TGD AND EEG

Matti Pitkänen

Köydenpunojankatu D 11, 10900, Hanko, Finland

Preface

This book belongs to a series of online books summarizing the recent state Topological Geometrodynamics (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 Geometrodynamics (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 coupled 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 particle do not differ from on 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 propagatos 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 of 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.

Matti Pitkänen

Hanko,
September 15, 2010

Acknowledgements

Neither TGD nor these books would exist without the help and encouragement of many people. The friendship with Heikki and Raija Haila and their family have been kept me in contact with the everyday world and without this friendship I would not have survived through these lonely 32 years most of which I have remained unemployed as a scientific dissident. I am happy that my children have understood my difficult position and like my friends have believed that what I am doing is something valuable although I have not received any official recognition for it.

During last decade Tapio Tammi has helped me quite concretely by providing the necessary computer facilities and being one of the few persons in Finland with whom to discuss about my work. I have had also stimulating discussions with Samuli Penttinen who has also helped to get through the economical situations in which there seemed to be no hope. The continual updating of fifteen online books means quite a heavy bureaucracy at the level of bits and without a systemization one ends up with endless copying and pasting and internal consistency is soon lost. Pekka Rapinoja has offered his help in this respect and I am especially grateful for him for my Python skills. Also Matti Vallinkoski has helped me in computer related problems.

The collaboration with Lian Sidoroff 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 particualr, 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.

Matti Pitkänen

Hanko,
September 15, 2010

Contents

List of Figures

Chapter 1

Introduction

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 [27]. 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 [1, 2, 3, 5, 4, 6, 7] about TGD and eight online books about TGD inspired theory of consciousness and of quantum biology [8, 9, 10, 11, 12, 13, 14, 14].

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 decade of the second millenium the basic three strongly interacting threads in the tapestry of quantum TGD.

For few yeas ago the discussions with Tony Smith generated a fourth thread which deserves the name 'TGD as a generalized number theory'. 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.

The fifth thread came with 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.

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 [1, 2, 3, 5, 4, 6, 7] about TGD and eight online books about TGD inspired theory of consciousness and of quantum biology [8, 9, 10, 11, 12, 13, 14, 14] are warmly recommended to the interested reader.

1.2 Basic Ideas of TGD

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

1.2.1 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 the interior of the future light cone of the Minkowski space (to be referred as light cone in the sequel) and $CP_2 = SU(3)/U(2)$ is the complex projective space of two complex dimensions [16, 31, 34, 19]. The identification of the space-time as a submanifold [33, 30] 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 [Misner-Thorne-Wheeler, Logunov *et al*]. The actual choice $H = M^4_+ \times CP_2$ implies the breaking of the Poincare invariance in the cosmological scales but only at the quantum level. 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.

1.2.2 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.

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

The problem is that the two approaches 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 is "vapor phase" that is a "gas" of particle like 3-surfaces (counterpart of the "baby universies" of GRT) and the nonconservation of energy in GRT corresponds to the transfer of energy between the topological condensate and vapor phase.

1.3 The five threads in the development of quantum TGD

The development of TGD has involved four strongly interacting threads: physics as infinite-dimensional geometry; p-adic physics; TGD inspired theory of consciousness and TGD as a generalized number theory. In the following these five threads are briefly described.

1.3.1 Quantum TGD as configuration space spinor geometry

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 are the following ones:

a) 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 [35, 32, 29]. 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.

b) Configuration space is endowed with the 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.

1.3.2 p-Adic TGD

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 puzzless 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. 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. 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.

Despite these frustrating uncertainties, the number of the applications of the poorly defined p-adic physics growed 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.

1.3.3 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 [8, 9, 10, 11, 12, 13, 14, 14].

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

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

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'.

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.

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!).

a) 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).

b) 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 [25]. 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 $p = 2, 3, 5, ...$. 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 pinary 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 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 [17]. The application 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 pinary 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 $p = 2^k - n$ pinary 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.

1.3.4 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. For few yeas ago the discussions with Tony Smith generated a fourth thread which deserves the name 'TGD as a generalized number theory'. It relies on the notion of number theoretic compactifiction stating that space-time surfaces can be regarded either as hyper-quaternionic, and thus maximally associative, 4-surfaces in M^8 identifiable as space of hyper-octonions or as surfaces in $M^4 \times CP_2$ [16].

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 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.

1.3.5 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 [40] 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 [18].

Already before learning about Nottale's paper I had proposed the possibility that Planck constant is quantized [33] and the spectrum is given in terms of logarithms of Beraha numbers: the lowest Beraha number B_3 is completely exceptional in that it predicts infinite value of Planck constant. The inverse of the gravitational Planck constant could correspond a gravitational perturbation of this as $1/\hbar_{gr} = v_0/GMm$. The general philosophy would be that when the quantum system would become non-perturbative, a phase transition increasing the value of $\hbar$ occurs to preserve the perturbative character and at the transition $n = 4 \rightarrow 3$ only the small perturbative correction to $1/\hbar(3) = 0$ remains. This would apply to QCD and to atoms with $Z > 137$ as well.

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 [18].

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.

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.

a) 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.

b) 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 [20].

Dark matter hierarchy leads to detailed quantitative view about quantum biology with several testable predictions [20]. The applications to living matter suggests that the basic hierarchy corresponds to a hierarchy of Planck constants coming as $\hbar(k) = \lambda^k(p)\hbar_0$, $\lambda \simeq 2^{11}$ for $p = 2^{127-1}$, $k = 0, 1, 2, ...$ [20]. Also integer valued sub-harmonics and integer valued sub-harmonics of λ might be possible. Each p-adic length scale corresponds to this kind of hierarchy and number theoretical arguments suggest a general formula for the allowed values of Planck constant λ depending logarithmically on p-adic prime [22]. Also the value of $\hbar_0$ has spectrum characterized by Beraha numbers $B_n = 4cos^2(\pi/n)$, $n \geq 3$, varying by a factor in the range $n > 3$ [22]. It must be however emphasized that the relation of this picture to the model of quantized gravitational Planck constant h_{gr} appearing in Nottale's model is not yet completely understood.

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 [20]. Also a generalization of the notion of genetic code emerges resolving the paradoxes related to the standard dogma [22, 20]. 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 [20].

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 [16, 20]. 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.

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 simplest dimensional estimate gives for the average increment τ of geometric time in quantum jump $\tau \sim 10^4\ CP_2$ times so that $2^{127} - 1 \sim 10^{38}$ quantum jumps are experienced during secondary p-adic time scale $T_2(k = 127) \simeq 0.1$ seconds which is the duration of physiological moment and predicted to be fundamental time scale of human consciousness [24]. A more refined guess is that $\tau_p = \sqrt{p}\tau$ gives the dependence of the duration of quantum jump on p-adic prime p. By multi-p-fractality predicted by TGD and explaining p-adic length scale hypothesis, one expects that at least $p = 2$-adic level is also always present. For the higher levels of dark matter hierarchy τ_p is scaled up by $\hbar/\hbar_0$. One can 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 [22].

Higher levels of dark matter hierarchy provide a 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 [16], 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 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 [20]. $k = 7$ 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 [22, 20]. 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.

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

The TGD based general view about EEG developed in this book relies on the following general picture.

1. TGD Universe is fractal containing fractal copies of standard model physics at various space-time sheets and labeled by the collection of p-adic primes assignable to elementary particles and by the level of dark matter hierarchy characterized partially by the value of Planck constant labeling the pages of the book like structure formed by singular covering spaces of the imbedding space $M^4 \times CP_2$ glued together along a four-dimensional back. Particles at different pages are dark relative to each other since purely local interactions defined in terms of the vertices of Feynman diagram involve only particles at the same page. Fractality includes also a hierarchy of conscious entities-selves- and also moment of consciousness identified as quantum jump has fractal structure.

2. A central notion is that of magnetic body. Magnetic body acts as an intentional agent using biological body as a motor instrument and sensory receptor. There is an entire hierarchy of magnetic bodies associated with various body parts and characterized by the respective p-adic length scale $L_p = L(k)$, $p \simeq 2^k$, and the level of dark matter hierarchy labeled by rational number characterizing the value of Planck constant involved. There are indications that the values of Planck constant given by $\hbar = 2^{11k_d}\hbar_0$ are favored in living matter. The values of p and $\hbar/\hbar_0$ could be seen as kind of intelligence and spiritual quotients.

3. Magnetic body controls the biological body and receives information from it. The hierarchy of EEGs (more generally the counterparts of EEG associated with Z^0, and W bosons and gluons) consisting of dark bosons with energies above thermal threshold by the large value of $\hbar$, is the central aspect of this activity.

4. Cyclotron radiation assignable to cyclotron Bose-Einstein condensates at magnetic body and Josephson radiation assignable to Josephson junctions associated with the cell membrane and other electret type structures abundant in living matter are in a dominant role concerning communication and control. In particular, Cyclotron and Josephson frequencies correspond to EEG frequencies which together with p-adic length scale hypothesis leads to a highly predictive scenario.

5. The vision about DNA as topological quantum computer leads to a rather detailed view about how genome and cell membrane interact. Nucleotides and lipids would be connected by magnetic flux tubes carrying dark matter with varying values of Planck constant and define braiding affected by the 2-D flow of the lipids in liquid crystal state and giving rise to a topological

quantum computation with program modules defined by standard liquid flow patterns resulting via quantum self organization process in presence of metabolic energy feed.

6. Sensory qualia could be associated with the generalized di-electric breakdowns between sensory organ and its magnetic body behaving somewhat like a capacitor. The cyclotron phase transitions of Bose-Einstein condensates of biologically important ions generated by the dark EEG photons at the magnetic body generate magnetic somatosensory qualia identifiable as our cognitive and emotional qualia. Long ranged charge entanglement made possible by W MEs (topological light rays) are essential element of all motor control and generate exotic ionization of nuclei (new nuclear physics predicted by TGD) in turn inducing classical electric fields at space-time sheets carrying ordinary matter. These fields generate various responses such as ionic waves and nerve pulses yielding the desired physiological responses.

The plan of the book is roughly following. The chapter describing the magnetic sensory canvas hypothesis is followed by a model for nerve pulse and by three chapters devoted to EEG. A speculative chapter discussing the possible role of exotic neutrinos in hearing and cognition concludes the book.

The seven online books about TGD [1, 2, 3, 5, 4, 6, 7] and eight online books about TGD inspired theory of consciousness and quantum biology [8, 9, 10, 11, 12, 13, 14, 14] are warmly recommended for the reader willing to get overall view about what is involved.

1.5 The contents of the book

1.5.1 Magnetic Sensory Canvas Hypothesis

There are very general objections against the idea that ultimate sensory representations are realized inside brain. For instance, any computer scientist, unless informed about materialistic dogmas, would argue that the processing of the sensory data must be separated from its representation. How this could occur if sensory and other representations are realized inside brain, is however difficult to see.

In TGD approach these objections lead to the view that the magnetic flux tube structures associated with the primary sensory organs and higher levels of central nervous system define a hierarchy of sensory and other representations outside brain with magnetic flux tubes serving as the sensory canvas to which place coding by magnetic transition frequencies generates sensory sub-selves and associates with them various sensory qualia and features by quantum entanglement. Thus brain could be much like a RAM memory containing a collection of features in random order and the ordering would be induced by the sensory map to the magnetic sensory canvas. MEs define the sensory projections and EEG MEs correspond to our level in this hierarchy of projections. The sizes of these sensory selves are of order ME sizes ($L(EEG) = c/f(EEG)$) and thus or order Earth size at least. Thus TGD based view about sensory representations is a diametrical opposite of the standard view in which sensory representations are miniatures.

The construction of a more detailed model is based on the following assumptions.

a) Sensory qualia are at the level of primary sensory organs having their own magnetic bodies and entangled with the cognitive and symbolic representations of the perceptive field in brain in turn entangled with the points of the sensory magnetic canvas. The entanglement between primary sensory organs and brain and TGD based view about long term memory resolves the basic objections against this view, and one can understand the differences between sensory experience, imagination, dreams, and hallucinations and various strange phenomena like synesthesia, Anton's syndrome, and blind sight.

b) Second essential element is the mirror mechanism of long term memories. To remember something in the geometric past at temporal distance T is to look at a magnetic mirror with length $L = cT/2$. At quantum level quantum entanglement is involved and means sharing of mental images between recent me and the me of the geometric past (or some other self responsible for the memory representations). This requires that magnetic flux tubes involved with long term memories have astrophysical lengths with light year being the natural length unit. For magnetic fields this indeed makes sense. This picture can be applied to construct a model of long term episodal and declarative memories. The magnetic body (the "me") uses brain as a time mirror by generating a negative energy ME representing a signal propagating along magnetic flux tube to the brain and entangling magnetic body with brain. The negative energy ME is time reflected as a positive energy ME able to communicate classical information to the magnetic body possibly using p-adic cognitive code. Phase conjugate laser wave is the physical counterpart of negative energy ME.

c) Libet's findings about strange causal anomalies related to the passive aspects of consciousness support strongly the notion of magnetic body and lead to the conclusion that sensory experiences are geometric memories of magnetic body in time scale of .5 seconds about what happens in at the level of material body. Libet's findings about active aspects of consciousness in turn allow to conclude that motor activity is very much like active precognition and mirror image of sensory perception. A beautiful general scenario unifying sensory perception, long term memories, and motor action emerges and allows to explain phenomena like sensory rivalry difficult to understand in neuro-science framework. It must be however admitted that sensory canvas hypothesis is far from being established even in TGD framework: one can also defend the minimal model in which personal magnetic body is responsible only for the realization of long term memories and sensory, symbolic, and cognitive representations are realized only at the level of the material body.

d) Dark matter hierarchy based on a hierarchy of increasing values of Planck constant predicts a hierarchy of generalized EEGs. The generalized EEGs make it possible for the magnetic bodies to receive sensory information from biological body and quantum control it. The resulting detailed model of ordinary EEG predicts correctly the band structure and narrow resonance bands.

