 leaks out when the secondary beam branches from A_1 . It however turns out that "time refraction" in which negative energy signal is amplified in the branching must occur in order to explain the experimental findings.
3. The dimensional control parameters are following.
 - i) The width L of the beam is certainly a control parameter and determines the size of the crossing region, which as such has no relevance in TGD framework since anomalous interference is not assumed to be the underlying mechanism. The wavelength $\lambda = c/f$ of the photon beam is second candidate for a control parameter. The distance d from the detector to the attenuator also distinguishes between A_1 and A_2 attenuation. Together with the attenuation strength A this would make four control variables. The overall size of the system, call it X , is a further control variable which can be however eliminated if scaling invariance holds true by taking X as a length unit.
 - ii) The critical value of L is reported to be the same for $d = d_1$ and d_2 . When L is below the critical value L_{cr} a steady state $V \neq 0$ becomes possible. Below it $V \rightarrow 0$ corresponds to the steady state at the one-photon limit. Hence L plays the role of the splitting factor of cusp catastrophe. The critical value of L for IR photons and microwave photons differs by a factor of order two (change of p-adic miracle wavelength) so that there is a weak dependence on the wavelength and λ acts as a non-trivial control parameter. In the first approximation one can forget λ as an active control variable.
 - iii) The variable d representing distance between attenuator and detector is a candidate for a further control variable. The experiments do not allow to decide whether d is a relevant control variable.

The minimum option is based on the identification of A , L , and discrete variable i as control variables.

A more detailed specification of the catastrophe theoretic model

The equation for the charge of the photodiode modelled as a capacitor reads as

$$\begin{aligned} \frac{dQ}{dt} &= C(V) \frac{dV}{dt} \\ &= I_B(A) + I_D(V, A, L, \lambda) - I_A(A, i, L, \lambda) \equiv F(V, A, L, i, \lambda) . \end{aligned} \quad (9.4.2)$$

Here $I_B(A)$ denotes the contribution of the beam of photons. In the absence of new physics it would be the only term at the right hand side. I_B is obviously proportional to A :

$$I_B(A) = A \times I_B(A = 1) ,$$

and thus decreases with attenuation. I_D corresponds to the current due to the spontaneous generation of negative energy photons by detector and received by attenuator. I_A is the corresponding current induced by the attenuator competing with the detector about energy resources. The first guess is that A_1 and A_2 differ in the sense that part of the beam of the negative energy photons from attenuator A_1 can split into two beams: hence the functional form of I_A is different for $i = 1$ and $i = 2$.

The asymptotic steady states satisfy

$$\frac{dQ}{dt} = F(V) = 0 . \quad (9.4.3)$$

This gives an expression of V as a zero of the function appearing at the right hand side. The dependence of C on V does not matter in the adiabatic situation. Since there is only one state variable involved, one can always write the right hand sided $F(V)$ as a gradient of a potential function Φ :

$$F(V) = \frac{d\Phi}{dV} , \quad (9.4.4)$$

so that catastrophe theory applies and irrespective of the form of potential the situation is diffeomorphic with a butterfly catastrophe with additional discrete control variable i and expected to reduce to cusp catastrophe in the range of control variables studied in the experiments.

From the behavior of V as a function of A one can deduce the following.

1. If d would appear as an argument of I_D asymptotics would not be the same for $d = d_1$ and $d = d_2$ unless one has $I_D(d_1) \simeq I_D(d_2)$ for large values of A . Hence it seems that I_D does not depend on d . The dependence of $I_A(A, i, \dots)$ on i is reflected in the difference of the graphs of $V = f_{A_i}(A)$, $i = 1, 2$ as function of attenuation.
2. I_A must be negligible at the limit $A \rightarrow 0$ of high attenuation since the asymptotic value of V does not depend on whether A_1 or A_2 is attenuated. Too strong an attenuation would mean that the attenuator is not anymore able to emit appreciably negative energy photons. $I_A \propto A(1 - A)$ is the first guess for I_A . For 30 dB attenuation one would have $A = 10^{-3}$ so that I_A would be indeed small.

In principle the model based on the emission of negative energy photons is able to reproduce the observed behavior for V . $I_B \propto A$ decreases as the attenuation increases whereas the current I_A induced by the generation of negative energy photons from the attenuator increases when the attenuation parameter increases since the probability for generation of negative energy photons is expected to grow with the size of attenuator and thus with $1 - A$. Thus the observed change of sign of V for A_1 attenuation can occur for

$$\begin{aligned} I_D(A, \dots) &< I_A(A, i = 1, \dots) , \\ I_B(A) &< I_A(A, i = 1) . \end{aligned} \quad (9.4.5)$$

The condition

$$I_A(A, 1) > I_A(A, 2) \tag{9.4.6}$$

must be satisfied and could relate to the branching of the primary beam and less probably with the value of the parameter d . This condition is not consistent with the expectation that $I_A(A, 1)$ is a fraction of $I_A(A, 2)$. Branching should induce an amplification of the negative energy signal. This would suggest that the branching corresponds to a "time refraction" in which the refracted part of the signal corresponds to positive energy photons.

9.5 Miscellaneous

To make things easier to the reader, I summarize briefly the earlier ideas related to quantum control up to the crucial ideas related to the dark matter hierarchy. I also include a section about possible realization of four-wave mechanism under "attribute" miscellaneous since this mechanism makes rather strong assumptions and is probably not generic enough in its present form. Reader can safely skip over this section at the first reading.

9.5.1 Older ideas

Homeopathy in many-sheeted space-time and scaling laws

The attempt to understand homeopathy the framework provided by many-sheeted space-time [K36] leads to a general vision about the role of MEs, magnetic flux tubes and magnetic mirrors allowing to understand the fundamental recognition mechanisms of bio-molecules in terms of electromagnetic bridges defined by MEs and magnetic flux tubes. This vision allows to build a general model for paranormal phenomena and the same fundamental mechanisms seem to be behind astonishingly wide repertoire of poorly understood phenomena in the borderlines of the existing science.

An important piece in the puzzle comes from the scaling law of homeopathy [K36]. The law states that high and low frequencies accompany each other, the frequency ratio being $f_{high}/f_{low} \simeq 2 \times 10^{11}$ in the simplest situation (the ratio can actually vary). The TGD based interpretation is that ELF MEs are responsible for quantum entanglement in macroscopic, even astrophysical, length scales. Microwave (in particular) MEs propagating effectively as mass-less particles along ELF MEs in turn induce self-organization by serving effectively as 'food' of the plasmoidic life forms at the receiving end. This mechanism would be behind both the endo- and exogenous realizations of intentions as actions, that is ordinary motor actions and phenomena like remote healing and psychokinesis.

Also sensory representations at the personal magnetic canvas and magnetosphere rely on this mechanism, and in this case life-forms are mental images getting at least partially their metabolic energy from brain. This picture which in fact emerged from a model of a rather exotic event (Fatima Marian apparition) provides a view about how low and high frequency MEs are involved with the bio-control, sensory representations, and remote mental interactions. Also a general view about UFO experiences emerges.

One can imagine several interpretation for the scaling law of homeopathy discussed in [K36]. The following interpretation is one of them.

1. The $v = L \times f_{low} = c \times (f_{ELF}/f_h)$ scaling law, which first emerged in the quantum model of EEG and later in the model of homeopathy, can be understood and generalized. What the scaling law means that system with size L and generating MEs with frequencies coming as multiples of $f_h = c/L$ is sensitive to only few low frequencies f_{low} and this is essentially due to the fact that various mechanical, chemical, or electromagnetic wave phenomena propagate only with preferred velocities v .
2. EEG waves and the wave motion associated with homeopathic effects are only special instances of the scaling law. Ca^{++} waves which proliferate living systems provide an especially important realization for the law: the velocity v varies from one nm/s to one m/s and thus spans nine orders of magnitude but varies around a given value typically only by a factor of order three.

3. Given scaling law allows a concrete interpretation in terms of mechanisms transforming low frequency MEs to high frequency MEs generating coherent photons and vice versa. This means transformation of macroscopic control commands to molecular control commands and molecular sensory data to macro-sopic sensory representations. $f_h \leftrightarrow f_{low}$ transformation is central in both the generation of the low frequency em MEs defining sensory projectors and the realization of the motor commands represented in terms of low frequency MEs transformed to high frequency MEs via $f_{low} \rightarrow f_h$ transformation.
4. A much deeper explanation for the scaling law of homeopathy is based on the quantization of Planck constant. Number theoretical arguments suggest a general formula for the allowed values of λ [K29] as $\lambda = n$ where n characterizes the quantum phase $q = \exp(i\pi/n)$ characterizing Jones inclusion [K92]. The values of n for which quantum phase is expressible in terms of squared roots are number theoretically preferred and correspond to integers n expressible as $n = 2^k \prod_n F_{s_n}$, where $F_s = 2^{2^s} + 1$ is Fermat prime and each of them can appear only once. The lowest Fermat primes are $F_0 = 3, F_1 = 5, F_2 = 17, F_3 = 257, F_4 = 2^{16} + 1$. The prediction is that also n -multiples of p -adic length scales are possible as preferred length scales.

The scaling factor 2×10^{11} corresponds with 1.5 per cent accuracy to the integer $n_F = 2^{36} \times 3 \simeq 2.03 \times 10^{11}$ defining a Fermat polygon. This suggests an interpretation in terms of a decay of dark photon with a given wave-length to a bundle of n_F ordinary photons with the same wavelength. The energy of the dark photon would be by a factor n_F higher. This process could serve as an effective tool of bio-control. Dark photon could also transform to an ordinary photon with wavelength shorter by factor $1/n_F$. Quite generally, integers n_F defining Fermat polygons are a reasonable guess for the generalization of the scaling law of homeopathy and the search for these scaling factors could provide an experimental means of identifying the values of Planck constant relevant for living matter.

The time units of everyday life could reflect the properties of the dark matter hierarchy responsible for the control of living matter, in particular those of the sub-hierarchy defined by Fermat polygons. Indeed, one year corresponds to $n_F = 4 \times 3$ months, one month to $n_F = 2 \times 3 \times 5$ days, one day to $n_F = 8 \times 3$ hours, one hour to $n_F = 60 = 4 \times 3 \times 5$ minutes, and one minute to $n_F = 60$ seconds.

TGD inspired quantum biology and number theoretical considerations suggest preferred values for $r = \hbar/\hbar_0$. p -Adic length scale hypothesis favors powers of two as values of r . Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1+i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241, \dots\}$ are expected to be physically highly interesting and up to $k = 127$ indeed correspond to elementary particles. The number theoretical miracle is that all the four p -adic length scales with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μ m). The question has been whether these define scaled up copies of electro-weak and QCD type physics with ordinary value of \hbar . The proposal that this is the case and that these physics are in a well-defined sense induced by the dark scaled up variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$. This proposal will be referred to as Mersenne hypothesis.

The model of bio-photons

The model of bio-photons emerged as a natural application of these ideas. Simple mathematical facts about the decay of the delayed luminescence induced by an external perturbation like light signal, lead to a model in which pairs of positive and negative energy MEs transversal to and moving in opposite directions along DNA strand and it conjugate generate coherent bio-photons. What is important is that a rather detailed model for how MEs and supra current circuits interact results. And most importantly, it becomes clear that negative energy MEs, perhaps the most science fictive piece of the new physics predicted by TGD, are indeed there and could be identified as space-time correlates for phase conjugate photons.

Topological self-referentiality

The longstanding problem has been the lack of understanding about how MEs relate to the existing physics and chemistry. Thus there has been a chronic uncertainty about whether MEs really are there or not, to say nothing about quantitative models for the dynamics and interaction of MEs with ordinary matter. This frustrating situation changed dramatically with the discovery of the topological

self-referentiality, which means that topological field quanta of the classical fields, in particular MEs and magnetic flux tubes, associated with the material system provide a topological representation for the theory about the material system. In particular, and very importantly, negative energy MEs provide representation for the binding energies.

Generation of coherent quantum states and generation of usable energy as sides of the same coin

The generation of bound states with binding energy liberated as a usable energy allows one particular realization of the quantum credit card mechanism. In this case absorption of negative energy photons (or more general bosonic quanta) would lead to a formation of the bound state. The transition between two bound bound states is a more general manner to realize the mechanism.

A more concrete model is in terms of the time mirror mechanism. Negative energy topological light rays are expected to be accompanied by negative energy negative energy photons identifiable as phase conjugate photons. They represent a negative energy signal sent into the geometric past where it is reflected back and possibly amplified. This can occur for instance when negative energy (phase conjugate) photons are absorbed by a population inverted laser so that cascade like dropping of atoms to the ground state occurs and generates much strong positive energy signal received by the sender of the negative energy signal. Time mirror mechanism could make possible new technologies such as instantaneous remote energy utilization, instantaneous active remote sensing, and instantaneous communications over arbitrarily long distances. Time mirror mechanism is an essential element in the models of remote metabolism, long term memory, intentional generation of motor actions, sensory perception, and remote mental interactions.

The generalization of four-wave mechanism involving generalization of standing waves provides a more concrete model of time mirror mechanism and provides a mechanism of remote metabolism in which system sucks energy from environment by sending negative energy particles such as phase conjugate photons. The geometric time reversal of second law is a signature of the process and the decay of system looks like self-assembly from the point of view of observer with standard arrow of geometric time. Generalized four-wave mechanism provides also a model over unity energy production and classical communications to the geometric past. In TGD inspired theory of consciousness and bio-matter this mechanism is central and underlies the models of metabolism, intentional action, and long term memory.

This observation leads to a quantum vision about energy economy in living matter: generation of the macroscopic coherence involving also binding of mental images to larger ones and liberation of a usable energy are different sides of the same coin. Besides, or perhaps even instead, the ordinary metabolism, quantum metabolism should be key element of living matter. Indeed, also ordinary metabolism might be accompanied by the effective over-unity energy production implied by the generation of quantum bound state entanglement with accompanying emission of negative energy photons say. This should reflect experimentally as apparently miraculous ability of the organism to cope without the use of the metabolic energy (brings in mind the stories about the feats of yogies!). Anomalies of this kind have been indeed observed at the level of neuronal metabolism and nano-biology is just questioning the basic assumptions of the Newtonian biology.

Left-brain-right brain, DNA strand-conjugate strand

Second vision is that various binary structures such as DNA and lipid layers of the cell membrane apply a division of labor analogous to what happens between left and right brain hemispheres. The first member of the pair is specialized to generate bound state entanglement and is accompanied by negative energy MEs whereas second member is accompanied by positive energy MEs providing usable energy. This energy in turn makes possible processes like nerve pulse propagation and DNA transcription. The generation of ME pairs could be actually a universal mechanism of energy liberation in living matter. Even right and left brain hemisphere would apply similar division of labor: at this level bound state entanglement would be a quantum correlate for higher level notions like creativity and spirituality. This division of labor seems to continue even to the level of society.

Information molecules as quantum links in quantum web

The third vision relates to the deeper interpretation of chemical communications and biological information molecules. There are full reasons to believe that substructures of these molecules can have bound state entanglement with the surrounding world. This entanglement can be interpreted in terms of 'telepathic' quantum communications. In fact, I introduced already few years ago the notion semi-trance as entanglement with higher level selves but at this time I had not yet understood that quantum jump involves also state function preparation process realized as a cascade of self measurements against which only bound state entanglement is stable.

The bound state entanglement represented by the negative energy MEs is very much like a link to web in email and the transfer of the neural transmitters from the axon to the postsynaptic neuron is like an email message with a set of quantum links to the quantum web represented by the state of the neural transmitter + environment. Note that this means that information content of the message can be very high in this case, much higher than the single bit of the neural net models. Same should hold true for information molecules in general. In this chapter this vision will be touched only very briefly.

I cannot avoid the temptation to relate this new vision to the situation in what is called globalizing world. The proponents of the market economy emphasize the deterministic nature of world economy as justification for the breakdown of well-fare society relying on social justice and mutual caring. Rather, the game theoretic view about society as a collection of individuals competing furiously to steal maximum amount of money is the key piece of this philosophy. Commitment is a word often used by our leaders: this commitment is not however stable and continues only as long as the committing person has not found an organization guaranteeing even more astrophysical salary. The foregoing considerations suggests a different view about society. Suppose that the generation of bound states at the level of society is a physical correlate for commitment. If so, commitment would mean the ability to generate usable energy from 'nothing'. This view would provide more than a metaphorical justification for the belief that the society based on trust and real commitment is able to solve problems which seem completely insurmountable when seen from the desperately narrow social-Darwinistic game-theoretic perspective of the modern market economy.

In this form the idea remains still at the level of philosophy. The model for DNA as topological quantum computer [K28], which in turn inspired a model for protein folding [K4], leads to a detailed realization of this idea.

1. The magnetic flux tubes connecting various biomolecules and act as braid strands carrying four different colors corresponding to nucleotides A,T,G,C and represented as quarks u, d and their antiquarks u_c, d_c . The flux tubes can end to donors of hydrogen bonds and in this case the flux tube corresponds to hydrogen bond.
2. Acceptors of hydrogen bonds (aromatic rings, $O =$ atoms) act as plugs in the network in the sense that there is incoming flux tube and outgoing flux tube with the same color. The molecules XMP , $X = A, T, G, C$ and also their XDP and XTP variants could act as standardized plugs. A weaker hypothesis is that phosphates take this role. In this framework the ATP molecule moving to F_1 catalyst (molecular machine) would be a plug in the flux tube and $ATP \rightarrow ADP + P_i$ process would cut this flux tube and form a connection to the location of F_1 . This process would be the basic process modifying the network defined by colored flux tubes and would typically initiate topological quantum computation. The process would also mean the formation of a link in the web defined by the flux tubes and the basic job of ATP molecules would be to carry these plugs to various places to form new connections. Reconnection mechanism for the flux tubes would be the mechanism allowing the modification of this web.

Earlier ideas about how motor control is realized

The basic ideas behind TGD based view of motor control developed before the discovery of dark matter hierarchy are following.

1. Computer sitting at its own terminal metaphor with astrocytes taking the role of keyboard.
2. Gardener metaphor: control means essentially a selection of patterns from primordial chaos constrained only by sensory input by amplifying these patterns by providing the needed energy.

Since astrocytes are metabolic sources of brain, they are good candidates for controllers. Also the need to cleanly separate motor control signals from sensory signals supports this view.

3. Quantum metabolism: quantum control involves also signals propagating to the geometric past having identification as phase conjugate photons and inducing transitions of subsystems of brain and body to lower energy levels. As a special case quantum bound states are formed and binding energy is liberated as a metabolic energy. This requires what might be called over-unity energy production. The anomalously low oxidative metabolism at neuronal level could be a signature of this mechanism.
4. Puppets in string mechanism: strings start already from the magnetic body. Indeed, to gain precise control it is necessary to locate the end of the ME precisely on the desired point in brain. This might be too strong a requirement: it could be that all parts of the brain receive the same control signal and interpret it in their own manner. Resonance is an essential element of the interpretation mechanism: various structures pick up only certain frequencies from the control command and amplify and transform the signal at these frequencies to various kinds of chemical, mechanical and electrical signals. Even in this case it seems that pre-existing p-adic or real MEs is the only reasonable option. p-Adic MEs would have interpretation as geometric correlates of intentions. Corresponding magnetic flux tube structures are pre-existing and real.
5. Motor control and sensory input must separate from each as completely as possible. If motor control relies on negative energy MEs and sensory representations on positive energy MEs, this is achieved. This would mean that magnetic bodies suck the metabolic energy needed to build photons associated with scaled up variants of EEG from brain and body. This energy is an important factor in metabolism since the energies of photons involved must be above the thermal threshold at room temperature.
6. The communication of the control signals must be based on a highly symbolic representation. The prototype realization for this is monochromatic reference wave generating a complex hologram. For obvious reasons this is not a safe option: some kind of linguistic structure allowing to eliminate the possibility that undesired signals are interpreted as control signals must be present. Natural language is the highest level language that we know. This suggests that the signals represented by negative energy MEs are transformed to Ca^{++} waves and the frequency for their generation correlates with the level of dark matter hierarchy involved. Ca^{++} waves indeed appear in wide frequency scale.