1.5.2 Quantum Model for Bio-Superconductivity

The model for generalized EEG relates very closely to the general model of high T_c superconductivity. This motivates a separate discussion of the vision about bio-super-conducitivity in TGD Universe.

1. General mechanisms of bio-superconductivity

The many-sheeted space-time concept provides a very general mechanism of superconductivity based on the 'dropping' of charged particles from atomic space-time sheets to larger space-time sheets. The first guess was that larger space-time sheets are very dry, cool and silent so that the necessary conditions for the formation of high T_c macroscopic quantum phases are met.

The possibility of large $\hbar$ quantum coherent phases makes however the assumption about thermal isolation between space-time sheets un-necessary. At larger space-time sheet the interactions of the charged particles with classical em fields generated by various wormhole contacts feeding gauge fluxes to and from the space-time sheet in question give rise to the necessary gap energy. The simplest model for Cooper pair is space-time sheet containing charged particles having attractive Coulombic interaction with the quarks and antiquarks associated with the throats of the wormhole contacts.

Wormhole contacts can be interpreted as Higgs type fields and photon massivation could be understood in terms of a coherent state of charged wormhole contacts. The coherent states of charged wormhole contacts and of Cooper pairs do not imply non-conservation of energy, charge, and fermion number in zero energy ontology.

A crucial element is quantum criticality predicting a new kind of superconductivity explaining the strange features of high T_c super-conductivity. There are two kinds of Cooper pairs, exotic Cooper pairs and counterparts of ordinary BCS type Cooper pairs. Both correspond to a large value of Planck constant. Exotic Cooper pairs are quantum critical meaning that they can decay to ordinary electrons. Below temperature $T_{c_1} > T_c$ only exotic Cooper pairs with spin are present and their finite lifetime implies that super-conductivity is broken to ordinary conductivity satisfying scaling laws characteristic for criticality. At T_c spinless BCS type Cooper pairs become stable and exotic Cooper pairs can decay to them and vice versa. An open question is whether the BCS type Cooper pairs can be present also in the interior of cell.

These two superconducting phases compete in certain narrow interval around critical temperature for which body temperature of endotherms is a good candidate in the case of living matter. Also high T_c superfluidity of bosonic atoms dropped to space-time sheets of electronic Cooper pairs becomes possible besides ionic super conductivity. Even dark neutrino superconductivity can be considered below the weak length scale of scaled down weak bosons.

Magnetic magnetic flux tubes and sheets are especially interesting candidates for supra current carries. In this case the Cooper pairs must have spin one and this is indeed possible for exotic Cooper pairs. The fact that the critical magnetic fields can be very weak or large values of $\hbar$ is in accordance with the idea that various almost topological quantum numbers characterizing induced magnetic fields provide a storage mechanism of bio-information.

This mechanism is extremely general and in principle works for electrons, protons, ions, charged molecules and even exotic neutrinos and an entire zoo of high T_c bio-superconductors, super-fluids and Bose-Einstein condensates is predicted. Of course, there are restrictions due to the thermal stability it room temperature and it seems that only electron, neutrino, and proton Cooper pairs are possible at room temperature besides Bose-Einstein condensates of all bosonic ions and their exotic counterparts resulting when some nuclear color bonds become charged.

2. Hierarchies of preferred p-adic length scales and values 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.

The hypothesis that Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1 + i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241..\}$ (the number theoretical miracle is that all the four p-adic length scales sith $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm) define scaled up copies of electro-weak and QCD type physics with ordinary value of $\hbar$ and that these physics are induced by dark variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$, and the resulting picture finds support from the ensuing models for biological evolution and for EEG [20]. This hypothesis - to be referred to as Mersenne hypothesis - replaces the earlier rather ad hoc proposal $r = \hbar/\hbar_0 = 2^{11k}$ for the preferred values of Planck constant.

3. Fractal hierarchy of magnetic flux sheets and the hierarchy of genomes

The notion of magnetic body is central in the TGD inspired theory of living matter. Every system possesses magnetic body and there are strong reasons to believe that the magnetic body associated with human body is of order Earth size and that there could be an entire hierarchy of these bodies with even much larger sizes. Therefore the question arises what one can assume about these magnetic bodies. The quantization of magnetic flux suggests an answer to this question.

1. The quantization condition for magnetic flux reads in the most general form as $\oint (p-eA)\cdot dl = n\hbar$. If supra currents flowing at the boundaries of the flux tube are absent one obtains $e\int B\cdot dS = n\hbar$, which requires that the scaling of the Planck constant scales up the flux tube thickness by r^2 and scaling of B by $1/r$. If one assumes that the radii of flux tubes do not depend on the value of r, magnetic flux is compensated by the contribution of the supra current flowing around the flux tube: $\oint (p - eA) \cdot dl = 0$. The supra currents would be present inside living organism but in the faraway region where flux quanta from organism fuse together, the quantization conditions $e\int B \cdot dS = n\hbar$ would be satisfied.

2. From the point of view of EEG especially interesting are the flux sheets which have thickness $L(151) = 10$ nm (the thickness of cell membrane) carrying magnetic field having strength of endogenous magnetic field. In absence of supra currents these flux sheets have very large total transversal length proportional to r^2. The condition that the values of cycloctron energies are above thermal energy implies that the value of r is of order 2^{k_d}, $k_d = 44$. Strongly folded flux sheets of this thickness might be associated with living matter and connect their DNAs to single coherent structure. One can of course assume the presence of supra currents but outside the organism the flux sheet should fuse to form very long flux sheets.

3. Suppose that the magnetic flux flows in head to tail direction so that the magnetic flux arrives to the human body through a layer of cortical neurons. Assume that the flux sheets traverse through the uppermost layer of neurons and also lower layers and that DNA of each neuronal nuclei define a transversal sections organized along flux sheet like text lines of a book page. The total length of DNA in single human cell is about one meter. It seems that single organism cannot provide the needed total length of DNA if DNA dominates the contribution. This if of course not at all necessarily since supra currents are possible and outside the organism the flux

sheets can fuse together. This implies however correlations between genomes of different cells and even different organisms.

These observations inspire the notion of super- and hyper genes. As a matter fact, entire hierarchy of genomes is predicted. Super genes consist of genes in different cell nuclei arranged to threads along magnetic flux sheets like text lines on the page of book whereas hyper genes traverse through genomes of different organisms. Super and hyper genes provide an enormous representative capacity and together with the dark matter hierarchy allows to resolve the paradox created by the observation that human genome does not differ appreciably in size from that of wheat.

1.5.3 Quantum Model for Hearing

The quantum model of hearing has evolved through several twists and turns. The emergence of zero energy ontology, the explanation of dark matter in terms of a hierachy 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. This also modified dramatically the speculative ideas about the role of neutrinos in hearing.

Also in the recent view long range weak 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 wheras 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, take this role.

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 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.

The model for hearing follows as a special case from the general model for sensory receptor and representations.

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 quantative 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.

1.5.4 TGD Inspired Model for Nerve Pulse

The basic idea behind the model of nerve pulse is that some kind of quantum jump reduces the magnitude of membrane potential below the threshold leading to the generation of nerve pulse. Several identification of this quantum jump have been discussed during years but no really convincing option has been found. The evolution of ideas about dark matter hierarchy and associated hierarchy of Planck constants led to a breakthrough in several sectors. The assignment the predicted ranged classical weak and color gauge fields to dark matter hierarchy was the crucial step and led among other things to a model of high T_c superconductivity predicting the basic scales of cell, to a generalization of the genetic code to a hierarchy of genetic codes.

1. Background

The basic philosophy behind the model is following.

1. In TGD Universe the function of EEG and its variants is to make possible communications from the cell membrane to the magnetic body and the control of the biological body by the magnetic body via magnetic flux sheets traversing DNA by inducing gene expression. This leads to the notions of super- and hyper-genome predicting coherent gene expression at level of organs and population.

2. The assignment the predicted ranged classical weak and color gauge fields to dark matter hierarchy was a crucial step in the evolution of the model, and led among other things to a model of high T_c superconductivity predicting the basic scales of cell, and also to a generalization of EXG to a hierarchy of ZXGs, WXGs, and GXGs corresponding to Z^0, W bosons and gluons.

3. Dark matter hierarchy and the associated hierarchy of Planck constants plays a key role in the model. For instance, in the case of EEG Planck constant must be so large that the energies of dark EEG photons are above thermal energy at the physiological temperature. The assumption that a considerable fraction of the ionic currents through the cell membrane are dark currents flowing along the magnetic flux tubes explains the strange findings about ionic currents through cell membrane. Concerning the model of nerve pulse generation, the newest input comes from the model of DNA as a topological quantum computer and experimental findings challenging Hodgkin-Huxley model as even approximate description of the situation.

4. The identification of the cell interior as gel phase containing most of water as structured water around cytoskeleton - rather than water containing bio-molecules as solutes as assumed in Hodkin-Huxley model - allows to understand many of the anomalous behaviors associated with the cell membrane and also the different densities of ions in the interior and exterior of cell at qualitative level. The proposal of Pollack that basic biological functions involve phase transitions of gel phase generalizes in TGD framework to a proposal that these phase transitions are induced by quantum phase transitions changing the value of Planck constant. In particular, gel-sol phase transition for the peripheral cytoskeleton induced by the primary wave would accompany nerve pulse propagation. This view about nerve pulse is not consistent with Hodkin-Huxley model.

2. New view about nerve pulse generation

The basic hypothesis has been that quantum jump takes the resting potential below the threshold for the generation of nerve pulse. One can imagine several manners for how this could happen. Quite recently I learned that nerve pulse propagation seems to be an adiabatic process and thus does not dissipate: the authors propose that 2-D acoustic soliton is in question. Adiabaticity is what one expects if the ionic currents are dark currents (large $\hbar$ and low dissipation) or even supra currents. Furthermore, Josephson currents are oscillatory so that no pumping is needed. Combining this input with the model of DNA as topological quantum computer (tqc) leads to a rather precise model for the generation of nerve pulse.

1. The system would consist of two superconductors- microtubule space-time sheet and the space-time sheet in cell exterior- connected by Josephson junctions represented by magnetic flux tubes defining also braiding in the model of tqc. The phase difference between two super-conductors would obey Sine-Gordon equation allowing both standing and propagating solitonic solutions. A sequence of rotating gravitational penduli coupled to each other would be the mechanical analog for the system. Soliton sequences having as a mechanical analog penduli rotating with constant velocity but with a constant phase difference between them would generate moving kHz synchronous oscillation. Also moving oscillations in EEG range can be considered and would require larger value of Planck constant in accordance with vision about evolution as gradual increase of Planck constant.

2. During nerve pulse one pendulum would be kicked so that it would start to oscillate instead of rotating and this oscillation pattern would move with the velocity of kHz soliton sequence. The velocity of kHz wave and nerve pulse is fixed by periodic boundary conditions at the ends of the axon implying that the time spent by the nerve pulse in traveling along axon is always a multiple of the same unit: this implies kHz synchrony. The model predicts the value of Planck constant for the magnetic flux tubes associated with Josephson junctions and the predicted force caused by the ionic Josephson currents is of correct order of magnitude for reasonable values of the densities of ions. The model predicts kHz em radiation as Josephson radiation generated by moving soliton sequences. EEG would also correspond to Josephson radiation: it could be generated either by moving or standing soliton sequences (latter are naturally assignable to neuronal cell bodies for which $\hbar$ should be correspondingly larger): synchrony is predicted also now.

3. The previous view about microtubules in nerve pulse conduction can be sharpened. Microtubular electric field (always in the same direction) could explain why kHz and EEG waves and nerve pulse propagate always in same direction and might also feed energy to system so that solitonic velocity could be interpreted as drift velocity. This also inspires a generalization of the model of DNA as tqc sine also microtubule-cell membrane systems are good candidates for performers of tqc. Cell replication during which DNA is out of game seems to require this and microtubule-cell membrane tqc would represent higher level tqc distinguishing between multi-cellulars and mono-cellulars.

4. New physics would enter in several manners. Ions should form Bose-Einstein cyclotron condensates. The new nuclear physics predicted by TGD predicts that ordinary fermionic ions (such as K^+, Na^+, Cl^-) have bosonic chemical equivalents with slightly differing mass number. Anomalies of nuclear physics and cold fusion provide experimental support for the predicted new nuclear physics. Electronic supra current pulse from microtubules could induce the kick of pendulum inducing nerve pulse and induce a small heating and expansion of the axon. The return flux of ionic Josephson currents would induce convective cooling of the axonal membrane. A small transfer of small positive charge into the inner lipid layer could induce electronic supra current by attractive Coulomb interaction. The exchange of exotic W bosons which are scaled up variants of ordinary $W^{\pm}$ bosons is a natural manner to achieve this if new nuclear physics is indeed present.