Internal speech would very naturally represent this communication from the sensory canvas. Internal speech involves only single voice at time and this suggests that only one command is given at one time and all astrocyte synticia of the cortex receive it and interpret it in their own manner. There could be an entire hierarchy of internal speeches corresponding to various frequency and length scales and levels of dark matter hierarchy and also other wave forms than sound could define internal speeches.

9.5.2 Generalized-four wave mechanism as a basic mechanism of remote metabolism

Generalized four-wave mechanism provides a concrete realization for the more general time mirror mechanism underlying remote metabolism and many other mechanism important for the functioning of the living matter in TGD Universe. Generalized four-wave mechanism also provides a connection with the existing physics of phase conjugate waves.

Time mirror mechanism

Time mirror mechanism could make possible new technologies such as instantaneous remote energy utilization, instantaneous active remote sensing, and instantaneous communications over arbitrarily long distances. Time mirror mechanism is an essential element in the models of remote metabolism, long term memory, intentional generation of motor actions, sensory perception, and remote mental interactions. What happens that negative energy topological light rays propagating to the direction

of the geometric past are reflected back in time direction and return as positive energy topological light rays (photons could accompany the rays).

This apparently paradoxical sounding language makes sense since the experienced time corresponds to a sequence of quantum jumps recreating space-time surface again and again and the correspondence between these times follows from quantum-classical correspondence: the contents of conscious experience in the essentially four-dimensional classical universe are dominated by contributions, which are sharply localized with respect to the geometric time. This creates the illusion that the classical universe is 3-dimensional. It is essential that the field equations determining the space-time surfaces as field analogs of Bohr orbits are not fully deterministic. Only this makes it possible for the classical dynamics to mimic the non-deterministic quantum dynamics.

Negative energy topological light rays can induce the dropping of ions from atomic to larger space-time sheets. The liberated zero point kinetic energy means that the system can act as an over-unity energy source. Negative energy topological light rays, presumably having phase conjugate laser waves as standard physics counterparts, would be accompanied by negative energy photons and these would induce the dropping of charged particles to larger space-time sheets without emission of photons. The experiments of Feinberg, in particular the experiment in which a chicken was irradiated by phase conjugate laser waves, demonstrate that the system was transparent to phase conjugate laser waves at visible lengths. Indeed, if the phase conjugate photons have negative energies above the thermal energy, say at energies corresponding to visible wave lengths, there is no excited atomic system able to absorb negative energy photons inducing the return to the ground state.

The pairs of atomic and larger space-time sheets can act as many-sheeted population inverted lasers with frequencies which are universal constants of nature, and defined as differences of zero point energies whose values are predicted by the p-adic length scale hypothesis. If the intensity of the negative energy photons is above some critical value, the particles in the excited state of the many-sheeted population inverted laser drop to the ground state in a cascade like manner (the probability of dropping of charged particle is proportional to the number of charged particles already present at larger space-time sheet and thus to the intensity and duration of negative energy topological light ray irradiation). The time reflection thus involves an amplification and negative energy photons serve only the role of controller. The system becomes over-unity energy source making possible remote energy utilization.

Four-wave interaction and time mirror mechanism

Four-wave interaction is the basic mechanism producing phase conjugate laser waves, and TGD approach leads to a generalization of this [I101] [K11]. Four-wave interaction becomes the basic mechanism of intentional action and is behind the basic biological and brain functions like (actually remote) metabolism and long term memory. The findings of Tiller [J99] about physical correlates of intentional action find a nice explanation in this framework.

There are several open questions about four-wave interaction. Could four-wave interaction or its generalization provide a deeper understanding of the scaling law of homeopathy stating that low and high frequencies appear in pairs [K36]? Could the basic function of probe and conjugate beams be the amplification of the standing wave interference pattern by remote metabolism? Does the standing wave formed by the reference beams serve as a kind of standardized hologram? Is it possible to generalize the notion of hologram in order to get rid of the reference beams?

The standing wave interference pattern represents a synchronous oscillation of the entire system and would be an excellent physical correlate for the ability of living organisms to act as coherent wholes. The standing wave resulting as the interference pattern of waves propagating in opposite directions would serve kind of a standardized hologram parameterized by the wavelength λ_h . The interference pattern can be also kicked into a motion by Lorentz boost, and the propagation velocity of the interference pattern is an additional characteristic of the pattern.

Probe and phase conjugate beams in four-wave interaction could in turn be interpreted in terms of remote metabolism. System sends negative energy topological light rays (or massless extremals, MEs) to the geometric past and receives as a response positive energy MEs, and amplification can occur in this process so that negative energy signal serves only a role of control signal. Its generation would utilize the energy provided by the remote metabolism. The emission of negative energy ME would switch on the positive energy laser of the geometric past generating probe beam. The energy source could be system in its geometric past or some system in the environment.

Standing wave is basic element of the mechanism and its generation would require energy obtained by emitting phase conjugate photons. Standing wave need not result only as an interference of classical em wave propagating in opposite directions, but could correspond to any standing wave. Plasma resonances are an especially interesting candidate for a standing wave since plasma frequency does not depend on wave vector at all in lowest approximation. This means that there is no dispersion and the pattern formed by plasma waves is oscillatory. I have indeed proposed that this kind of plasma wave patterns are in key role in living matter. The plasma wave pattern would get the energy of its self-organization by sending (say) negative energy photons.

One can imagine a metabolic hierarchy which is obtained by a time reversal from the dissipation hierarchy for which energy from long length scales gradually dissipates to short length scales. The dissipation of the energy of a hydrodynamic vortex by the gradual decay to smaller vortices is a basic example of this process. Now this kind of process would be replaced by a self-assembly starting from the most energetic level and involve radiation of phase conjugate waves with decreasing frequency scales. The lowest level would correspond to ordinary metabolic mechanism, magneto-static waves could be at the next level and the counterparts of magneto-static waves for Cooper pairs at magnetic flux tubes could be also present and correspond to very low frequencies.

In living matter metabolic energy feed corresponds to the "pumping" and drives protons back to the atomic space-time sheets, and the same would be true now. This hints to a somewhat pessimistic conclusion from the point of view of over unity enthusiast: if the system gains its energy by dropping its own protons to larger space-time sheets, it cannot work for too long. This might relate to the continually occurring optimistic reports about free energy production followed by silence. The point of over unit technology would not be however tapping endlessly energy about vacuum but the possibility of remote metabolism which could make un-necessary for system to carry energy storages with itself and allow extreme flexibility and instantaneous generation of energy when needed.

TGD view about four-wave mechanism

It is not obvious what the description of four-wave mechanism is at the basic level in TGD framework. In Maxwellian approach one introduces non-linear F^4 term in the Lagrangian, where F is field strength. This approach must be replaced by something else in TGD level if one wants a microscopic description.

To end up with this description by making first the question how to understand amplitude modulation. Even this is not enough. One must ask what is the first principle description for the linear superposition of fields in TGD framework.

1. Superposition of fields in terms of flux quanta

In TGD Universe gauge fields are replaced with topological field quanta. Examples are topological light rays, magnetic flux tubes and sheets, and electric flux quanta carrying both magnetic and electric fields. Flux quanta form a fractal hierarchy in the sense that there are flux quanta inside flux quanta. It is natural to assume quantization of Kähler magnetic flux. Braiding and reconnection are basic topological operations for flux quanta.

One important example is the description of non-perturbative aspects of strong interactions in terms of reconnection of color magnetic flux quanta carrying magnetic monopole fluxes [K33, K47]. These objects are string like structures and one can indeed assign to them string world sheets. The transitions in which the thickness of flux tube increases so that flux conservation implies that part of magnetic energy is liberated unless the length of the flux quantum increases, are central in TGD inspired cosmology and astrophysics. The magnetic energy of flux quantum is interpreted as dark energy and magnetic tension as negative "pressure" causing accelerated expansion.

This picture is beautiful and extremely general but raises challenges. How to describe interference and linear superposition for classical gauge fields in terms of topologically quantized classical fields? How the interference and superposition of Maxwellian magnetic fields is realized in the situation when magnetic fields decompose to flux quanta? How to describe simple systems such as solenoidal current generating constant magnetic field using the language of flux quanta?

The basic question concerns the elegant description of superposition of classical fields in terms of topological field quanta. What it means that electromagnetic fields - say magnetic - fields superpose.

1. In Maxwell's linear theory the answer would be trivial but not now. Linear superposition holds true only inside topological light rays for signals propagating in fixed direction with light velocity

and with same local polarization. The easy solution would be to say that one considers small perturbations of background space-time sheet and linearizes the theory. Linearization would apply also to induced gauge fields and metric and one would obtain linear superposition approximately. This does not look elegant. Rather, quantum classical correspondence requires the space-time counterpart for the expansion of quantum fields as sum of modes in terms of topological field quanta. Topological field quanta should not lose their identity in the superposition.