3. The function of neural transmitters

TGD leads to a general view about the functions of membrane oscillations, nerve pulse and neural transmitters. Electromagnetic membrane oscillations induced by Z^0 MEs provide a realization of the memetic code as a fundamental cognitive code. The binding of various information molecules to the corresponding receptors gives rise to neuronal qualia analogous to tastes and odors but providing information about external world whereas ordinary receptors give information about nearby environment. At our level of hierarchy these qualia probably correspond to emotions in consistency with the finding that neurotransmitters can be identified as information molecules. Neurotransmitters might be also seen as conscious links in quantum web. The view that inhibition actually requires active energy feed and that excitation occurs automatically in the absence of the energy feed and induces entanglement with environment, is defended. This view conforms with Huxley's vision about brain as a filter inhibiting conscious experiences.

4. Empirical evidence for axonal super-conductivity

A p-adic hierarchy of super-conductivities is the basic prediction of TGD inspired model of living matter. The many-sheeted model of the effective electronic super-conductivity explains at quantitative level the findings of Hafedh Abdelmelek and his group about the reduction of the axonal resistivity in the range of physiological temperatures. Although the original model is probably non-realistic the observations are consistent with the recent views about nerve pulse.

5. Microtubular level

The view about what happens at the micro-tubular level during synchronous neuronal firing relies on a many-sheeted model for sol-gel phase transitions as conscious bits and on the seesaw mechanism of remote metabolism according to which sol-gel transitions induces gel-sol transitions elsewhere in the cell and vice versa. Micro-tubular surfaces can be seen as analogs of cortical sensory and motor areas providing kind of conscious log files about sensory and motor history of the cell in terms of conformational transitions of tubulin dimers representing conscious bits.

What happens at the micro-tubular level during the nerve pulse, how gel phase differs from sol phase, and what occurs in sol-gel transition, belong to the principal challenges for quantum theories of consciousness. Charge entanglement associated with various bosonic ions allows to tackle these questions. The Bose-Einstein condensates of hydrogen atoms at tubular $k = 139$ space-time sheets form a bundle behaving like a liquid crystal identifiable as the gel phase. Positive and negative energy IR photons at energy of .1 eV belong to the predicted fractal hierarchy of metabolic currencies, and allow to control the stability of this B-E condensate so that a precisely targeted control of the cellular state by local sol-gel transitions becomes possible. Albrecht-Buehler has demonstrated that photons with this energy have a maximal effect on cells.

Negative energy MEs are especially important: they make possible intentional action at the micro-tubular level, they are crucial for the understanding of the micro-temporal quantum coherence, and have also inspired the notions of remote metabolism and quantum credit card. The newest discovery along this line is what might be called seesaw mechanism of energy metabolism. Seesaw mechanism minimizes dissipative losses and allows to understand how micro-tubular surfaces provide dynamical records for the cellular sol-gel transitions, and thus define fundamental micro-tubular representation of declarative long term memories. Also the notion of micro-tubuli as quantum antennae becomes precisely defined.

The model of DNA as topological quantum computer brings in a new element. Microtubule-axonal membrane system could perform topological quantum computation just as DNA-membrane (nuclear and perhaps also cell membrane) system has been proposed to do. The braiding of the magnetic flux tubes connecting microtubules to axon would define tqc programs and also provide a representations for sensory input from sensory organs in time scale shorter than millisecond if one assumes that gel-sol-gel transition of microtubule accompanies the nerve pulse. Whether one it one say that nerve pulse is initiated at microtubular or axonal level or by both collectively is not clear since the magnetic flux tubes connecting these two systems make them to act like single coherent whole.

1.5.5 Dark Matter Hierarchy and Hierarchy of EEGs

The emergence of zero energy ontology, the explanation of dark matter in terms of a hierachy 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.

Also long range weak forces 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. This leads to a correct prediction for the frequencies of peak sensitivity for photoreceptors - something highly non-trivial remembering that also the large parity breaking effects in living matter find a natural explanation. Second quantitative key observation was that for electrons and quarks the time scales of causal diamonds correspond to fundamental biorhythms assignable to central nervous system.

The general model for EEG follows neatly from this picture combined with the general model of high T_c superconductivity. A fractal hierarchy of EEGs and its generalizations identified in terms of Josephson radiation is predicted with levels labeled by p-adic length scales and the value of $\hbar$ at various levels of dark matter hierarchy. Cell membrane would represent only one level in this hierarchy. Besides EEG one would have its counterparts for various organs, organelles and even cell. Also the possibility of ZEG, WEG and QEG corresponding to Z^0 bosons, W bosons, and gluons must be considered.

1. Fractal hierarchy of EEGs

EEG is replaced with a fractal hierarchy of EEGs corresponding to various values of Planck constants involved.

1. There are three contributions to EEG besides the contributions due to the neural noise and evoked potentials. These contributions correspond to Schumann frequencies, cyclotron frequencies f_c of biologically important ions in magnetic field $B_{end} = .2$ Gauss, and to the Josephson frequencies f_J associated with Josephson junctions assigned with cell membranes. If Josephson radiation modulates cyclogtron radiation also the frqequencies $mf_J \pm nf_c$ appear in the spectrum.

2. In standard model $f_J = ZeV/\hbar$ would determined by the membrane potential and would correspond to energy in infrared. This sounds completely reasonable. TGD however suggests that cell membrane as a critical system correspond to an almost vacuum extremal. This predicts classical Z^0 field proportional to em field to which nuclei and neutrinos are assumed to couple. This would explain chiral selection in living matter and predict correctly the frequencies of peak sensitivity for photoreceptors as Josephson frequencies assignable to the biologically most important ions. The effective couplings of ions to membrane potential are modified and the Josephson frequencies correspond to energies in visible and UV range. Bio-photons and EEG could be seen as manifestations of one and same thing: Josephson radiation with a large value of Planck constant with energies of biophotons and frequencies of EEG.

3. An important point is that the ions involved must behave like bosons. For cyclotron condensates either Cooper pairs of ordinary fermionic ions or exotic ions chemically similar to their standard counterparts obtained from neutral bosonic atom by making one or more neutral color flux tubes connecting nucleons charged. For Josephson radiation only the latter option works. TGD based nuclear physics indeed predicts this kind of nuclei and there is experimental evidence for their existence.

4. For cyclotron frequencies the extremals are assumed to be far from vacuum extremals carrying very small classical Z^0 fields but nonvanishing classical W fields and color fields (with $U(1)$ holonomy). The corresponding flux quanta would naturally correspond to flux sheets traversing through DNA strands while Josephson radiation would propagate along flux tubes parallel to the cell membrane. Far from biological body one expects both kinds of flux quanta to fuse to form larger ones so that one has parallel space-time sheets carrying cyclotron *resp.* Josephson radiation. Wormhole contacts between Josephson and cyclotron flux sheets would induce a non-linear interaction giving rise to a superposition of harmonics of Josephson and cyclotron frequencies.

5. Josephson frequencies are assignable to the cell membrane and would naturally correspond to the communication of sensory data to the magnetic body. This would suggest that cyclotron frequencies are assignable to the magnetic flux sheets going through DNA strands responsible for quantum control via genome expression. This picture might be too naive. Josephson radiation would induce transitions between cyclotron states should generate sensory representations at magnetic body so that both frequencies would be involved with sensory representations. Furthermore, the identification of motor action as time reversal of sensory perception allwed by zero energy ontology would mean that same mechanisms are at work for negative energies (phase conjugate radiation). Resonance is achieved if the condition $mf_J = nf_c$ is satisfied. For small values of integers m and n the condition is quite restrictive. Schumann frequencies can be assigned with the magnetic body of Earth and would correlate with the collective aspects of consciousness.

6. The model of hearing forces to assume quite a wide spectrum of Planck constants- at least the values coming as powers of two and the safest assumption is that at least integer multiples of the ordinary Planck constant are possible. Josephson radiation and cyclotron radiation have same scale if $B_{end} \propto 1/\hbar$ proportionality holds true. For 5 Hz Josephson frequency and membrane potential and for V=.70 mV corresponding to the resting potential of neuron one obtains $r = (0.96, 1.20, 1.34, 1.01) \times 2^{47}$. For Ca^{++} ion r is very near to a power of 2.

2. Basic aspects of EEG

Consider now how one could understand basic characteristics of EEG during wake-up and sleep in this framework.

1. For small amplitudes and for the lowest harmonics this implies that alpha band to which the cyclotron frequencies most biologically important bosonic ions corresponds has as satellites theta and beta bands. Higher harmonics correspond to gamma and higher bands having also satellites.

2. For large amplitudes EEG becomes chaotic which is indeed the property of beta band during say intense concentration or anxiety. The findings of Nunez about narrow 1-2 Hz wide bands at 3,5,7 Hz and 13,15,17 Hz confirm with the prediction of satellite bands and fix the Josephson frequency to 5 Hz. This picture explains the general characteristics of EEG in wake-up state qualitatively and quantitatively.

3. In order to understand the characteristics during various stages of deep sleep one must assume that the cyclotron frequency scale of ions is scaled down by a factor of 1/2. The simplest explanation is that the value of Planck constant increases by a factor 2 in a phase transition having interpretation as a leakage of cell membrane space-time sheet between the pages of Big Book defined by the generalized imbedding space. During stage 4 sleep only only DNA cyclotron frequencies in delta band are around 1 Hz and just above the thermal threshold are predicted to be present. This stage could correspond to a value of Planck constant which is 4 times its value in wake-up state.

The generalization of the model for EEG hierarchy to the case of ZEGs is straightforward and Josephson frequency spectrum is the same. Any atom, almost always boson, has an exotically charged counterpart with same statistics so that very rich spectrum of Bose-Einstein condensates results.

3. The effects of ELF em fields on brain

The experimental data about the effects of ELF em fields at cyclotron frequencies of various ions in Earth's magnetic field on vertebrate brains were crucial for the development of the model of EEG. As a matter fact, it was the attempt to explain these effects, which eventually led to the discovery of the fractal hierarchy of EEGs and its generalizations.

The reported effects occur for harmonics of cyclotron frequencies of biologically important ions in Earth's magnetic field. They occur only in amplitude windows. The first one is around 10^{-7} V/m and second corresponds to the range $1-10$ V/m: the amplitudes of EEG waves are in the range 5-10 V/m. The effects are present only in the temperature interval 36-37 C.

1. Cyclotron frequencies led to the vision about cyclotron condensates of biologically important ions and their Cooper pairs at the flux quanta of dark magnetic field with so large Planck constant that the energies of cyclotron photons are above thermal threshold. The model for EEG and biophotons in terms of Josephson radiation from cell membrane which is almost vacuum extremal allows to make this model more quantitative.

2. The temperature window has one interpretation in terms of a competion of almost vacuum extremal property of cell membrane possible above some critical temperature and high T_c superconductivity possible below some critical temperature.

3. The amplitude window 10^{-7} V/mfollows from a quantized form of Faraday law whose existence is supported by the fact that space-time sheets are analogs of Bohr orbits in exact sene. The quantisation condition relates the amplitude of electric field to Planck constant and frequency. For the value $r = \hbar/\hbar_0 = 2^{47}$ of Planck constant required by 5 Hz Josephson frequency the 10^{-7} V/m amplitude is predicted correctly.

4. The amplitude window around 1-10 V/m (EEG amplitudes are in the range 5-10 V/m) follows if the values of Planck constant in the range $10^7r - 10^8r$ can be justified. A possible justification is based on the observation that for $r_1 = 10^8r$ the Compton wave length of intermediate gauge bosons corresponds to $k = 163$ defining Gaussian Mersenne and wavelength corresponding to 2 eV energy for photon which also corresponds to bio-photon energies assignable to 70 mV resting potential of neuron membrane. Electron's Compton length corresponds for $r_1 = 10^8r$ to 28 cm, which defines the size scale of brain. One might hope that these findings could allow to build an internally consistent story about what happens.

4. Vision about biological evolution and evolution of brain

The proposed model for EEG, the idea that Gaussian Mersennes (four of them are in the range 10 nm-2.5 micrometers) define p-adic length scales allowing exotic variants of color and electro-weak physics with light intermediate gauge bosons at space-time sheets near vacuum extremals, and the assumption that the preferred values of Planck constant are such that they relate these p-adic scales to each other leads to a detailed quantitative vision about evolution of life as emergence of longer scales belonging to this hierarchy and as special case also to a vision about evolution of cell, nervous system, EEG, and long term memory. The model predicts a hierarchy of preferred size scales for various sub-systems of organisms and corresponding time scales identifiable in terms of bio-rhythms and memory span.

1.5.6 Quantum Model for EEG

In the previous chapter the overall TGD based view about EEG was discussed. According to this view, the basic function of EEG is to induce cyclotron phase transitions at the magnetic body and thus to produce what might be called higher level sensory qualia identified as emotions and cognitions. In this chapter the relationship between EEG and nerve pulse patterns is discussed in TGD framework.

The relationship between nerve pulse patterns and EEG (also ZEG) is one of the basic challenges of the theory. The question is whether nerve pulse patterns could give rise to EEG patterns and vice versa, and what could be the underlying mechanisms. The deep difference between TGD and the conventional neuroscience is the presence of the hierarchy of magnetic bodies, cyclotron transitions, and MEs. This makes possible to consider alternatives for the identification of EEG resonance frequencies as resonance frequencies of nerve circuits.

Nerve pulses generate EEG MEs and the frequency of the nerve pulses determines the rate at which EEG MEs are generated rather than the frequency of EEG MEs. Pendulum metaphor suggests how spike patterns amplify EEG waves at frequencies, which appear as resonances in the autocorrelation function of the spike sequence: when the pendulum is kicked at correct half of its period its oscillation frequency remains unchanged but amplitude and phase suffer discontinuous changes. The EEG waves generated by subsequent nerve pulses tend to interfere constructively resulting in amplification if the EEG frequency corresponds to a resonance frequency of the spike autocorrelation function.