2. In the spirit of topological field quantization it would be nice to have topological representation for the superposition and interference without any linearization. To make progress one must return to the roots and ask how the fields are operationally defined. One has test particle and it experiences a gauge force in the field. From the acceleration of the test particle the value of field is deduced. What one observes is the superposition of gauge forces, not of gauge fields.
 - (a) Let us just assume that we have two space-time sheets representing field configurations to be effectively superposed. Suppose that they are "on top" of each other with respect to CP_2 degrees of freedom so that their M^4 volumes overlap. The points of the sheets representing the field values that would sum in Maxwell's theory are typically at distance of CP_2 radius of about 10^4 Planck lengths. Wormhole contacts representing the interaction between the field configurations are formed. Hence the analog of linear superposition does not hold true exactly. For instance, amplitude modulation becomes possible. This is however not essential for the argument.
 - (b) Test particle could be taken to be fermion which is simultaneously topologically condensed to both sheets. In other words, fermionic CP_2 type almost vacuum extremal touches both sheets and wormhole throats at which the signature of the induced metric changes is formed. Fermion experiences the sum of gauge forces from the two space-time sheets through its wormhole throats. From this one usually concludes that superposition holds true for the induced gauge fields. This assumption is however not true and is also unnecessary in the recent case. In case of topological light rays the representation of modes in given direction in terms of massless extremals makes possible to realize the analogy for the representation of quantum field as sum of modes. The representation does not depend on approximate linearity as in the case of quantum field theories and therefore removes a lot of fuzziness related to the quantum theory. In TGD framework the bosonic action is indeed extremely non-linear.
3. This view about linear superposition has interesting implications. In effective superposition the superposed field patterns do not lose their identity which means that the information about the sources is not lost - this is true at least mathematically. This is nothing but quantum classical correspondence: it is the decomposition of radiation into quanta which allows to conclude that the radiation arrives from a particular astrophysical object. It is also possible to have superposition of fields to zero field in Maxwellian sense but in the sense of TGD both fields patterns still exist. Linear superposition in TGD sense might allow testing using time dependent magnetic fields. In the critical situation in which the magnetic field created by AC current passes through zero, flux quanta have macroscopic size and the direction of the flux quantum changes to opposite.

2. *The description of amplitude modulation and four wave action in TGD Universe*

Also the phenomena of amplitude modulation and four-wave interaction would be effects appearing as quantal reactions of charged particles to the presence of space-time sheets carrying fields. They need not be present for induced gauge fields. One might perhaps even say that these effects appear only at the level of conscious perception involving quantum jumps but not at the level of classical fields.

The summation of effects of em fields can induce amplitude modulation. If charged particles have topological sum contacts to the two space-time sheets carrying classical fields with different frequencies, the rate for quantum jumps is proportional to the modulus squared for the sum of the forces caused by these fields, and one obtains amplitude modulation visible as different and sum of the frequencies involved. In the case of massless extremals the sum and difference of frequencies appear only if MEs corresponding to opposite directions of 3-momentum are present. This leads to an effect that would be

regarded as being caused by a standing electromagnetic wave. MEs correspond to waves propagating in single direction for a given sign of frequency, and in TGD framework it is highly implausible that standing waves could be realized as classical gauge fields.

Similar description applies to four-wave mechanism. Four space-time sheets can give rise to the sums of four frequencies appearing with both signs in the sum and the temporally constant effect is obtained when the sum of the frequencies vanishes.

Fröhlich's coherent dipole oscillations and generalized four-wave mechanism

Any oscillation for which frequency is independent of the wave vector defines an ideal generalized standing wave able to suck energy from the environment by sending phase conjugate photons at the frequency of the wave. Plasma oscillations are basic example of this kind of waves. Magnetostatic waves, which might be relevant for the strange behavior of rotating magnetic systems and bifilar coils [K83], represent a second example. Now however the frequency depends on the angle θ between the wave vector and magnetic field. One can wonder whether magnetostatic waves could be replaced by their electret versions for which the permanent electric dipoles possessing spin oscillate around the equilibrium positions in self-generated electric field and experience the torque $p \times E$.

1. Dispersion relation for the magnetostatic waves of magneto-electret

The equations for magnetostatic waves [D38] can be generalized in a straightforward manner. The units in the sequel is chosen such that one has $\epsilon_0 = \mu_0 = c = \hbar = 1$.

1. The equation relating angular momentum J to magnetic momentum μ : $J = \gamma\mu$ and the expression for the magnetic torque $\tau_m = \mu \times B$ are central. Now also the electric torque $\tau_e = p \times E$ is present.
2. Assume that the dispersive medium is magnetically linear but as an electric has electric and polarization fields E_0 and P_0 satisfying $E_0 = -P_0$ even in the absence of external field D :

$$\begin{aligned} B &= H + M \quad , \quad D = E + P \quad , \\ H &= \mu B \quad , \quad D = \epsilon(E + P_0) \quad , \quad P = (\epsilon - 1)E + \epsilon P_0 \quad . \end{aligned} \tag{9.5.1}$$

D clearly vanishes for the ground state.

3. Assume that ground state fields have constant values so that one has

$$\begin{aligned} M &= M_0 + m(t) \quad , \quad H = H_0 + h(t) \quad , \\ E &= P_0 + e(t) \quad , \quad D = \epsilon e(t) \quad , \quad P = P_0 + p(t) = \epsilon P_0 + (\epsilon - 1)e(t) \quad . \end{aligned}$$

The further assumption is that M_0, B_0 and P_0 are in the same direction, say z-direction, and that m, b, p, e are orthogonal to z-direction.

4. The equations of motion for the magnetization follow from those for single magnetic moment

$$\begin{aligned} \frac{dm}{dt} &= \gamma(M \times H + P \times E) = \frac{\gamma e}{M}(M_0 \times h - H_0 \times m - \epsilon e \times P_0) \quad , \\ \gamma &= \frac{ge}{2M} \end{aligned} \tag{9.5.2}$$

M can be taken as a mass scale characterizing the electric dipole as a quantum system as a magnetic system. The first naive guess would be that M is identifiable as the mass of the dipole and g denotes the Lande factor appearing in the expression of the magnetic moment in terms of spin $\mu = geS/2M$, e denotes elementary charge. Note that the electric dipole need not possess a net charge and therefore the net charge q appearing in the formula in the case of elementary

particle is replaced by $q = e$ and the generalized Lande factor g characterizes the spin of the atom or a molecule. In the case of quantum coherence in spin degrees of freedom, the magnetic moment of the molecule would in a reasonable approximation result by the summation of angular momenta of composite atoms determining also the net magnetic moment. Hence the mass scale could be actually given by the mass of nucleon or even electron whose contribution dominates over nuclear contribution by a factor of about $m_p/m_e \simeq 2 \times 10^3$. In this case the mass scale M would correspond naturally to electron mass.

5. Maxwell's equation $\nabla \times E = -\partial_t B$ for plane waves gives

$$e = -\frac{k}{\omega} \times b, \quad (9.5.3)$$

and one can write $e \times P_0 = P_0 \cos(\theta) b$ so that the equation of motion for the magnetization reads as

$$\begin{aligned} i\omega m &= \gamma [M_0 \times h - H_0 \times m - \epsilon P_0 \cos(\theta) b] \\ &= \frac{\gamma e}{M} [(M_0 - \epsilon P_0 \cos(\theta)) h - (H_0 + \epsilon P_0 \cos(\theta)) m]. \end{aligned} \quad (9.5.4)$$

This equation differs from the equation in a purely magnetostatic case only in that one must replace the parameters H_0 and M_0 with modified parameters:

$$\begin{aligned} M_0 &\rightarrow M_0 - \epsilon P_0 \cos(\theta), \\ H_0 &\rightarrow H_0 + \epsilon P_0 \cos(\theta). \end{aligned} \quad (9.5.5)$$

6. From the equation above one can express m in terms of h using the so called Polder's susceptibility tensor

$$\begin{aligned} \begin{pmatrix} m^x \\ m^y \end{pmatrix} &= \begin{pmatrix} \chi & -i\kappa \\ i\kappa & \chi \end{pmatrix}, \\ \chi &= \frac{\omega_0 \omega_1}{\omega_0^2 - \omega^2}, \quad \kappa = \frac{\omega \omega_1}{\omega_0^2 - \omega^2}. \end{aligned} \quad (9.5.6)$$

In a purely magnetostatic case the parameters are counter parts of Larmor frequencies in fields H and M and satisfy $\omega_0 = \omega_H = e\gamma H_0/M$ and $\omega_1 = \omega_M = e\gamma M_0/M$, where M denotes the mass of the magnetic dipole. In the more general case one has

$$\begin{aligned} \omega_0 &\rightarrow \gamma(H_0 + \epsilon P_0 \cos(\theta)), \\ \omega_1 &\rightarrow \gamma(M_0 - \epsilon P_0 \cos(\theta)). \end{aligned} \quad (9.5.7)$$

7. Maxwell's equation $\nabla \cdot B = 0$ and the assumption $\nabla \times H = 0$ implying $H = -\nabla \Psi$ combined with $B = \mu \cdot H$, with dynamical permittivity tensor

$$\mu = \begin{pmatrix} 1 + \chi & -i\kappa & 0 \\ i\kappa & 1 + \chi & 0 \\ 0 & 0 & 1 \end{pmatrix}, \quad (9.5.8)$$

gives

$$(1 + \chi)(\partial_x^2 + \partial_y^2)\Psi + \partial_z^2\Psi = 0 . \quad (9.5.9)$$

For plane waves one obtains the dispersion relation

$$\chi \sin^2(\theta) = -1 . \quad (9.5.10)$$

Substituting this to the expression of ξ one obtains the dispersion relation

$$\omega^2 = \omega_0(\omega_0 + \omega_1 \sin^2(\theta)) . \quad (9.5.11)$$

2. Dispersion relation for a pure electret

Consider now the the special case $H_0 = M_0 = 0$. The dispersion relation gives now

$$\omega = \frac{eg}{2M} P_0 \cos^2(\theta) = \omega_L \frac{\epsilon P_0}{B} \cos^2(\theta) . \quad (9.5.12)$$

The frequency depends only on the direction of propagation and for the wave vectors in the cone $\theta = \text{constant}$ frequency is same for all Fourier components so that the situation is almost ideal since the formation of 2-dimensional periodically recurring self-organization patterns is possible. Note that the allowed wave vectors form a double cone. The frequency coding of the angle θ occurs.