1. *Generalization of the model for sensory receptor and new view about hearing*

The relationship between nerve pulse patterns and EEG (also ZEG) is one of the basic challenges of the theory. The question is whether nerve pulse patterns could give rise to EEG patterns and vice versa, and what could be the underlying mechanisms. In TGD framework on ecan consider alternatives for the identification of EEG resonance frequencies as resonance frequencies of nerve circuits and dark matter hierarchy challenges the earlier speculative TGD inspired models for sensory qualia and sensory organ. An updating of the capacitor model of the sensory receptor by replacing the capacitor with Josephson junctions between sensory organ and its magnetic body must be considered. The question arises whether sensory organs define not only sensory, but also corresponding cognitive and emotional representations. The fact that nerve pulses tend to destroy the temporal coherence of cognitive and emotional representations encourages the identification of glial cells and their magnetic bodies as carriers of higher level cognitive and emotional representations. The model of hearing leads to further ideas. For instance, the transformation of the sensory input to signals propagating along axonal microtubuli could make possible to feed sensory input into brain and possibly back to sensory organs at least in the case of vision and hearing.

2. *Features*

Walter Freeman has identified spatially amplitude modulated synchronous but non-periodic EEG patterns serving as correlates for conscious percepts. The identification as MEs is possible and the spectrum of durations for the synchronous time patterns encourages the interpretation of these patterns as an electromagnetic realization of genetic code words. A compression of memetic code words defined by the nerve pulse patterns giving rise to abstraction and classification would be in question. The representation would be achieved by the amplitude modulation of the alpha waves by higher harmonics of alpha frequencies. In the case of hearing the contraction seems to be un-necessary and memetic code could perhaps be realized also at the level of features. This would explain the completely exceptional role of the language in cognition.

3. Synchronization

Synchronization in and between various cortical areas is known to occur with millisecond precision. Also disjoint brain regions can be in synchrony. This is difficult to understand without synchronizing agent oscillating at kHz frequency. In TGD framework magnetic body is the natural agent inducing the synchrony and MEs could induce the synchronization. Synchronization would naturally occur at the frequency corresponding to a duration of the bit of the memetic code.

4. Stochastic resonance

Concerning the mapping of EEG frequencies to nerve pulse patterns, stochastic resonance promotes itself as a basic mechanism. In bistable systems stochastic resonance allows to amplify very weak periodic signals by utilizing white noise. Stochastic resonance is known to be relevant also at the neuronal level as demonstrated by the autocorrelation functions for spike sequences exhibiting peaks at the harmonics of the signal frequency. Neuron is however far from being bistable system, and this raises the question whether bi-stability might be present at some deeper quantal level.

5. Temporal codings

The conventional view that the information content of conscious experience is determined completely by rate coding from nerve pulse patterns does not seem plausible in TGD framework. Indeed, p-adic cognitive codes define an entire hierarchy of binary codes associated with the p-adic frequencies and frequency coding would apply only to the average intensity of the sensory input. For high stimulus intensities the duration of the bit of the p-adic cognitive codeword tends to become shorter. This is comparable to the increase of the speech rate during a high state of arousal, and conforms with the observed shift of EEG towards higher frequencies in this kind of situation. There is a lot of experimental evidence supporting the existence of various kinds of temporal codings, and these codings are discussed in TGD framework.

6. Scaling law

Scaling law provides bird's eye view about transitions which can represent conscious-to-us qualia at given level of the p-adic self hierarchy. The law relates two levels of self hierarchy corresponding to mental images associated with magnetic bodies of astrophysical size and with physical bodies, the latter with size not much larger than brain size. Scaling law assumes that self sizes L at given p-adic level k are between the p-adic length scales $L(k)$ and $L(k(next))$. Scaling law is of form $L = v/f$ and relates ELF self size characterized by ELF frequency f to the self size L and to the effective phase velocity v of the EEG wave.

Scaling law also suggested by the experimental work with the effects of ELF radiation in water. Scaling law can be explained in terms of phase transitions transforming large hbar photons to ordinary ones and vice versa. The chapter ends with the discussion about possible implications of the scaling law concerning EEG.

Bibliography

Books about TGD

[1] M. Pitkänen (2006), *Topological Geometrodynamics: Overview*.
http://tgd.wippiespace.com/public_html/tgdview/tgdview.html.

[2] M. Pitkänen (2006), *Quantum Physics as Infinite-Dimensional Geometry*.
http://tgd.wippiespace.com/public_html/tgdgeom/tgdgeom.html.

[3] M. Pitkänen (2006), *Physics in Many-Sheeted Space-Time*.
http://tgd.wippiespace.com/public_html/tgdclass/tgdclass.html.

[4] M. Pitkänen (2006), *p-Adic length Scale Hypothesis and Dark Matter Hierarchy*.
http://tgd.wippiespace.com/public_html/paddark/paddark.html.

[5] M. Pitkänen (2006), *Quantum TGD*.
http://tgd.wippiespace.com/public_html/tgdquant/tgdquant.html.

[6] M. Pitkänen (2006), *TGD as a Generalized Number Theory*.
http://tgd.wippiespace.com/public_html/tgdnumber/tgdnumber.html.

[7] M. Pitkänen (2006), *TGD and Fringe Physics*.
http://tgd.wippiespace.com/public_html/freenergy/freenergy.html.

Books about TGD Inspired Theory of Consciousness and Quantum Biology

[8] M. Pitkänen (2006), *TGD Inspired Theory of Consciousness*.
http://tgd.wippiespace.com/public_html/tgdconsc/tgdconsc.html.

[9] M. Pitkänen (2006), *Bio-Systems as Self-Organizing Quantum Systems*.
http://tgd.wippiespace.com/public_html/bioselforg/bioselforg.html.

[10] M. Pitkänen (2006), *Quantum Hardware of Living Matter*.
http://tgd.wippiespace.com/public_html/bioware/bioware.html.

[11] M. Pitkänen (2006), *Bio-Systems as Conscious Holograms*.
http://tgd.wippiespace.com/public_html/hologram/hologram.html.

[12] M. Pitkänen (2006), *Genes and Memes*.
http://tgd.wippiespace.com/public_html/genememe/genememe.html.

[13] M. Pitkänen (2006), *Magnetospheric Consciousness*.
http://tgd.wippiespace.com/public_html/magnconsc/magnconsc.html.

[14] M. Pitkänen (2006), *Mathematical Aspects of Consciousness Theory*.
http://tgd.wippiespace.com/public_html/mathconsc/mathconsc.html.

[15] M. Pitkänen (2006), *TGD and EEG*.
http://tgd.wippiespace.com/public_html/tgdeeg/tgdeeg.html.

References to the chapters of the books about TGD

[16] The chapter *TGD as a Generalized Number Theory: Quaternions, Octonions, and their Hyper Counterparts* of [5].
http://tgd.wippiespace.com/public_html/tgdnumber/tgdnumber.html#visionb.

[17] The chapter *TGD as a Generalized Number Theory: p-Adicization Program* of [5].
http://tgd.wippiespace.com/public_html/tgdnumber/tgdnumber.html#visiona.

[18] The chapter *Dark Forces and Living Matter* of [6].
http://tgd.wippiespace.com/public_html/paddark/paddark.html#darkforces.

[19] M. Pitkänen (2006), *Physics in Many-Sheeted Space-Time.*
http://tgd.wippiespace.com/public_html/tgdclass/tgdclass.html.

[20] The chapter *Was von Neumann Right After All* of [3].
http://tgd.wippiespace.com/public_html/tgdquant/tgdquant.html#vNeumann.

[21] The chapter *TGD and Astrophysics* of [4].
http://tgd.wippiespace.com/public_html/tgdclass/tgdclass.html#astro.

References to the chapters of the books about TGD Inspired Theory of Consciousness and Quantum Biology

[22] The chapter *Many-Sheeted DNA* of [12].
http://tgd.wippiespace.com/public_html/genememe/genememe.html#genecodec.

[23] The chapter *Topological Quantum Computation in TGD Universe* of [12].
http://tgd.wippiespace.com/public_html/genememe/genememe.html#tqc.

[24] The chapter *Dark Matter Hierarchy and Hierarchy of EEGs* of [13].
http://tgd.wippiespace.com/public_html/tgdeeg/tgdeeg.html#eegdark.

[25] The chapter *Quantum Theory of Self-Organization* of [9].
http://tgd.wippiespace.com/public_html/bioselforg/bioselforg.html#selforgac.

[26] The chapter *Genes and Memes* of [12].
http://tgd.wippiespace.com/public_html/genememe/genememe.html#genememec.

Articles related to TGD

[27] Pitkänen, M. (1983) International Journal of Theor. Phys. ,22, 575.

Mathematics

[28] T. Eguchi, B. Gilkey, J. Hanson (1980). Phys. Rep. 66, 6, 1980.

[29] Wallace (1968): *Differential Topology.* W. A. Benjamin, New York.

[30] Spivak, M. (1970): *Differential Geometry I,II,III,IV.* Publish or Perish. Boston.

[31] Hawking, S.,W. and Pope, C., N. (1978): *Generalized Spin Structures in Quantum Gravity.* Physics Letters Vol 73 B, no 1.

[32] Thom, R. (1954): Commentarii Math. Helvet., 28, 17.

[33] Eisenhart (1964), *Riemannian Geometry.* Princeton University Press.

[34] G. W. Gibbons, C. N. Pope (1977): *CP_2 as gravitational instanton.* Commun. Math. Phys. 55, 53.

[35] Milnor, J. (1965): *Topology form Differential Point of View.* The University Press of Virginia.

[36] Pope, C., N. (1980): *Eigenfunctions and $Spin^c$ Structures on CP_2* D.A.M.T.P. preprint.

Cosmology and astrophysics

[37] D. Da Roacha and L. Nottale (2003), *Gravitational Structure Formation in Scale Relativity.* astro-ph/0310036.

Chapter 2

Magnetic Sensory Canvas Hypothesis

2.1 Introduction

There are very general objections against the idea that the ultimate sensory representations are inside brain. For instance, any computer scientist, unless informed about materialistic dogmas, would argue that the processing of the sensory data must be separated from its representation. How this could occur if sensory and other representations are realized inside brain, is however difficult to see. The classical experiments of Libet relating to the active and passive aspects of conscious experience [71, 123, 61] provide a strong empirical support for the view that signals from central nervous system (CNS) spend .3-.5 seconds to propagate somewhere else. If the propagation occurs with the velocity of light, the distance in question is measured using the circumference of the Earth as a natural unit.

2.1.1 Sensory canvas hypothesis

In TGD approach these objections lead to the view that the magnetic flux tube structures associated with the central nervous system (CNS) could define a hierarchy of sensory, symbolic, and cognitive representations outside brain with magnetic flux quanta of the magnetic bodies serving as the canvas to which place coding by magnetic frequency generates sub-selves (mental images about "simple feeling of existence") and associates with them various sensory qualia and symbolic and cognitive features by quantum entanglement. Thus brain could be much like a RAM memory containing a collection of features in random order and the ordering would be induced only by the sensory map to the magnetic sensory canvas. Are our sensory representations at the magnetic flux tubes of Earth's magnetic field or are personal magnetic bodies needed? Since space travellers experience the world very much like us and have survived, the most plausible conclusion is that the magnetic sensory canvas is personal. This conclusion is also supported by the fact that the value of the magnetic field explaining the harmonics of 15 Hz as Ca^{++} cyclotron frequencies is .2 Gauss rather than .5 Gauss.

2.1.2 Why the world is not experienced to rotate as head rotates?

The question which originally led to the notion of the sensory magnetic canvas was "Why the world is not experienced to rotate as head rotates?". If one assumes that sensory representations are completely inside the cortex and that the positions of various visual mental images in the visual cortex remain fixed with respect to cortex as is done in the standard neuroscience, the entire sensory representation rotates thus with the head and one could argue that the world is experienced to rotate.

If one accepts the sensory magnetic sensory canvas hypothesis situation changes. Assuming that

1. the objects of the perceptive field induce sensory mental images (sub-selves) already at the level of sensory organs (in particular, retinas) and representations at corresponding magnetic bodies;

2. these mental images, being self-organization patterns, whose boundaries are determined by the gradients of illumination, do not rotate as the head or eye rotates;

3. the points of the retina correspond to fixed points of the visual cortex in topographic manner;

4. the projections to the sensory magnetic canvas from the visual cortex occur orthogonally;

one can answer the question. Note that the personal sensory magnetic body is fixed with respect to head and rotates with it whereas the representation projected to it and defining a self-organization pattern does not. In other words, magnetic body acts like a canvas.

MEs define this sensory projection and EEG MEs correspond to our level in this hierarchy of projections. The sizes of these sensory selves are of order ME sizes ($L(EEG) = c/f(EEG)$) and thus or order Earth size at least. Thus TGD based view about sensory and other representations is a diametrical opposite of the standard view in which sensory representations are miniatures.

Some comments about terminology are in order. Sensory representations involve besides the primary sensory qualia the symbolic representations constructed by brain giving meaning for the sensory input. I will use also the phrase "cognitive representation". Space-time correlates for cognitive representations are tentatively identified as p-adic space-time sheets coinciding with real space-time sheets in resolution defined by some cutoff length scale: in general the intersection with real space-time sheets is discrete set of rational points common to reals and p-adic number fields. p-Adic space-time sheets are also identified as correlates for intentions and the realization of intention as action is tentatively identified as a quantum jump replacing p-adic space-time sheet with a real one in such a manner that conservation laws are satisfied.