The external magnetic field is replaced by the polarization field in the formula for the Larmor frequency. In the expression for the magnetic moment in terms of spin ($\mu = gqS/2M$) the mass of the elementary particle is replaced by the mass M of the dipolar molecule. Recall however that in case of quantum coherence even electron mass would be more appropriate mass scale. For instance, if macroscopic quantum phase consisting of electron Cooper pairs is in question the mass scale would be $2m_e$ and spin could be rather large.

p-Adic fractality leads to an estimate for the maximal frequency of the waves as a function of the size of the electret molecule.

1. The idea that the non-quantum coherent physics of a many-particle system formed by smaller space-time sheets topologically condensed at a given space-time sheet is simulated in terms of quantum coherent physics of a space-time sheet containing them, encourages to consider the possibility that the space-time sheets of tubulin molecules possess a magnetic moment, which has an order of magnitude equal to a thermal expectation value of the magnetic moment in the shorter length scales. There would be of course hierarchy of temperatures involved. The magnetic moment could be due to a condensate of Cooper pairs of electrons at a magnetic flux tube structure accompanying the tubulin molecule.
2. p-Adic fractality encourages to think that the net electronic spin and thus magnetic moment is same in each p-adic length scale and thus of order of electronic magnetic moment. If similar scaling holds true for the electric dipole moment assumed to be $p = na$, $a = L(137)$ in atomic length scale, then the polarization in the p-adic length scale $L(k)$ would satisfy

$$P_0(L(k)) = \frac{n}{a^2} \times \left[\frac{L(137)}{L(k)} \right]^3 = \frac{n}{a^2} \times 2^{3(137-k)/2} .$$

Taking the Larmor frequency $f_0 = 12$ GHz of electron ($m_e = 10^{-3}m_p/2$) in the magnetic field of one Tesla ($Tesla \simeq 10^{-4}/a^2$, $a = .1$ nm for $\hbar = c = 1$) as as reference, one can write the estimate for the maximal frequency f_m as

$$f_m(k) = \epsilon n g \times 10^4 \times 2^{3(137-k)/2} \times f_0 .$$

For instance, for $k = 151$ corresponding to the length scale of 10 nm giving a good estimate for the size of a tubulin molecule, the estimate for the frequency would be $f \sim \epsilon n g \times .05$ GHz.

3. A possible connection with Fröhlich's hypothesis

If the mass scale M corresponds to the mass of the molecule, the result conforms with the hypothesis of Fröhlich [185] that coherent electric dipole oscillations in the nanosecond scale are crucial for the functioning of the living matter. This hypothesis is a crucial piece of many quantum theories of consciousness. In TGD framework the interpretation would be different: coherent dipole oscillations would be responsible for the generation of periodically recurring (two-dimensional) mental images able to suck their energy from their environment by sending phase conjugate photons. The usual view that the energy is pumped to system by an external agent is in conflict with the goal of explaining consciousness from the first principles.

Living matter is populated by electrets but micro-tubules are perhaps the most prominent electrets from the point of view of quantum theories of consciousness. In this case the situation would be 2-dimensional from the beginning. As already found, the estimate based on the notion of many-sheeted space-time and p-adic fractality gives $f_m \sim \epsilon n g \times .05$ GHz, which is in GHz scale for $\epsilon n g \sim 20$. The di-electric constant of water is $\epsilon = 79$ for a pressure of 1 atm and temperature of 20 C so that there are good hopes that f_m corresponds to GHz scale. Of course, there is a fractal hierarchy of frequencies f_m scaling as $f_m \propto 2^{3(137-k)/2}$ ranging to the visible frequencies.

Chapter 1

Appendix

A-1 Basic properties of CP_2

A-1.1 CP_2 as a manifold

CP_2 , the complex projective space of two complex dimensions, is obtained by identifying the points of complex 3-space C^3 under the projective equivalence

$$(z^1, z^2, z^3) \equiv \lambda(z^1, z^2, z^3) . \quad (\text{A-1.1})$$

Here λ is any non-zero complex number. Note that CP_2 can be also regarded as the coset space $SU(3)/U(2)$. The pair z^i/z^j for fixed j and $z^i \neq 0$ defines a complex coordinate chart for CP_2 . As j runs from 1 to 3 one obtains an atlas of three coordinate charts covering CP_2 , the charts being holomorphically related to each other (e.g. CP_2 is a complex manifold). The points $z^3 \neq 0$ form a subset of CP_2 homeomorphic to R^4 and the points with $z^3 = 0$ a set homeomorphic to S^2 . Therefore CP_2 is obtained by "adding the 2-sphere at infinity to R^4 ".

Besides the standard complex coordinates $\xi^i = z^i/z^3$, $i = 1, 2$ the coordinates of Eguchi and Freund [A15] will be used and their relation to the complex coordinates is given by

$$\begin{aligned} \xi^1 &= z + it , \\ \xi^2 &= x + iy . \end{aligned} \quad (\text{A-1.2})$$

These are related to the "spherical coordinates" via the equations

$$\begin{aligned} \xi^1 &= r \exp\left(i \frac{(\Psi + \Phi)}{2}\right) \cos\left(\frac{\Theta}{2}\right) , \\ \xi^2 &= r \exp\left(i \frac{(\Psi - \Phi)}{2}\right) \sin\left(\frac{\Theta}{2}\right) . \end{aligned} \quad (\text{A-1.3})$$

The ranges of the variables r, Θ, Φ, Ψ are $[0, \infty], [0, \pi], [0, 4\pi], [0, 2\pi]$ respectively.

Considered as a real four-manifold CP_2 is compact and simply connected, with Euler number Euler number 3, Pontryagin number 3 and second $b = 1$.

A-1.2 Metric and Kähler structure of CP_2

In order to obtain a natural metric for CP_2 , observe that CP_2 can be thought of as a set of the orbits of the isometries $z^i \rightarrow \exp(i\alpha)z^i$ on the sphere S^5 : $\sum z^i \bar{z}^i = R^2$. The metric of CP_2 is obtained by projecting the metric of S^5 orthogonally to the orbits of the isometries. Therefore the distance between the points of CP_2 is that between the representative orbits on S^5 .

The line element has the following form in the complex coordinates

$$ds^2 = g_{a\bar{b}} d\xi^a d\bar{\xi}^b , \quad (\text{A-1.4})$$

where the Hermitian, in fact Kähler metric $g_{a\bar{b}}$ is defined by

$$g_{a\bar{b}} = R^2 \partial_a \partial_{\bar{b}} K , \quad (\text{A-1.5})$$

where the function K , Kähler function, is defined as

$$\begin{aligned} K &= \log(F) , \\ F &= 1 + r^2 . \end{aligned} \quad (\text{A-1.6})$$

The Kähler function for S^2 has the same form. It gives the S^2 metric $dzd\bar{z}/(1+r^2)^2$ related to its standard form in spherical coordinates by the coordinate transformation $(r, \phi) = (\tan(\theta/2), \phi)$.

The representation of the CP_2 metric is deducible from S^5 metric is obtained by putting the angle coordinate of a geodesic sphere constant in it and is given

$$\frac{ds^2}{R^2} = \frac{(dr^2 + r^2 \sigma_3^2)}{F^2} + \frac{r^2(\sigma_1^2 + \sigma_2^2)}{F} , \quad (\text{A-1.7})$$

where the quantities σ_i are defined as

$$\begin{aligned} r^2 \sigma_1 &= \text{Im}(\xi^1 d\xi^2 - \xi^2 d\xi^1) , \\ r^2 \sigma_2 &= -\text{Re}(\xi^1 d\xi^2 - \xi^2 d\xi^1) , \\ r^2 \sigma_3 &= -\text{Im}(\xi^1 d\bar{\xi}^1 + \xi^2 d\bar{\xi}^2) . \end{aligned} \quad (\text{A-1.8})$$

R denotes the radius of the geodesic circle of CP_2 . The vierbein forms, which satisfy the defining relation

$$s_{kl} = R^2 \sum_A e_k^A e_l^A , \quad (\text{A-1.9})$$

are given by

$$\begin{aligned} e^0 &= \frac{dr}{F} , & e^1 &= \frac{r\sigma_1}{\sqrt{F}} , \\ e^2 &= \frac{r\sigma_2}{\sqrt{F}} , & e^3 &= \frac{r\sigma_3}{F} . \end{aligned} \quad (\text{A-1.10})$$

The explicit representations of vierbein vectors are given by

$$\begin{aligned} e^0 &= \frac{dr}{F} , & e^1 &= \frac{r(\sin\Theta \cos\Psi d\Phi + \sin\Psi d\Theta)}{2\sqrt{F}} , \\ e^2 &= \frac{r(\sin\Theta \sin\Psi d\Phi - \cos\Psi d\Theta)}{2\sqrt{F}} , & e^3 &= \frac{r(d\Psi + \cos\Theta d\Phi)}{2F} . \end{aligned} \quad (\text{A-1.11})$$

The explicit representation of the line element is given by the expression

$$ds^2/R^2 = \frac{dr^2}{F^2} + \frac{r^2}{4F^2} (d\Psi + \cos\Theta d\Phi)^2 + \frac{r^2}{4F} (d\Theta^2 + \sin^2\Theta d\Phi^2) . \quad (\text{A-1.12})$$

The vierbein connection satisfying the defining relation

$$de^A = -V_B^A \wedge e^B, \quad (\text{A-1.13})$$

is given by

$$\begin{aligned} V_{01} &= -\frac{e^1}{r_2}, & V_{23} &= \frac{e^1}{r_2}, \\ V_{02} &= -\frac{e^2}{r}, & V_{31} &= \frac{e^2}{r}, \\ V_{03} &= (r - \frac{1}{r})e^3, & V_{12} &= (2r + \frac{1}{r})e^3. \end{aligned} \quad (\text{A-1.14})$$

The representation of the covariantly constant curvature tensor is given by

$$\begin{aligned} R_{01} &= e^0 \wedge e^1 - e^2 \wedge e^3, & R_{23} &= e^0 \wedge e^1 - e^2 \wedge e^3, \\ R_{02} &= e^0 \wedge e^2 - e^3 \wedge e^1, & R_{31} &= -e^0 \wedge e^2 + e^3 \wedge e^1, \\ R_{03} &= 4e^0 \wedge e^3 + 2e^1 \wedge e^2, & R_{12} &= 2e^0 \wedge e^3 + 4e^1 \wedge e^2. \end{aligned} \quad (\text{A-1.15})$$

Metric defines a real, covariantly constant, and therefore closed 2-form J

$$J = -ig_{a\bar{b}}d\xi^a d\bar{\xi}^b, \quad (\text{A-1.16})$$

the so called Kähler form. Kähler form J defines in CP_2 a symplectic structure because it satisfies the condition

$$J^k_r J^{rl} = -s^{kl}. \quad (\text{A-1.17})$$

The form J is integer valued and by its covariant constancy satisfies free Maxwell equations. Hence it can be regarded as a curvature form of a $U(1)$ gauge potential B carrying a magnetic charge of unit $1/2g$ (g denotes the gauge coupling). Locally one has therefore

$$J = dB, \quad (\text{A-1.18})$$

where B is the so called Kähler potential, which is not defined globally since J describes homological magnetic monopole.