2.1.3 Model for the sensory representations

The construction of a more detailed model is based on the following assumptions.

1. Sensory qualia are at the level of primary sensory organs having their own magnetic bodies and entangled with the cognitive and symbolic representations of the perceptive field in brain in turn entangled with the points of the sensory magnetic canvas. The entanglement between primary sensory organs and brain and TGD based view about long term memory resolves the basic objections against this view, and one can understand the differences between sensory experience, imagination, dreams, and hallucinations and various strange phenomena like synesthesia, Anton's syndrome, and blind sight.

2. Second essential element is the mirror mechanism of long term memories. To remember something in the geometric past at temporal distance T is to look at a magnetic mirror with length $L = cT/2$. At quantum level quantum entanglement is involved and means sharing of mental images between recent me and the me of the geometric past (or some other self responsible for the memory representations). This requires that magnetic flux tubes involved with long term memories have astrophysical lengths with light year being the natural length unit. For magnetic fields this indeed makes sense. This picture is of course dramatically over-simplified. A more realistic model of long term episodal and declarative memories in which the magnetic body uses time mirror mechanism by sending entangling negative energy ME to the brain making possible sharing of mental images. From brain negative energy MEs are time reflected back as positive energy MEs and are possibly amplified. Positive energy MEs can give rise to classically communicated declarative memories. This means that the distance along a flux tube of the personal magnetic body codes for the temporal distance to geometric past.

3. The already mentioned findings of Libet about strange causal anomalies related to the passive aspects of consciousness lead to the conclusion that sensory experiences are geometric memories of the personal magnetic body in time scale of .3-.5 seconds about what happens in at the level of material body. Libet's findings about active aspects of consciousness in turn allow to conclude that also motor activity must involve time mirror mechanism with negative energy topological light rays sent to the geometric past and inducing the neural activity as a response. Without this mechanism we could not survive using .3-.5 seconds old sensory data. A beautiful general scenario for the realization of intentions and unifying sensory perception, long term memories, and motor action emerges and allows to explain phenomena like sensory rivalry difficult to understand in neuroscience framework.

The flux tube structure associated with the Earth's magnetic field could define or at least closely relate sensory canvases of Mother Gaia and of smaller magnetospheric selves. It is quite conceivable that also magnetosphere contains various kinds of representations of the information from brain and body. The local direction of Earth's magnetic field at cortex should fix the orientation of the projectors associated with the sensory representations in the co-rotating inner magnetosphere. Pyramidal neurons contain magnetic crystals and also haemoglobin molecules are magnetic and their alignment with the local magnetic field of Earth would make this possible.

These representations could be responsible for the third person perspective which is also an integral part of our consciousness: the mechanism providing the third person aspect would be sharing of the mental images by quantum entanglement. Out-of-body experiences and near death experiences could be one particular manifestation for this component of consciousness. The magnetospheric representations could be also responsible for long term memory representations.

There are reasons to believe that also the non-rotating outer magnetosphere might contain representations. For these representations the projectors should be parallel to the flux tubes of a magnetic field which is stationary with respect to Earth. The flux tubes of the outer magnetosphere might be able to penetrate to some extent the inner magnetosphere and attach to brain or body. For instance, the magnetic field created by the magnetic particles in lungs is of the same magnitude as the magnetic field in the plasma sheet at the night side of Earth.

2.1.4 EEG as a communication and control tool of magnetic body

The progress made during the year 2005 in the understanding of the dark matter hierarchy stimulated a quantum leap in many branches of TGD with the model of the magnetic body included. This forced some updating of also this chapter although I tried to not destroy the original flavor of the chapter. I also added a section about about a hierarchy of generalized EEGs associated with the dark matter hierarchy making possible for the magnetic bodies to receive sensory information from biological body and quantum control it. The chapter "The Hierarchy of Generalized EEGs and Dark Matter Hierarchy" [20] provides a detailed vision about magnetic body as an intentional agent receiving sensory input from the biological body and using it as a motor instrument.

In this chapter a general vision about the magnetic sensory canvas hypothesis is discussed. The discussion continues in [22]. These chapters are not a reviews of the final results after the dust has settled but document the development of ideas as it has occurred and is still occurring. There are many mammoth bones and little inconsistencies, and often the simple final picture is achieved by a lot of painful sidetracking. The very name "Magnetic sensory canvas hypothesis" of this chapter is a good example of this problem: both symbolic, cognitive and sensory mental images entangle with the magnetic body so that the attribute "sensory" is somewhat misleading. Furthermore, motor control aspect is equally important. Perhaps a better title would be "Magnetic body hypothesis". My sincere apologies for the reader for this: I can do only my best!

2.2 Where me is?

A concrete model of consciousness requires a specification of the self that I am used to call "me". The standard neuroscience approach would not hesitate in identifying "me" with the neural activities or of their seat and thus localizing it inside head. The notions of the many-sheeted space-time and ELF ME allow to take a fresh look at the problem.

2.2.1 Is "me" outside my body or does it contain it?

There are several both TGD based arguments and arguments based on basic facts about sensory experiencing supporting the view that "me" is not completely inside my head or physical body. More precisely, it might be possible to identify visual and auditory fields more or less as an extension of my body as the following arguments suggest.

1. p-Adic cognitive maps discussed [16] map typically inside to outside and vice versa. Does this imply that the cognitive and sensory maps of the external world are outside my body? Am I looking the sensory image of the external world in the spherical mirror provided by my brain. I know that the image of the external world is in question but I do not realize that I am not that

image. Of course, "me" could contain also the body and the sensory mental images about body would be located in body region and help to generate the illusion that I am nothing but my body, or actually brain as well-informed neuroscientist would believe. To get rid of the mirror illusion one must break the mirror and physical death is the final manner to achieve this. Near death experiences indeed involve the experience of looking one's own body from outside (these experiences are discussed in [24] and [34]).

A further interesting point is that imbedding-space points p-adically near to each other are faraway in the real sense. Simple intentions have p-adically small space-time sheets as their correlates and corresponding desires represented by their real counterparts have a maximal number of rational imbedding space points in common. Thus simple desires have large real space-time sheets as their correlates. Therefore astrophysical and even cosmic length scales are natural for cognition and intention, and the evolution of cognition from small to large length scales in a p-adic sense corresponds to the evolution from long towards short real length scales like a carving of a statue by adding details. The learning of a motor skill proceeding from clumsy whole-body movements to refined movements involving a minimal number of body parts is an excellent example of this aspect of cognitive evolution.

2. The paradigm of four-dimensional brain leads to believe that long term memories are perceptions with the objects of the perceptive field located in the geometric past (and Libet's experiments lead to the conclusion that sensory percepts are memories in time scale of .5 seconds!). But why not also the objects of visual and auditory field *spatially* external to me should not be sensorily represented outside my body. Same applies also to the parts of body external to the brain. This leaves several options. For instance, fundamental sensory representations could be realized using entanglement with the objects of the perceptive field as an auxiliary tool to deduce distances and sizes of objects of the perceptive field. Perceptive field would in some sense become a part of its sensory representation. It could also be that sensory representations occur at magnetic bodies and in quite different length scales.

We indeed experience external world like an external observer looking at the projection of the image of the external world on a sensory canvas defined by brain: the orientation or motion of canvas does not matter.

2.2.2 Sensory canvas hypothesis and some problems related to sensory representations

There are several basic problems related to the sensory representations, which could be solved if "me" is outside my body.

Problems with reference frames

The problems related to reference frames associated with retina, head and body result if one assumes that the reference frame of the conscious observer is that of brain as is natural to assume if brain is the seat of conscious experience.

1. Retina defines the reference frame for patterns of neural activity and topographical mapping of neural activity in retina to the visual cortex means that the motion of eye induces a motion of the pattern of neural activity inside brain. Why saccadic motion or larger scale rotation of eye (resulting from the change of the direction of gaze) does not give rise to experienced motion of the external world relative to head?

2. Also my head and body can move. Why I do not experience world moving around when I turn my head or move my body? The picture of world at the surface of cortex changes its position certainly. It is difficult to imagine how brain could be able to compute and make the corrections cancelling *totally* this sensation.

Essentially brain is able to experience the external world as it would look like if seen from outside with eyes and brain serving as a moving canvas at which the visual information is projected. That is: the conscious observer effectively looks the situation, not in the reference frame of the head, but in the reference frame of the environment. As if the sensory representation (defined to include also symbolic and cognitive aspects besides purely sensory aspects) would be realized outside cortex at some kind of canvas stationary with respect to head by utilizing the topographic map between retina and visual cortex, and by projecting data from the visual cortex in a direction orthogonal to it. Although the head and canvas rotate, the projected sensory picture realized as a self-organization pattern, would remain stationary.

Problems related to stereovision and perspective

There are also problems related to the stereo vision.

1. How the position coordinate of the objects of the external world orthogonal to the retina is represented in cortex. How the three-dimensional representation is possible inside the very thin cortex? It seems that there is a projective mapping involved mapping the exterior of sphere to its interior but how can we experience the inverse of it, if the inverse mapping is not realized physically somehow?

2. The standard argument is that stereo vision produces three-dimensionality, is not totally convincing. Contrary to what text books tell me to experience, I stubbornly see three-dimensionally also using single eye (I have not tested how long this heretic sensory perception lasts). Note that one must make a clear difference between stereo vision as sensory experience and as cognitive experience with information about distances.

3. There is no doubt that the distances of objects of the perceptive field are determined somehow by brain but how they are represented consciously? Again, a projection to the external world is the most natural manner to represent the result of the computations realistically.

4. If sensory representations are realized outside brain, the phenomenon of the perspective would become trivial since it is the basic aspect of projective geometry. More precisely, the distance resolution ΔL for the objects of perceptive field is essential. The angular resolution for objects decreases as $\Delta\theta = \Delta L/R$ as a function of distance of the objects so that very distant objects with a given spatial separation cannot be resolved for each other. If the tracks of the railroad cannot be resolved very far from each other, it is natural to expect that they are experienced to converge to single point.

2.2.3 Are the primary sensory organs the seats of sensory qualia?

There are also many strange facts about sensory perception, which cease to be so strange if "me" is outside my body or rather, contains it. The most elegant picture results when one assumes that primary sensory qualia are seated at the level of sensory organs, and entangle with the cognitive and symbolic representations produced by brain. These mental images in turn would entangle with the magnetic body of astrophysical size.

1. Imagination could be understood as perception without sensory qualia. During dreaming and presumably also hallucinations the back-projection into eyes would "qualiafy" the symbolic representations. The movements of eyes during REM sleep could be understood as a part of this process. Similar phenomenon is associated also with ears: here Z^0 magnetic flux tubes might be involved with the back projection and auditory canvas might be Z^0 magnetic body. It is perhaps not a mere coincidence that the frequency $f \sim 10^3$ Hz which corresponds to a wavelength of order head size is critical frequency from the point of view of the neurophysiology of hearing, and that the duration of a single bit of the memetic codon is of the order of millisecond. That physical pain is not experienced during dreams would be due to the natural absence of the back-projections producing pain.

2. The hallucinations in which some objects of the perceptive field are either miniature sized of gigantic could be understood. The back-projection to the retinae would realize faithfully the unrealistic relative sizes of the imagined objects.

3. The phenomenon of phantom leg could be understood if the mirror mechanism of long term memories is accepted. Phantom leg would in the geometric past and the pain would be remembered pain or rather, sharing of the pain experienced in the geometric past subjectively now. Phantom leg could be also genuine in the sense that it could consist of magnetic flux tube structures and MEs which remain when the biological organization at the atomic space-time sheet is destroyed.

4. How do I know that nerve pulse activity represents something outside my material body and not inside it? How do I know that the sound I hear does not originate inside my head? If the basic sensations are created already at the level of sensory organs, the boundary between internal and external worlds, it is easier to understand why we can make this distinction. If one accepts the possibility of entanglement of the sensory organs with the objects of the perceptive field, it is even easier to understand why we are able to tell that the sound originates from the external world. This would also help to deduce the distances and sizes of the objects of the perceptive field.

5. This general view generalizes also to the motor actions. In some sense, motor imagination would be a motor action starting from some level above muscles and proceeding backwards in the geometric time. Thoughts as internal speech could be understood as a special case of this mechanism. Of course, the mechanism must involve both time directions and a more precise view about motor action as time reversal of memory recall, reducing at the limit of short time spans to sensory perception, will be discussed later.

Of course, one can invent objections against sensory magnetic canvas hypothesis and the hypothesis that primary sensory qualia are seated at the level of sensory organs.

1. Microwave hearing is a phenomenon in which microwaves generate a sensation of hearing [42]. There are several reasons to believe that the primary stimulus does not enter the ears but cortex [22]. The hypothesis that sensory organs are the seats of the sensory qualia can be saved only if a back-projection from cortex to ears is involved. Microwave MEs would be able to generate something analogous to electrical stimulation of auditory areas. Note that back-projections to ears can generate oto-acoustic sounds heard even by outsiders. The auditory back projections could be realized also in terms of membrane oscillations. The back projection to eyes could also involve em MEs at visible frequencies.

2. If odors and tastes reduce to the binding of the chemicals to the sensory receptors, it is difficult to imagine that back-projection mechanism could produce odor hallucinations. Hence either long term sensory memories or, less probably, sharing of mental images by quantum entanglement should be in question. One can of course question the hypothesis that odor qualia require the chemical binding: there is evidence [47] that the odor perception of insects is analogous to infrared vision, seeing the infrared light generated by the odorant molecules [26]. Moreover, olfactory receptors resemble visual receptors. If so, then odor sensations might be produced also by back-projection mechanism using IR MEs. Also hallucinated pain could be used as an objection since it is difficult to imagine why evolution would or could have produced a back-projection for the pain sensation. Long term memories as in the case of phantom pain could be however in question.

3. Is the sensory magnetic canvas really needed for sensory representations? Could the magnetic bodies associated with sensory organs be enough so that our magnetic body would be like a trees with roots identifiable as magnetic bodies of the sensory organs and carrying the fundamental sensory representations. Higher level symbolic and cognitive representations corresponding to the branches of the tree yielded by cortex would entangle with the sensory world represented by the roots. Brain would be really analyzer not the builder of sensory experience in this view.

   The requirement that long term memories are there, forces the introduction of the personal magnetic body with astrophysical size. It would be also in a conflict with fractality to exclude the entanglement in the length scale of the personal magnetic body if it is allowed in shorter length scales. This objection however forces to take seriously the possibility that the representations at the personal/cortical magnetic body are very abstract, and that the topographical mapping of the perceptive field to the personal magnetic body is un-necessary. One possibility is that the personal magnetic body is specialized to geometric memories with the length of magnetic flux tube defining the time span of the memory quite generally. In fact, the experimental findings of Libet force to conclude that sensory perception is a particular case of geometric memory.

4. This line of view forces to consider the possibility that seeing the object of the visual field is a more active process than we are accustomed to think. Could MEs emanate from eyes and form join along boundaries bonds with the object of the visual field so that seeing would be in certain sense like tactile sensing, touching by MEs, somewhat like the bats hear? The cartoon pictures in which rays emanate from eyes would contain a seed of truth. In the case of hearing the MEs could play a role of radar.

   The scaling law of homeopathy [16] states that high and low frequency MEs appear as pairs. The high frequency MEs representing visible light from the external world might arrive along ELF MEs to the eyes, and eyes could even send very weak "radar rays" along MEs and reflected from the objects of the visual field. In particular, the MEs serving as radar rays might allow to deduce information about the distances to the objects of the visual field. This hypothesis does not imply that the magnetic bodies associated with the eyes would be of the same size as the visual field: much larger size is suggested by the 80 Hz resonance frequency involved with the retinae. Note also that we are able to see ordinary 2-dimensional pictures as 3-dimensional, and perceive a 3-dimensional object in a 2-dimensional picture containing only a chaotic set of points (auto-stereogram). Therefore brain can construct three-dimensional sensory percepts also without the active interaction with the external world.

In fact, the vision about magnetic body as active perceiver using the time mirror mechanism with negative energy MEs time reflected from the biological body as positive energy MEs realizes the idea about sensory perception as an active radar like process. Now brain and body becomes the objects at which time reflection occurs. Something similar is expected to occur at the lower levels of the hierarchy.

2.2.4 Altered states of geometric consciousness

The proposed view about sensory representations could explain several mysterious looking phenomena related to tactile senses of which representative examples are described in [60]. Phantom leg and projected pain (say feeling heart pain in left arm) are standard examples. Remote tactile sensing is experienced every-daily. For instance, car driver feels the wheels on the road. The projection to sensory canvas would explains this sensation but one could also consider the possibility that the car becomes a part of body by entanglement. One fascinating applications of remote tactile sensing is based on vision based vibratory sense: TV picture is coded into skin vibrations and patient soon learns to see the world in this manner. People learn also to "see" by hearing. These phenomena cease to be strange when one realizes that geometric qualia accompany in principle all senses. The hypothesis that also the objects of external world are represented as sensory sub-selves (mental images) such that also the visual, auditory and tactile sensory fields become parts of self, explains remote tactile sensing.

Some personal altered states of tactile consciousness resembling hypnagogic state deserve to be mentioned here. The state involves strong illusion of being fully awake and about transition to a state in which body is felt to be in fluctuating wavelike state changing its shape freely. Also the experience about flying to the roof is often involved. Often I can see own body (as 'insider', OBE is not in question) and it is often deformed in bizarre manner. A possible interpretation is that in absence of the sensory input from external world, the values of the spatial coordinates associated with mind like sheets representing body parts in the somatosensory cortex vary widely from their normal values and that dreamer can change these values in certain limits at his will.

2.3 A model for sensory representations, long term memories, and motor actions

In this section a model of sensory representations will be developed from the assumptions that sensory representations are realized on magnetic body (magnetic sensory canvas) and that sensory organs are the seats of the sensory qualia. It turns out that the model is essentially equivalent with the model of long term memories and that its temporal mirror image yields a general model for motor actions. The general vision is inspired by and explains Libet's strange findings about active and passive aspects of consciousness.

2.3.1 Magnetic body as the sensory canvas

Many-sheeted space-time concept makes it possible to project the sensory, symbolic and cognitive mental images the external world using MEs and magnetic flux tube structures.

1. Place coding by cyclotron frequency scale could easily wake-up mental images representing the positions of the objects of the perceptive field in the magnetic body. A more attractive manner to see the situation is to identify magnetic body as an active perceiver sending negative energy topological light rays time reflected at the biological body as positive energy topological light rays and providing information about its state much like the ordinary reflection of light provides information about the object of the perceptive field.

2. The distance of the point of the flux tube from the sensory organ could be coded to the thickness of the flux tube which in turn defines the cyclotron frequency. Most naturally, the strength of the field is the strength of the corresponding Maxwellian magnetic field and the density of the magnetic flux tubes is scaled accordingly from the requirement of the quantization of magnetic flux.

3. The radial EEG MEs assigned with the cortical axons in the TGD based model of EEG could serve as projectors having contacts with the magnetic flux tubes of the personal magnetic body. MEs would entangle cortical mental images and sensory mental images at sensory organs with the "simple feeling of existence" mental images at the points of the magnetic body. Note that the magnetic bodies of sensory organs could carry the fundamental sensory representations.

4. The EEG frequency and its harmonics associated with ME would induce magnetic quantum phase transitions at the magnetic canvas and wake-up mental image at a distance corresponding to the estimated distance of the object of the perceptive field but which need not be same. The association of visual colors with the points of the perceptive field would result from the retina-magnetic body entanglement. Auditory experience might involve a similar mapping but might use Z^0 magnetic field as canvas. Also ears contain strong back-projections necessary for auditory dreams.

5. EEG MEs serving as projections to the magnetic canvas results in the cyclotron transitions at the magnetic flux tubes of endogenous magnetic field having strength $\simeq .2$ Gauss (experiments of Blackman and others), which is 2/5 times the nominal value .5 Gauss for the Earth's magnetic field. At the magnetic flux tubes of the personal magnetic canvas similar process occurs. The rate for the transitions should be maximized in both cases. At the magnetic body this is achieved if the super-conduction ion at the magnetic flux tube is first 'kicked' to a smaller space-time sheet wherefrom it 'drops' back to the magnetic flux tube, and because of its zero point kinetic energy enters into a high n cyclotron state, which in turn decays by emitting harmonics of the cyclotron frequency. The 'kicking' is achieved if the ELF ME responsible for the entanglement contain microwave MEs, which generate join along boundaries bonds connecting magnetic flux tube with smaller space-time sheets. This in turn leads to the breaking of super-conductivity and primitive metabolic cycle in which ions flow to the atomic space-time sheets and back to the magnetic flux tube. This would mean that the microwave radiation from brain serves as the 'food' of the primitive plasmoid like life form representing the simple 'feeling of existence' mental image at the magnetic sensory canvas.

   Both the quantum entanglement with the mediation of of ELF MEs giving rise to the fusion of mental images, and a classical communication by the transfer (say) microwave MEs and inducing self-organization at the magnetic body, are involved. This mechanism is the basic mechanism of remote mental interactions in TGD Universe.

6. An entire hierarchy of sensory representations are predicted and also primary sensory organs could have this kind of representations at their personal magnetic bodies. For instance, retinae

could carry this kind of representations realized in the same manner as the cortical representations. These representations would entangle with cortical representations.

2.3.2 The mental images at the personal magnetic body

The sizes of the images of the objects of the cortical sensory representation located outside the body would not correspond to the real size of the objects of the perceptive field. The sizes of ELF ME are typically of order Earth size and this gives upper bound for the size of the representative objects. If brain itself generates the magnetic canvas then it might be natural to expect that the scaling factor involved is one but one must be very cautious in making any strong conclusions. The problem are that it is not at all clear how this scaling factor could be achieved and how it could be useful. Furthermore, the requirement that the magnetic field strength along the flux tube varies very slowly supports the view that the sub-selves at magnetic body ("simple feeling of existence") can have sizes of order ELF ME.

The mapping of the apparent EEG wavelengths to ELF ME lengths $L = c/f$ defined by the formula $\lambda = v/f = (v/c)L$ for EEG frequency f in terms of its apparent wavelength $\lambda = v/f$ would is consistent with the idea that cortical objects could be scaled-up by a factor $c/v \sim 10^7$! Thus these mental images could be even of the order of the size of Earth! If so they could be extremely stable against external perturbations. In particular, the motion of the head and body would not affect the magnetic and Z^0 magnetic fields in this distance scale so that the problem of reference frame would be solved since "me" would be understood as a gigantic magnetic structure using brain and body as a sensory and motor organ. Obviously, this picture is the diametrical opposite provided by the standard neuroscience.

A more detailed model for the sensory representations requires a more comprehensive view about the personal magnetic body. One can make only tentative guesses in this respect.

1. The personal magnetic body interacts with the external world, in particular, with the Earth's magnetic field and with the solar wind carried by the solar magnetic field. Hence the idea about personal magnetic body as a structure analogous to the Earth's magnetosphere is worth of testing. Personal magnetosphere could decompose into a part moving with the physical body and analogous to the inner magnetosphere, and a stationary, highly stretched, part analogous to the outer magnetosphere at the night side of Earth. Also part residing outside the Earth's magnetosphere should be present. Earth's magnetosphere-solar magnetic field interaction would be replaced by personal magnetosphere-Earth's magnetosphere interaction.

2. Solar wind might enclose part of the personal magnetic body inside the Earth's magnetosphere, whereas the interaction with the flux tubes of the Earth's magnetic field could force the flux tubes of the personal magnetic body to be more or less parallel to them. Incoherent summation of the personal and terrestrial magnetic fields, fractality, plus the fact that the field strengths associated with the flux tubes of the personal magnetic body should decrease much slower with the distance from Earth's surface than those of the Earth's magnetic field, are consistent the possibility that the flux tubes of the personal magnetic body with field strengths stronger that that of the Earth's magnetic field reside inside the magnetic flux tubes of the Earth's magnetic field in far-away regions. That part of the personal magnetic body which corresponds to field strengths weaker that the strength of the Earth's magnetic field could quite well have size measured in light years.

3. The highly self-organizing plasma sheet at the equitorial plane at the night side of the Earth's outer magnetosphere is an especially interesting structure as far as personal and magnetospheric sensory representations are considered. For the fractal option the plasma sheet of the Earth's magnetosphere would contain plasma sheets inside plasma sheets, in particular the plasma sheets associated with the personal magnetic bodies. Personal and magnetospheric sensory representations would correspond to different levels of the same fractal structure.

4. Also the intra-terrestrial part of the Earth's magnetosphere is important for the magnetospheric sensory representations and, if the fractality hypothesis holds true, also for the personal ones. The strange co-incidences of important cavity resonance frequencies of intra-terrestrial structures with EEG resonance frequencies, and the fractal correspondence between the architectures of

brain and magnetosphere [22] support the view that personal magnetic body extends also to the interior of Earth. The flux tubes of the Earth's magnetic field (with field strength increasing faster than for the flux tubes of the personal magnetic body) would be however contained *inside* those of the personal magnetic body in this region. The intra-terrestrial consciousness would therefore represent sub-...-selves of ours, something analogous to Id whereas magnetospheric sensory representations would correspond to the super ego. This interpretation conforms with the proposal that intra-terrestrial life forms are possible in the many-sheeted space-time, and that crop circle formations could be interpreted as attempts of ITs to communicate about their existence [22, 21].

5. Probably it makes sense to speak about Z^0 magnetosphere (both solar and terrestrial). Z^0 magnetic flux tube structures are crucial for the model of long term memories [25], and the sizes of the flux tube structures associated with the personal Z^0 magnetic body should be measured in light years. This suggests that also much weaker personal magnetic and Z^0 magnetic fields with the lengths of the closed flux tubes measured in light years are relevant.

2.3.3 Cortex as a collection of attributes assigned to the objects of perceptive field represented at magnetic canvas

One of the basic problems related to the understanding of the information processing in brain is how various attributes are assigned to the object of the perceptive field. What is known that brain recognizes features and these features/attributes seem to be located in a more or less random looking manner all around cortex. This brings strongly in mind random access memory or computer game in which various little program modules realized as records in random access memory represent collection of standard sound effects. A strong hint is the empirical evidence for the view that the resonance frequencies associated with the autocorrelation functions of nerve pulse patterns, and thus presumably also coding EEG frequencies, are same for the features associated with a given object of the perceptive field. The challenge is to understand how the picture based on a collection of MEs projecting features to the magnetic canvas could allow to understand what is behind these observations.

The view about MEs associating attributes to the object of the perceptive field by waking up sub-selves in the magnetic flux tube structure serving as a sensory canvas suggests an elegant interpretation for these facts.

1. Brain writes the music played by the sensory organs to notes. Accordingly, cortex can be regarded as a collection of regions specialized to represent various kinds of standard features interpreted as cognitive and symbolic representations for the sensory input whereas sensory qualia are realized at the level of sensory organs. Features need not be simple: arbitrary complicated collections of them, such as symbolic representations familiar faces are also possible features. Even entire dynamical processes (selves) could serve as features. Cortical mental images entangled also with sensory mental images a the level of sensory organs and at various organs. The pain in the heart is really in the heart.