It should be noticed that the magnetic flux of J through a 2-surface in CP_2 is proportional to its homology equivalence class, which is integer valued. The explicit representations of J and B are given by

$$\begin{aligned} B &= 2re^3, \\ J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) = \frac{r}{F^2} dr \wedge (d\Psi + \cos\Theta d\Phi) + \frac{r^2}{2F} \sin\Theta d\Theta d\Phi. \end{aligned} \quad (\text{A-1.19})$$

The vierbein curvature form and Kähler form are covariantly constant and have in the complex coordinates only components of type (1,1).

Useful coordinates for CP_2 are the so called canonical coordinates in which Kähler potential and Kähler form have very simple expressions

$$\begin{aligned} B &= \sum_{k=1,2} P_k dQ_k, \\ J &= \sum_{k=1,2} dP_k \wedge dQ_k. \end{aligned} \quad (\text{A-1.20})$$

The relationship of the canonical coordinates to the "spherical" coordinates is given by the equations

$$\begin{aligned}
P_1 &= -\frac{1}{1+r^2} , \\
P_2 &= \frac{r^2 \cos \Theta}{2(1+r^2)} , \\
Q_1 &= \Psi , \\
Q_2 &= \Phi .
\end{aligned} \tag{A-1.21}$$

A-1.3 Spinors in CP_2

CP_2 doesn't allow spinor structure in the conventional sense [A10]. However, the coupling of the spinors to a half odd multiple of the Kähler potential leads to a respectable spinor structure. Because the delicacies associated with the spinor structure of CP_2 play a fundamental role in TGD, the arguments of Hawking are repeated here.

To see how the space can fail to have an ordinary spinor structure consider the parallel transport of the vierbein in a simply connected space M . The parallel propagation around a closed curve with a base point x leads to a rotated vierbein at x : $e^A = R_B^A e^B$ and one can associate to each closed path an element of $SO(4)$.

Consider now a one-parameter family of closed curves $\gamma(v) : v \in (0, 1)$ with the same base point x and $\gamma(0)$ and $\gamma(1)$ trivial paths. Clearly these paths define a sphere S^2 in M and the element $R_B^A(v)$ defines a closed path in $SO(4)$. When the sphere S^2 is contractible to a point e.g., homologically trivial, the path in $SO(4)$ is also contractible to a point and therefore represents a trivial element of the homotopy group $\Pi_1(SO(4)) = Z_2$.

For a homologically nontrivial 2-surface S^2 the associated path in $SO(4)$ can be homotopically nontrivial and therefore corresponds to a nonclosed path in the covering group $\text{Spin}(4)$ (leading from the matrix 1 to -1 in the matrix representation). Assume this is the case.

Assume now that the space allows spinor structure. Then one can parallel propagate also spinors and by the above construction associate a closed path of $\text{Spin}(4)$ to the surface S^2 . Now, however this path corresponds to a lift of the corresponding $SO(4)$ path and cannot be closed. Thus one ends up with a contradiction.

From the preceding argument it is clear that one could compensate the non-allowed -1 - factor associated with the parallel transport of the spinor around the sphere S^2 by coupling it to a gauge potential in such a way that in the parallel transport the gauge potential introduces a compensating -1 -factor. For a $U(1)$ gauge potential this factor is given by the exponential $\exp(i2\Phi)$, where Φ is the magnetic flux through the surface. This factor has the value -1 provided the $U(1)$ potential carries half odd multiple of Dirac charge $1/2g$. In case of CP_2 the required gauge potential is half odd multiple of the Kähler potential B defined previously. In the case of $M^4 \times CP_2$ one can in addition couple the spinor components with different chiralities independently to an odd multiple of $B/2$.

A-1.4 Geodesic sub-manifolds of CP_2

Geodesic sub-manifolds are defined as sub-manifolds having common geodesic lines with the imbedding space. As a consequence the second fundamental form of the geodesic manifold vanishes, which means that the tangent vectors h_α^k (understood as vectors of H) are covariantly constant quantities with respect to the covariant derivative taking into account that the tangent vectors are vectors both with respect to H and X^4 .

In [A5] a general characterization of the geodesic sub-manifolds for an arbitrary symmetric space G/H is given. Geodesic sub-manifolds are in 1-1-correspondence with the so called Lie triple systems of the Lie-algebra g of the group G . The Lie triple system t is defined as a subspace of g characterized by the closedness property with respect to double commutation

$$[X, [Y, Z]] \in t \text{ for } X, Y, Z \in t . \tag{A-1.22}$$

$SU(3)$ allows, besides geodesic lines, two nonequivalent (not isometry related) geodesic spheres. This is understood by observing that $SU(3)$ allows two nonequivalent $SU(2)$ algebras corresponding to

subgroups $SO(3)$ (orthogonal 3×3 matrices) and the usual isospin group $SU(2)$. By taking any subset of two generators from these algebras, one obtains a Lie triple system and by exponentiating this system, one obtains a 2-dimensional geodesic sub-manifold of CP_2 .

Standard representatives for the geodesic spheres of CP_2 are given by the equations

$$S_I^2 : \xi^1 = \bar{\xi}^2 \text{ or equivalently } (\Theta = \pi/2, \Psi = 0) ,$$

$$S_{II}^2 : \xi^1 = \xi^2 \text{ or equivalently } (\Theta = \pi/2, \Phi = 0) .$$

The non-equivalence of these sub-manifolds is clear from the fact that isometries act as holomorphic transformations in CP_2 . The vanishing of the second fundamental form is also easy to verify. The first geodesic manifold is homologically trivial: in fact, the induced Kähler form vanishes identically for S_I^2 . S_{II}^2 is homologically nontrivial and the flux of the Kähler form gives its homology equivalence class.

A-2 CP_2 geometry and standard model symmetries

A-2.1 Identification of the electro-weak couplings

The delicacies of the spinor structure of CP_2 make it a unique candidate for space S . First, the coupling of the spinors to the $U(1)$ gauge potential defined by the Kähler structure provides the missing $U(1)$ factor in the gauge group. Secondly, it is possible to couple different H -chiralities independently to a half odd multiple of the Kähler potential. Thus the hopes of obtaining a correct spectrum for the electromagnetic charge are considerable. In the following it will be demonstrated that the couplings of the induced spinor connection are indeed those of the GWS model [B5] and in particular that the right handed neutrinos decouple completely from the electro-weak interactions.

To begin with, recall that the space H allows to define three different chiralities for spinors. Spinors with fixed H -chirality $e = \pm 1$, CP_2 -chirality l, r and M^4 -chirality L, R are defined by the condition

$$\begin{aligned} \Gamma\Psi &= e\Psi , \\ e &= \pm 1 , \end{aligned} \tag{A-2.1}$$

where Γ denotes the matrix $\Gamma_9 = \gamma_5 \times \gamma_5$, $1 \times \gamma_5$ and $\gamma_5 \times 1$ respectively. Clearly, for a fixed H -chirality CP_2 - and M^4 -chiralities are correlated.

The spinors with H -chirality $e = \pm 1$ can be identified as quark and lepton like spinors respectively. The separate conservation of baryon and lepton numbers can be understood as a consequence of generalized chiral invariance if this identification is accepted. For the spinors with a definite H -chirality one can identify the vielbein group of CP_2 as the electro-weak group: $SO(4) = SU(2)_L \times SU(2)_R$.

The covariant derivatives are defined by the spinorial connection

$$A = V + \frac{B}{2}(n_+ 1_+ + n_- 1_-) . \tag{A-2.2}$$

Here V and B denote the projections of the vielbein and Kähler gauge potentials respectively and $1_{+(-)}$ projects to the spinor H -chirality $+(-)$. The integers n_{\pm} are odd from the requirement of a respectable spinor structure.

The explicit representation of the vielbein connection V and of B are given by the equations

$$\begin{aligned} V_{01} &= -\frac{e^1}{r} , & V_{23} &= \frac{e^1}{r} , \\ V_{02} &= -\frac{e^2}{r} , & V_{31} &= \frac{e^2}{r} , \\ V_{03} &= (r - \frac{1}{r})e^3 , & V_{12} &= (2r + \frac{1}{r})e^3 , \end{aligned} \tag{A-2.3}$$

and

$$B = 2re^3 , \tag{A-2.4}$$

respectively. The explicit representation of the vielbein is not needed here.