2. Basic feature-regions are like computer records. The information about the position of the feature in perceptive field could be represented by the entanglement of the feature with a particular part of, say, primary sensory area representing a point of the perceptive sphere.

3. The direction of the point of the perceptive field could be coded basically by the direction of the magnetic flux tube emerging from the particular position of the sensory area providing map for solid angles of the perceptive field. The mechanism would be based on resonance with Alfven waves associated with the magnetic flux tubes of personal magnetic body amplifying MEs in the direction of magnetic flux tubes. The length (fundamental frequency) of ME would code for the distance of the point of the perceptive field to the distance of the point of the sensory magnetic canvas. Frequency coding could be achieved by varying the local value of the magnetic field responsible for generating the cyclotron frequency. This coding could be either dynamical or static in which case distance could be most naturally coded to linear structures, most naturally in direction orthogonal to the cortical surface.

4. Features would be basically associated with sensory organs, various neural pathways and brain areas and coded partially by nerve pulse patterns. Features could be practically all kinds of

sub-selves generated by brain activity. Primary qualia could be realized at the level of sensory receptors if entire sensory pathways entangle with the magnetic body. It seems that the identification of sensory organs as seats of sensory qualia is the most, and perhaps the only, plausible option in TGD framework.

5. Projector MEs would be orthogonal to the sensory area where they emanate. The topographic mapping of the perceptive field to the sensory areas would guarantee that sensory images would remain stationary under rotations of head: although sensory magnetic sensory canvas would move the image projected to it would be stationary. MEs and magnetic flux tubes must be parallel if Alfwen wave resonance is involved. In this manner the experiences could remain private and the contribution from the other brains would remain negligible. Note however that people in very intimate contact could gradually share there magnetic sensory canvases: the anecdotes about gradually developing telepathic communications between the teachers and students of the meditative practices could involve this kind of sharing of computer screen between several users.

6. In this coding EEG MES would entangle with essentially all symbolic information about the perceptive field and the spectroscopy of consciousness would be realized in a strong sense.

Of course, the extreme flexibility of the entanglement mechanism of binding means that one can imagine almost unlimited number of variants about this basic option and the proposed variant can be defended only as the simplest one found hitherto. One can also allow the possibility that the sequence of entanglements begins from the perceptive field with the primary mental images at the level of sensory organs being entangled with objects of perceptive field.

Fractality suggests that there is a hierarchy of representations. In particular, cortex areas, brain nuclei and even cells could possess their own representations. The inactivity of the primary sensory areas during REM sleep could mean that during dream state sensory representations are non-cortical lower level representations or realized at higher sensory areas. Of course, lower level structures could define the projections to the magnetic sensory canvas also during wake-up consciousness. For instance, relay station like nuclei could act as relay stations for the projections realized at the magnetic body. Any brain area defining topographical map of sensory data is could candidate for defining a sensory representation.

The projector regions could serve as kind of central entanglers. Also the nuclei believed to somehow generate EEG resonance frequencies responsible for the binding of mental images are good candidates for the central entanglers. Thalamus is believed to generate 40 Hz rhythm and is thus a good candidate for the central sensory entangler and projector. Hippocampus generates hippocampal theta and could be the central memory entangler and projector. Frontal lobes generate slow EEG waves during cognitive activities and could act as cognitive entanglers and projectors.

This kind of architecture is expected to be realized at various length scales. Perhaps even at the length scale of genes. The remaining question is how motor activities are realized in this picture. The metaphor for consciousness as a computer sitting at its own terminal, which originally stimulated my personal attempts to understand consciousness, might help here. Computer screen corresponds to the magnetic canvas. The one who sits there presumably corresponds to our magnetic body (as far as conscious-to-us intentions are considered). The central unit corresponds to the brain. Sensory projector MEs are generated automatically by nerve pulse activity and code the picture on the monitor. W MEs as active quantum holograms acting as control commands generating nerve pulse patterns would provide a realization of keyboard. Thus it would seem that those aspects of the computer which are usually not regarded as fundamental in Turing machine paradigm are the most crucial for understanding the brain consciousness and computer programmers seem to mimic what happens inside (and outside) their own brain.

2.3.4 Place coding

If the personal magnetic body corresponds to the sensory experiencer and the intentional agent, the distance from the brain along the magnetic flux tube represents the temporal distance to the geometric past. It is however quite possible and even plausible that the length of the magnetic flux tube can code for some spatial distance and even more general geometric data. The arrow of the geometric time would order the spatial points. This kind of mapping from the spatial domain to the temporal domain to the personal magnetic body is naturally induced by any scanning like process performed by CNS, say saccadic motion or EEG waves propagating along cortex. Thus it makes sense to speak about place coding even if one does not assume that our body and environment are mapped to the personal magnetic body in a topographical manner.

The required place coding by frequency is easy to achieve. Any cylindrical flux tube for which magnetic field in the cylindrical coordinates is obtained from a vector potential $A_\phi(z,\rho,\phi) = B(z)\rho$ varying slowly with z gives rise to a magnetic field whose z-component varies slowly with z and for which the radial component $B_{rho} = \partial_z B(z)\rho$ is small. From the quantization of the magnetic flux the flux tube thickness behaves as

$$\frac{r}{r_0} \propto \frac{B_{earth}}{\sqrt{B(z)}} \ ,$$

and flux tube gets thinner if the field strength increases and vice versa. It the strength of the magnetic field is that of Earth's magnetic field at the surface of the retina or secondary sensory organ, one obtains frequency coding

$$\frac{f}{f_{earth}} = \frac{B(z)}{B_{earth}} \ .$$

This means that a given EEG frequency associated with, say color mental image, induces a magnetic quantum phase transition at a definite value of z and wakes up visual sub-self at that position. The resulting experience is colored point at a specific point of the visual field.

Optimal situation is achieved if the gradient of B with respect to z is very small. This would suggest that self sizes are of order of the size of ELF MEs waking-up the mental images. This would mean that the total increment of $B(z)$ along flux tube would be measured using B_{earth} as a natural unit. p-Adic length scale hypothesis suggests that the thickness of the magnetic flux tube varies between two p-adic length scales and thus by a small power of 2.

It deserves to be noticed that a given EEG frequency f can wake up a number of copies of sensory images corresponding to various ions at positions related to each other by

$$\frac{B(z_1)}{B(z_2)} = \frac{A_1 Z_2}{A_2 Z_1} \ .$$

Here A_i and Z_i denote the mass numbers and charges of the ions, results. If $B(z)$ varies very slowly along the flux tube, the number of separate mental images is however small since the condition above cannot be satisfied for too large ratios on the right hand side. If $B(z)$ increases along the flux tube, the images associated with the light ions are nearer to the eye than those associated with the heavy ions.

This observation suggests that ions with nearly the same mass numbers could give rise to multiple sensory representations associated perhaps with same sensory sub-self. Of course, the degeneracy of the mental images might be undesirable and could be eliminated by adjusting the gradient of B to be so small that multiple sensory images are not generated inside given magnetic self. By a small adjusting of the strength of the magnetic field at eyeball or the radius of the secondary visual sensory organ could shifts between various types of ionic visual consciousness could be induced. For heavy ions, isotopic degeneracy would lead to large number of alternative modes of ionic consciousness and this might give rise to enhanced cognitive abilities.

How faithful is the metric correspondence between the visual field and its image at the magnetic body? The answer is to this question is not obvious. Also eyes are accompanied by magnetic bodies which could carry visual representations and primary sensory qualia. It could be that these representation are responsible for all what relates to the experienced metric aspects of the visual field. If this is the case, the representations at the personal magnetic body could be much more abstract and free from the constraint of the isometric correspondence. The hierarchy of sensory areas in brain indeed corresponds to an increasingly higher level of abstraction.

2.3.5 Magnetospheric sensory representations

It is difficult to exclude magnetospheric sensory representations if one accepts the notion of personal magnetic body and representations at it. These representations could give rise to the third person aspect of consciousness. Magnetosphere could contain multi-brained collective selves receiving sensory input from several brains simultaneously. Also Z^0 magnetosphere could contain representations carrying both sensory and and higher level symbolic and cognitive information from several brains.

The location of the magnetospheric representations could be stationary with respect to the inner magnetosphere. This would require that the MEs projecting the information to the magnetosphere emanate from the head in a direction which is fixed with respect to the local direction of the magnetic field of Earth (the MEs associated with the personal magnetic body would project in a direction orthogonal to the surface of cortex). Most naturally this direction would be the direction of the local magnetic field since this makes possible amplification based on Alfven wave resonance. Stationarity of the directions of MEs projecting to the magnetosphere could be achieved by the interaction of the magnetic dipoles with Earth's magnetic field forcing the directions of the magnetic dipoles to the direction of Earth's magnetic field and thus making brain a compass. Brain is indeed full of magnetic materials, human brain is a compass and humans have magnetic navigation sense.

Also eyes contain magnetic materials and presumably act as compasses so that eyes could generate the required magnetic fields defining a preferred reference frame for visual sub-selves. One can consider a hierarchy of compasses defined by the hierarchy of magnetic fields at various sheets of the many-sheeted space-time. For the sense of balance this kind of a preferred direction is essential.

Also a Z^0 magnetic compass based on Earth's magnetic field and Z^0 magnetic materials is possible. The fact that Z^0 magnetic fields are associated with hearing so closely in TGD framework supports the view that Z^0 magnetic compass could be related to the sense of balance. Children love to spin around. Since all atomic nuclei couple to Z^0 force, this spinning however generates net Z^0 currents generating additional Z^0 magnetic fields perturbing the Earth's Z^0 magnetic field. This in turn could cheat the Z^0 compass. This indeed happens. When the spinning stops, sensation of dizziness results and the world is experienced to spin.

2.3.6 Remote mental interactions and sensory magnetic canvas hypothesis

Could the possible sensory inputs from other brains to the personal magnetic body interfere with the sensory inputs from 'my brain'? This is probably not the case. It is however possible that the entanglement with the other magnetic bodies and possibly existing magnetospheric multi-brained selves leads to the sharing of mental images. Perhaps this is exactly what happens during sleep and actually makes possible development of social structures and culture. Note that this picture is consistent with what near death experiences and various altered states of consciousness achieved in meditative practices suggest.

There is some evidence for the possibility of a interaction between minds via projected sensory representations. Some dogs are able to anticipate the epileptic attacks of their master and are systematically trained for this purpose. Some dogs have an amazing skill to precognize that their master is coming home: ordinary sensory perception such as olfaction is excluded as an explanation. The practitioners of transcendental meditation claim that collective meditation can have a definite positive effect on conflict situations occurring at the other side of the world proportional to the square of the number of participants (coherence). The vision of Sheldrake [48] about morphogenetic fields making possible the claimed learning at the level of species could be modelled concretely in terms of this interaction.

The immediate prediction is that large scale phenomena affecting the magnetic field of Earth should have direct effects on our consciousness by the perturbation of the sensory representations at the other side of the world. There would be however no effect on primary sensory qualia if they are seated at the level of sensory organs nor on cognitive and symbolic mental images produced in brain. Telepathic sharing of mental images having would be one possible effect induced by Schumann resonances: the signature would be sensory experience with no neurophysiological correlates (in particular, there would be no back projection to sensory organs).

It is known that the statistics about mental states of patients of mental hospitals demonstrates strong correlation with magnetic storms induced by sun-spots. The magnetic perturbations induced by lightnings known as sferics are known to have a direct effect on EEG and brain functioning [39]. Tectonic activity, such as Earth quakes, can induce various kinds of hallucinations such as encounters with UFOs and religious experiences [70] perhaps involving sharing of mental images. Animals are even able to anticipate earth quakes. When the car ferry Estonia suffered a shipwreck for few years ago taking with it almost thousand people into the depths, hundreds of people reported they had experienced a nightmare obviously relating to this event. Sharing of mental images or sensory percepts produced by back-projection from symbolic representations created by or communicated to brain could be in question.

The known general features of remote mental interactions support the view that magnetospheric multi-brained selves serve as a kind of relay station or medium allowing the remote mental viewer to entangle with the target. Remote viewer would essentially see with the yes of this higher level self [20, 33].

2.3.7 Mirror mechanism of geometric memories

The mirror mechanism of long term memories involves several purely TGD based features [25].

1. The classical non-determinism making possible time-like quantum entanglement and sharing of mental images.

2. Space-time sheets with a negative time orientation allowing classical signals associated with negative energy MEs to propagate backwards in time and making possible entanglement.

3. The identification of the personal magnetic body as the experiencing intentional agent sending negative energy MEs parallel to the magnetic flux tubes to the brain acting as the time mirror. This option, forcing to take completely seriously the notion of the magnetic body, provides the most elegant identification of the time mirror discovered hitherto. If brain is identified as the sender of the negative energy MEs, the identification of the mirror and correct timing of pose problems. One possibility is that the closed flux loops associated with the personal magnetic and Z^0 magnetic bodies having sizes of order light years making it possible for negative energy MEs to repeatedly reflect along them and return back to the brain of the geometric past.

4. The possibility of MEs and magnetic flux tubes interacting weakly with the ordinary matter but strongly with living matter in cell length scales.