Let us first show that the charged part of the spinor connection couples purely left handedly. Identifying Σ_3^0 and Σ_2^1 as the diagonal (neutral) Lie-algebra generators of $SO(4)$, one finds that the charged part of the spinor connection is given by

$$A_{ch} = 2V_{23}I_L^1 + 2V_{13}I_L^2, \quad (\text{A-2.5})$$

where one have defined

$$\begin{aligned} I_L^1 &= \frac{(\Sigma_{01} - \Sigma_{23})}{2}, \\ I_L^2 &= \frac{(\Sigma_{02} - \Sigma_{13})}{2}. \end{aligned} \quad (\text{A-2.6})$$

A_{ch} is clearly left handed so that one can perform the identification

$$W^\pm = \frac{2(e^1 \pm ie^2)}{r}, \quad (\text{A-2.7})$$

where W^\pm denotes the charged intermediate vector boson.

Consider next the identification of the neutral gauge bosons γ and Z^0 as appropriate linear combinations of the two functionally independent quantities

$$\begin{aligned} X &= re^3, \\ Y &= \frac{e^3}{r}, \end{aligned} \quad (\text{A-2.8})$$

appearing in the neutral part of the spinor connection. We show first that the mere requirement that photon couples vectorially implies the basic coupling structure of the GWS model leaving only the value of Weinberg angle undetermined.

To begin with let us define

$$\begin{aligned} \bar{\gamma} &= aX + bY, \\ \bar{Z}^0 &= cX + dY, \end{aligned} \quad (\text{A-2.9})$$

where the normalization condition

$$ad - bc = 1,$$

is satisfied. The physical fields γ and Z^0 are related to $\bar{\gamma}$ and \bar{Z}^0 by simple normalization factors.

Expressing the neutral part of the spinor connection in term of these fields one obtains

$$\begin{aligned} A_{nc} &= [(c+d)2\Sigma_{03} + (2d-c)2\Sigma_{12} + d(n_+1_+ + n_-1_-)]\bar{\gamma} \\ &+ [(a-b)2\Sigma_{03} + (a-2b)2\Sigma_{12} - b(n_+1_+ + n_-1_-)]\bar{Z}^0. \end{aligned} \quad (\text{A-2.10})$$

Identifying Σ_{12} and $\Sigma_{03} = 1 \times \gamma_5 \Sigma_{12}$ as vectorial and axial Lie-algebra generators, respectively, the requirement that γ couples vectorially leads to the condition

$$c = -d. \quad (\text{A-2.11})$$

Using this result plus previous equations, one obtains for the neutral part of the connection the expression

$$A_{nc} = \gamma Q_{em} + Z^0(I_L^3 - \sin^2\theta_W Q_{em}) . \quad (\text{A-2.12})$$

Here the electromagnetic charge Q_{em} and the weak isospin are defined by

$$\begin{aligned} Q_{em} &= \Sigma^{12} + \frac{(n_+1_+ + n_-1_-)}{6} , \\ I_L^3 &= \frac{(\Sigma^{12} - \Sigma^{03})}{2} . \end{aligned} \quad (\text{A-2.13})$$

The fields γ and Z^0 are defined via the relations

$$\begin{aligned} \gamma &= 6d\bar{\gamma} = \frac{6}{(a+b)}(aX + bY) , \\ Z^0 &= 4(a+b)\bar{Z}^0 = 4(X - Y) . \end{aligned} \quad (\text{A-2.14})$$

The value of the Weinberg angle is given by

$$\sin^2\theta_W = \frac{3b}{2(a+b)} , \quad (\text{A-2.15})$$

and is not fixed completely. Observe that right handed neutrinos decouple completely from the electro-weak interactions.

The determination of the value of Weinberg angle is a dynamical problem. The angle is completely fixed once the YM action is fixed by requiring that action contains no cross term of type γZ^0 . Pure symmetry non-broken electro-weak YM action leads to a definite value for the Weinberg angle. One can however add a symmetry breaking term proportional to Kähler action and this changes the value of the Weinberg angle.

To evaluate the value of the Weinberg angle one can express the neutral part F_{nc} of the induced gauge field as

$$F_{nc} = 2R_{03}\Sigma^{03} + 2R_{12}\Sigma^{12} + J(n_+1_+ + n_-1_-) , \quad (\text{A-2.16})$$

where one has

$$\begin{aligned} R_{03} &= 2(2e^0 \wedge e^3 + e^1 \wedge e^2) , \\ R_{12} &= 2(e^0 \wedge e^3 + 2e^1 \wedge e^2) , \\ J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) , \end{aligned} \quad (\text{A-2.17})$$

in terms of the fields γ and Z^0 (photon and Z - boson)

$$F_{nc} = \gamma Q_{em} + Z^0(I_L^3 - \sin^2\theta_W Q_{em}) . \quad (\text{A-2.18})$$

Evaluating the expressions above one obtains for γ and Z^0 the expressions

$$\begin{aligned} \gamma &= 3J - \sin^2\theta_W R_{03} , \\ Z^0 &= 2R_{03} . \end{aligned} \quad (\text{A-2.19})$$

For the Kähler field one obtains

$$J = \frac{1}{3}(\gamma + \sin^2\theta_W Z^0) . \quad (\text{A-2.20})$$

Expressing the neutral part of the symmetry broken YM action

$$\begin{aligned} L_{ew} &= L_{sym} + f J^{\alpha\beta} J_{\alpha\beta} , \\ L_{sym} &= \frac{1}{4g^2} Tr(F^{\alpha\beta} F_{\alpha\beta}) , \end{aligned} \quad (\text{A-2.21})$$

where the trace is taken in spinor representation, in terms of γ and Z^0 one obtains for the coefficient X of the γZ^0 cross term (this coefficient must vanish) the expression

$$\begin{aligned} X &= -\frac{K}{2g^2} + \frac{fp}{18} , \\ K &= Tr [Q_{em}(I_L^3 - \sin^2\theta_W Q_{em})] , \end{aligned} \quad (\text{A-2.22})$$

In the general case the value of the coefficient K is given by

$$K = \sum_i \left[-\frac{(18 + 2n_i^2)\sin^2\theta_W}{9} \right] , \quad (\text{A-2.23})$$

where the sum is over the spinor chiralities, which appear as elementary fermions and n_i is the integer describing the coupling of the spinor field to the Kähler potential. The cross term vanishes provided the value of the Weinberg angle is given by

$$\sin^2\theta_W = \frac{9 \sum_i 1}{(fg^2 + 2 \sum_i (18 + n_i^2))} . \quad (\text{A-2.24})$$

In the scenario where both leptons and quarks are elementary fermions the value of the Weinberg angle is given by

$$\sin^2\theta_W = \frac{9}{(\frac{fg^2}{2} + 28)} . \quad (\text{A-2.25})$$

The bare value of the Weinberg angle is $9/28$ in this scenario, which is quite close to the typical value $9/24$ of GUTs [B7] .

A-2.2 Discrete symmetries

The treatment of discrete symmetries C, P, and T is based on the following requirements:

- a) Symmetries must be realized as purely geometric transformations.
- b) Transformation properties of the field variables should be essentially the same as in the conventional quantum field theories [B2] .

The action of the reflection P on spinors is given by

$$\Psi \rightarrow P\Psi = \gamma^0 \otimes \gamma^0 \Psi . \quad (\text{A-2.26})$$

in the representation of the gamma matrices for which γ^0 is diagonal. It should be noticed that W and Z^0 bosons break parity symmetry as they should since their charge matrices do not commute with the matrix of P .

The guess that a complex conjugation in CP_2 is associated with T transformation of the physicist turns out to be correct. One can verify by a direct calculation that pure Dirac action is invariant under T realized according to

$$\begin{aligned} m^k &\rightarrow T(M^k) , \\ \xi^k &\rightarrow \bar{\xi}^k , \\ \Psi &\rightarrow \gamma^1 \gamma^3 \otimes 1 \Psi . \end{aligned} \quad (\text{A-2.27})$$

The operation bearing closest resemblance to the ordinary charge conjugation corresponds geometrically to complex conjugation in CP_2 :

$$\begin{aligned} \xi^k &\rightarrow \bar{\xi}^k, \\ \Psi &\rightarrow \Psi^\dagger \gamma^2 \gamma^0 \otimes 1. \end{aligned} \tag{A-2.28}$$

As one might have expected symmetries CP and T are exact symmetries of the pure Dirac action.

A-3 Basic facts about induced gauge fields

Since the classical gauge fields are closely related in TGD framework, it is not possible to have space-time sheets carrying only single kind of gauge field. For instance, em fields are accompanied by Z^0 fields for extremals of Kähler action. Weak forces is however absent unless the space-time sheets contains topologically condensed exotic weakly charged particles responding to this force. Same applies to classical color forces. The fact that these long range fields are present forces to assume that there exists a hierarchy of scaled up variants of standard model physics identifiable in terms of dark matter.

Classical em fields are always accompanied by Z^0 field and some components of color gauge field. For extremals having homologically non-trivial sphere as a CP_2 projection em and Z^0 fields are the only non-vanishing electroweak gauge fields. For homologically trivial sphere only W fields are non-vanishing. Color rotations does not affect the situation.

For vacuum extremals all electro-weak gauge fields are in general non-vanishing although the net gauge field has $U(1)$ holonomy by 2-dimensionality of the CP_2 projection. Color gauge field has $U(1)$ holonomy for all space-time surfaces and quantum classical correspondence suggest a weak form of color confinement meaning that physical states correspond to color neutral members of color multiplets.

A-3.1 Induced gauge fields for space-times for which CP_2 projection is a geodesic sphere

If one requires that space-time surface is an extremal of Kähler action and has a 2-dimensional CP_2 projection, only vacuum extremals and space-time surfaces for which CP_2 projection is a geodesic sphere, are allowed. Homologically non-trivial geodesic sphere correspond to vanishing W fields and homologically non-trivial sphere to non-vanishing W fields but vanishing γ and Z^0 . This can be verified by explicit examples.

$r = \infty$ surface gives rise to a homologically non-trivial geodesic sphere for which e_0 and e_3 vanish imply the vanishing of W field. For space-time sheets for which CP_2 projection is $r = \infty$ homologically non-trivial geodesic sphere of CP_2 one has

$$\gamma = \left(\frac{3}{4} - \frac{\sin^2(\theta_W)}{2}\right) Z^0 \simeq \frac{5Z^0}{8}.$$

The induced W fields vanish in this case and they vanish also for all geodesic sphere obtained by $SU(3)$ rotation.

$Im(\xi^1) = Im(\xi^2) = 0$ corresponds to homologically trivial geodesic sphere. A more general representative is obtained by using for the phase angles of standard complex CP_2 coordinates constant values. In this case e^1 and e^3 vanish so that the induced em, Z^0 , and Kähler fields vanish but induced W fields are non-vanishing. This holds also for surfaces obtained by color rotation. Hence one can say that for non-vacuum extremals with 2-D CP_2 projection color rotations and weak symmetries commute.

A-3.2 Space-time surfaces with vanishing em, Z^0 , or Kähler fields

In the following the induced gauge fields are studied for general space-time surface without assuming the extremal property. In fact, extremal property reduces the study to the study of vacuum extremals and surfaces having geodesic sphere as a CP_2 projection and in this sense the following arguments are somewhat obsolete in their generality.

Space-times with vanishing em, Z^0 , or Kähler fields

The following considerations apply to a more general situation in which the homologically trivial geodesic sphere and extremal property are not assumed. It must be emphasized that this case is possible in TGD framework only for a vanishing Kähler field.

Using spherical coordinates (r, Θ, Ψ, Φ) for CP_2 , the expression of Kähler form reads as

$$\begin{aligned} J &= \frac{r}{F^2} dr \wedge (d\Psi + \cos(\Theta)d\Phi) + \frac{r^2}{2F} \sin(\Theta)d\Theta \wedge d\Phi , \\ F &= 1 + r^2 . \end{aligned} \quad (\text{A-3.1})$$

The general expression of electromagnetic field reads as

$$\begin{aligned} F_{em} &= (3 + 2p) \frac{r}{F^2} dr \wedge (d\Psi + \cos(\Theta)d\Phi) + (3 + p) \frac{r^2}{2F} \sin(\Theta)d\Theta \wedge d\Phi , \\ p &= \sin^2(\Theta_W) , \end{aligned} \quad (\text{A-3.2})$$

where Θ_W denotes Weinberg angle.

a) The vanishing of the electromagnetic fields is guaranteed, when the conditions

$$\begin{aligned} \Psi &= k\Phi , \\ (3 + 2p) \frac{1}{r^2 F} (d(r^2)/d\Theta)(k + \cos(\Theta)) + (3 + p) \sin(\Theta) &= 0 , \end{aligned} \quad (\text{A-3.3})$$

hold true. The conditions imply that CP_2 projection of the electromagnetically neutral space-time is 2-dimensional. Solving the differential equation one obtains

$$\begin{aligned} r &= \sqrt{\frac{X}{1-X}} , \\ X &= D \left[\left| \frac{k+u}{C} \right| \right]^\epsilon , \\ u &\equiv \cos(\Theta) , \quad C = k + \cos(\Theta_0) , \quad D = \frac{r_0^2}{1+r_0^2} , \quad \epsilon = \frac{3+p}{3+2p} , \end{aligned} \quad (\text{A-3.4})$$

where C and D are integration constants. $0 \leq X \leq 1$ is required by the reality of r . $r = 0$ would correspond to $X = 0$ giving $u = -k$ achieved only for $|k| \leq 1$ and $r = \infty$ to $X = 1$ giving $|u+k| = [(1+r_0^2)/r_0^2]^{(3+2p)/(3+p)}$ achieved only for

$$\text{sign}(u+k) \times \left[\frac{1+r_0^2}{r_0^2} \right]^{\frac{3+2p}{3+p}} \leq k+1 ,$$

where $\text{sign}(x)$ denotes the sign of x .

The expressions for Kähler form and Z^0 field are given by

$$\begin{aligned} J &= -\frac{p}{3+2p} X du \wedge d\Phi , \\ Z^0 &= -\frac{6}{p} J . \end{aligned} \quad (\text{A-3.5})$$

The components of the electromagnetic field generated by varying vacuum parameters are proportional to the components of the Kähler field: in particular, the magnetic field is parallel to the Kähler magnetic field. The generation of a long range Z^0 vacuum field is a purely TGD based feature not encountered in the standard gauge theories.

b) The vanishing of Z^0 fields is achieved by the replacement of the parameter ϵ with $\epsilon = 1/2$ as becomes clear by considering the condition stating that Z^0 field vanishes identically. Also the relationship $F_{em} = 3J = -\frac{3}{4} \frac{r^2}{F} du \wedge d\Phi$ is useful.

c) The vanishing Kähler field corresponds to $\epsilon = 1, p = 0$ in the formula for em neutral space-times. In this case classical em and Z^0 fields are proportional to each other:

$$\begin{aligned} Z^0 &= 2e^0 \wedge e^3 = \frac{r}{F^2}(k+u) \frac{\partial r}{\partial u} du \wedge d\Phi = (k+u) du \wedge d\Phi \ , \\ r &= \sqrt{\frac{X}{1-X}} \ , \ X = D|k+u| \ , \\ \gamma &= -\frac{p}{2} Z^0 \ . \end{aligned} \tag{A-3.6}$$

For a vanishing value of Weinberg angle ($p = 0$) em field vanishes and only Z^0 field remains as a long range gauge field. Vacuum extremals for which long range Z^0 field vanishes but em field is non-vanishing are not possible.

The effective form of CP_2 metric for surfaces with 2-dimensional CP_2 projection

The effective form of the CP_2 metric for a space-time having vanishing em, Z^0 , or Kähler field is of practical value in the case of vacuum extremals and is given by

$$\begin{aligned} ds_{eff}^2 &= (s_{rr}(\frac{dr}{d\Theta})^2 + s_{\Theta\Theta})d\Theta^2 + (s_{\Phi\Phi} + 2ks_{\Phi\Psi})d\Phi^2 = \frac{R^2}{4}[s_{\Theta\Theta}^{eff} d\Theta^2 + s_{\Phi\Phi}^{eff} d\Phi^2] \ , \\ s_{\Theta\Theta}^{eff} &= X \times \left[\frac{\epsilon^2(1-u^2)}{(k+u)^2} \times \frac{1}{1-X} + 1 - X \right] \ , \\ s_{\Phi\Phi}^{eff} &= X \times [(1-X)(k+u)^2 + 1 - u^2] \ , \end{aligned} \tag{A-3.7}$$

and is useful in the construction of vacuum imbedding of, say Schwartzchild metric.

Topological quantum numbers

Space-times for which either em, Z^0 , or Kähler field vanishes decompose into regions characterized by six vacuum parameters: two of these quantum numbers (ω_1 and ω_2) are frequency type parameters, two (k_1 and k_2) are wave vector like quantum numbers, two of the quantum numbers (n_1 and n_2) are integers. The parameters ω_i and n_i will be referred as electric and magnetic quantum numbers. The existence of these quantum numbers is not a feature of these solutions alone but represents a much more general phenomenon differentiating in a clear cut manner between TGD and Maxwell's electrodynamics.

The simplest manner to avoid surface Kähler charges and discontinuities or infinities in the derivatives of CP_2 coordinates on the common boundary of two neighboring regions with different vacuum quantum numbers is topological field quantization, 3-space decomposes into disjoint topological field quanta, 3-surfaces having outer boundaries with possibly macroscopic size.

Under rather general conditions the coordinates Ψ and Φ can be written in the form

$$\begin{aligned} \Psi &= \omega_2 m^0 + k_2 m^3 + n_2 \phi + \text{Fourier expansion} \ , \\ \Phi &= \omega_1 m^0 + k_1 m^3 + n_1 \phi + \text{Fourier expansion} \ . \end{aligned} \tag{A-3.8}$$

m^0, m^3 and ϕ denote the coordinate variables of the cylindrical M^4 coordinates) so that one has $k = \omega_2/\omega_1 = n_2/n_1 = k_2/k_1$. The regions of the space-time surface with given values of the vacuum parameters ω_i, k_i and n_i and m and C are bounded by the surfaces at which space-time surface becomes ill-defined, say by $r > 0$ or $r < \infty$ surfaces.

The space-time surface decomposes into regions characterized by different values of the vacuum parameters r_0 and Θ_0 . At $r = \infty$ surfaces n_2, ω_2 and m can change since all values of Ψ correspond to the same point of CP_2 : at $r = 0$ surfaces also n_1 and ω_1 can change since all values of Φ correspond to same point of CP_2 , too. If $r = 0$ or $r = \infty$ is not in the allowed range space-time surface develops a boundary.

This implies what might be called topological quantization since in general it is not possible to find a smooth global imbedding for, say a constant magnetic field. Although global imbedding exists

it decomposes into regions with different values of the vacuum parameters and the coordinate u in general possesses discontinuous derivative at $r = 0$ and $r = \infty$ surfaces. A possible manner to avoid edges of space-time is to allow field quantization so that 3-space (and field) decomposes into disjoint quanta, which can be regarded as structurally stable units a 3-space (and of the gauge field). This doesn't exclude partial join along boundaries for neighboring field quanta provided some additional conditions guaranteeing the absence of edges are satisfied.

For instance, the vanishing of the electromagnetic fields implies that the condition

$$\Omega \equiv \frac{\omega_2}{n_2} - \frac{\omega_1}{n_1} = 0 \quad , \quad (\text{A-3.9})$$

is satisfied. In particular, the ratio ω_2/ω_1 is rational number for the electromagnetically neutral regions of space-time surface. The change of the parameter n_1 and n_2 (ω_1 and ω_2) in general generates magnetic field and therefore these integers will be referred to as magnetic (electric) quantum numbers.

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