Mirror mechanism

Classically the mechanism of long term memory is extremely simple: one looks at time mirror at a distance of one light year and sees oneself in the geometric past at a distance of two years. Since the geometric past changes in each quantum jump, this mechanism explains why our long term memories are so unstable. One could see also other persons in the mirror and this could explain telepathic communications, the communications with the deceased, as well as identification experiences. The most natural identification of the seer is as the magnetic body and the mirror as the brain (my first guess was time mirror image of this!). The distance along the magnetic flux tube would corresponds to the distance to the geometric past.

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 assumption that the lengths scales of MEs and magnetic structures are identical implies that the frequency of ME equal to the magnetic transition frequency f_m fixes the length of the two MEs involved and thus the temporal location of the long term memory in the geometric past:

$$T = \frac{2}{f_m} \ .$$

This represents a frequency coding for the temporal location. In standard physics the idea about brain generating MEs with a frequency scale of the order of the inverse of lifetime does not make sense: in TGD context situation is different since this process occurs in subjective time. By the arguments discussed in more detail below, postive energy neutral MEs are ideal for communication of long term memories to the geometric future. The concrete mechanism for the generation of MEs as associated with transitions between almost degenerate configurations of spin glass with slightly different classical gravitational energies is discussed in [25].

More detailed model for long term memories

The realization of long term memories might be the basic function of the personal magnetic body.

1. Spontaneous episodal memories would be based on negative energy MEs entangling the geometric now with the geometric past and making possible sharing of mental images. In particular, sensory memories would rely on this mechanism. This mechanism could also make possible only the communication of the desire to remember to the geometric past in the case of an active memory recall and non-episodal memories. One can however wonder what distinguishes the resulting experience from precognition by the self of the geometric past: could it be that to precognize now is to remember in the geometric future? The fact that MEs represent channelled energy means that distance is not a problem as far as energetics is considered.

2. In the case of non-episodal memories the information could be communicated classically from the geometric past as 'bits' and be coded into the light like vacuum current associated with ME. If the magnetic body is the "me", positive energy MEs could simply travel along the same magnetic flux tube along which the negative energy ME arrived. Magnetic flux tube would act as a wave guide amplifying ME by Alfven resonance.

3. Neural MEs with negative energies are especially favored for quantum communications. The reasons are many-fold. The interaction with the matter is very weak in long length scales but strong in cellular length scales, negative energy implies that ME is identifiable as a virtual particle and analogous to a part of a Feynman diagram so that no dissipation is involved and quantum communication is possible. The reversal of the arrow of geometric time means also that there is not macroscopic dissipative dynamics which would spoil the quantum coherence.

4. The requirement that the receival process is highly selective suggests a resonance mechanism. This requires that the fundamental frequencies associated with MEs are somehow universal. p-Adic length scale hypothesis indeed predicts hierarchies of universal frequencies. A stronger requirement is that the receiving and sending structures are somehow similar, and many-sheeted space-time allows to realize this kind of option. Negative energy energy ME cannot be emitted unless there is a receiver absorbing the negative energy and in this manner providing energy for the sender by buy now-let others pay mechanism. The time mirrored positive energy ME can even amplify the reflected negative energy signal by stimulated transition to the ground state if the receiver is a many-sheeted analog of a population inverted laser.

5. Negative energy MEs represent time reversed level of the p-adic length scale hierarchy so that the dissipative effects associated with the space-time sheets with the normal arrow of time should not interfere with the quantum communication. This at least, when the energy of the negative energy ME has a magnitude larger than the thermal energy associated with the space-time sheets with which it interacts: there is simply no system which could make a transition to a lower energy state by the absorption of a negative energy ME. Furthermore, since systems with reversed arrow of geometric time are expected to have extremely low density, the dissipative effects in the reversed direction of time are expected to be small. Since the generation of negative energy MEs does not require energy feed, the memory recall to the geometric past occurs more

or less spontaneously, and the scanning of the geometric past becomes possible. In the case of precognition precognizer must intentionally receive negative energy MEs from the geometric future so that energy feed is needed. This perhaps explains why precognition is so rare. Note that p-adic variant of pre-cognition having interpretation as intentionality occurs easily since p-adic energy is conserved only in piecewise manner.

If this picture has captured something essential from the nature of the long term memories, the conclusion is that we are not at the top of the magnetic sensory hierarchy. Human body and brain generates extremely weak magnetic fields and the corresponding magnetic flux tube structures could make possible long term memories. Near death experiences [34] could be understood in this framework if the weak magnetic fields associated with the higher levels of the fractal hierarchy of magnetic structures utilize brain and body as kind of sensory and motor organs. Note that there is a flux tubes inside flux tubes structure so that ordinary sensory experiences can be associated also with these flux tubes.

2.3.8 Sensory perception, motor action, and time

TGD view about sensory perception differs dramatically from that of the standard neuroscience in that sensory organs (plus possibly their magnetic bodies) 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 [26]. 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 [26]. One can also consider the possibility that sensory organs and their magnetic bodies define the sensory capacitors whose discharges give rise to sensory qualia and that these magnetic bodies give also rise to low level cognitive and emotional representations.

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 [71, 123]. 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 [71, 61] 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 [61]. 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 paradoxal 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 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 [90]. 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 [123] 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

Consider now Libet's findings. 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 $\sim .5$ seconds.

2. 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.

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. 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! If the cortical stimulation generates sensory mental image at sensory organ by back projection then one could understand the change of the time ordering as resulting from .5 second lapse for the generation of back projection.

4. If the stimulation of the cortex begins in the interval $.25 - .5$ seconds after the stimulation of the skin, the stimulation of the skin is not consciously perceived. This effect is known as a backward masking. From the source it is not clear whether a minimal duration of .5 seconds of cortical stimulation is required for backward masking.

3. Explanation of Libet's findings

Consider now how one could understand these strange findings in the proposed model.

1. Visual and tactile sensory inputs enter into cortex essentially simultaneously so that the construction of symbolic representations at magnetic body is possible. The projection to the magnetic canvas by positive energy MEs and the generation of the magnetic quantum phase transition might quite well explain the time lapse of .5 seconds. The symbolic representation could contain also information about where to direct sensory attention. After this time interval negative energy ME possibly directing the attention to a particular part of the perceptive field would be generated and induce sharing of mental images .5 seconds in the geometric past. Note that this would automatically guarantee that symbolic and sensory representations at the magnetic bodies of sensory organs correspond to the same value of the geometric time.

2. The stimulation of the cortex lasting at least .5 seconds would generate a back projection to sensory organs. The minimal duration of .5 seconds for the cortical stimulation would seem rather natural in order to avoid back projections due to random neuronal fluctuations. This would explain why the temporal order of the sensory experiences generated by cortical and skin stimulation is reversed when cortical stimulation starts before the skin stimulation.

3. Consider now how the backwards masking could be understood. The cortical stimulation could generate a negative energy ME sent to the sensory organ and editing its geometric past at temporal distance of .5 seconds and depleting energy resources so that sensory organ cannot receive negative energy ME from magnetic body during the period of the cortical stimulation. Magnetic body would become sensorily blind to the input from the corresponding point of skin. Sensory blinding could be a clever manner to signal to the magnetic body that back projection is to be expected.

   The stimulated point of the cortical map would share the sensory mental image instead of the magnetic body and also give rise to a back projection: sensory mental image would be conscious to cortex but not to us! Magnetic body and cortex could be seen as competitors for resources in this kind of situation. Perhaps the electric stimulation induces some kind of neuronal starvation and forces the neuron to generate negative energy MEs entangling it with the sensory organs.

2.4 First attempts to relate sensory canvas idea to neuroscience

The challenge to relate sensory canvas hypothesis to the general qualitative features of EEG and to what is known about its evolution. The general knowledge about neural correlates of consciousness could also provide constraints for the model of how sensory representations are constructed. One could also try to find clear tests and even existing evidence for the hypothesis that there indeed are also other than neural correlates of consciousness (MEs projecting to the sensory canvas are obviously the candidate in present case).

There seems to be a general consistency of predictions of sensory canvas hypothesis with what is known about EEG. Mention only the evolution of EEG as the emergence of decreasing EEG frequency scales; the disappearance of alpha, beta and gamma bands from EEG during sleep; the existence of narrow coherent EEG sub-bands in all EEG bands; and also the complex fractal like coherency structures of EEG difficult to understand if EEG has a purely neural origin.

Brain is active also during sleep. Sensory canvas hypothesis encourages to think that, besides making possible consolidation of long term memories, this activity could serve the purposes of higher level multi-brained magnetic selves representing collective levels of consciousness receiving abstract non-sensory input from several brains at theta and delta frequencies. Of course, interaction could occur also in reverse direction and among other things explain the creative insights often achieved during sleep.

Computer metaphor would suggest that motor actions and sensory representations are basically identical procedures in TGD framework: only the final representation of the data file constructed by brain is different. As found, this is not quite the case: there is time reversal involved. Motor action is like precognitive recall whereas sensory experience is like geometric memory recall.

The considerations below rely on various review articles [44, 38, 57] about the recent situation concerning the understanding of EEG. Also the article [62] about neural correlates of consciousness, and the article [51] suggesting that primary sensory area V1 is crucial for conscious vision have been very useful in attempt to develop more concrete views about how sensory representations are constructed. I do not hesitate to admit that the model to be discussed is nothing more than a first attempt to relate the general idea of sensory canvas to the complex neuro reality and is severely restricted by my very limited knowledge about neuroscience (I am grateful for Gene Johnson for his patience while trying to teach me some basic facts about conscious brain).

2.4.1 Anatomical structure of the cortex and sensory canvas hypothesis

The anatomical structure and evolution of cortex inspires definite hypothesis about how brain constructs and realizes sensory representations at magnetic sensory canvas and how magnetic sensory canvas builds up motor actions. In order to avoid confusions I want to stress that sensory representations generated by brain are assumed to be symbolic representations assigning meaning to the raw sensory input and do not involve qualia, which in TGD Universe are most naturally assignable to the sensory organs.

Do primary sensory areas serve as gateways to the fundamental sensory canvas?

Is there single cortical magnetic body or several of them? Do various sensory areas define a hierarchy of magnetic bodies serving as sensory canvases ("sensory" is somewhat misleading here)? There are several arguments supporting the view that primary, and possibly secondary and tertiary sensory areas, but not necessarily higher areas, should be accompanied by separate magnetic bodies.

1. Computer metaphor encourages to consider the hypothesis that sensory representations and motor outputs have essentially the same character just like printout and monitor picture are different outputs of a same file in the case of a computer. First (with respect to the subjective time!) a rough sensory sketch is generated and then more and more details are added and the primary areas activate the final sensory representation just as in the case of motor output. As in the case of motor actions, higher levels of cortex simply select the activated sensory representation to be experienced consciously by us (binocular rivalry). The sequence of quantum entanglements proceeding from the magnetic body down to the magnetic bodies of sensory organs selects what is experienced consciously by us. There is probably a hierarchy of experiencers each characterized by particular selections.

2. The intention for motor activity is realized as p-adic MEs connecting magnetic body by entanglement sequence to motor organs and induces directly action at this level (buy now-let others pay principle and precise targeted realization of intention). This quantum communication like aspect is accompanied by classical communications from magnetic body to cortex and in terms of nerve pulse patterns from cortex to lower levels. Intention can be also initiated at higher level than motor organs and in this case motor imagination is in question.

3. Mental images are entangled with the mediation of the negative energy projector MEs along along magnetic flux tubes connecting magnetic bodies together. Hierarchical sequences of mental images result in this manner, and sensory qualia become associated with various higher level mental images. MEs can be thought of as representing radiation propagating in the wave channel represented by the magnetic flux tube and being reflected repeatedly. MEs need not be only simple cylindrical prototype MEs but can be also curved: this means that the number of reflections need not be too high. Magnetic flux tubes are essentially guides for MEs so that they do not "lose their way".

4. The motor-sensory analogy might provide also other new insights. For instance, basic elements making possible several potential motor actions might exist simultaneously as sub-selves representing imagined basic modules of motor activity at the level of cortex. The sequence of quantum entanglements would then select the desired motor action, much like the sensory percept is selected in the sensory rivalry. This would be like building a program from a set of active modules

selecting some subset of them or selecting one downwards path in a branching tree. The magnetic sensory representations associated with primary sensory organs without the higher level cognitive and symbolic associations could be seen as the counterparts of reflex actions.

Neural correlates of visual consciousness and motor-sensory analogy

The study of the neural correlates of visual consciousness reviewed in [62] allows to study the reasonability of the primary sensory areas as gateway to sensory canvas hypothesis and its variants.

1. Evolutionary argument suggests that both primary sensory organs and various sensory areas are accompanied by magnetic bodies providing increasingly abstract symbolic and cognitive representations for the sensory input. The neurons at the higher sensory areas indeed become increasingly complex and have increasingly wider receptive fields. In particular, in the case of vision the neuronal receptive fields at V4 and higher areas are also dynamical and determined by the attentional level. Color/orientation information and the information about motion are treated separately in parvo and magno cellular pathways in V1, V2 and V3 but not in V4 (for the organization of the visual pathways see [66]). These observations encourage the view that sensory areas define a hierarchy of separate magnetic bodies giving rise to more and more integrated conscious higher level representations of the sensory input. These representations define hierarchy of selves using the same brain and body.

2. The standard assumption about feed-forward hierarchy of the sensory areas leads to difficulties. For instance, in binocular rivalry of two competing visual stimuli feed to right and left eye, only the other stimulus is experienced at time. V1 and also V2 and V3 however contain neural representations of both stimuli. It has been also found that during the binocular rivalry the co-varying neural activities (seen by fMRI) in the extrastriatal visual cortex and in prefrontal cortex correlate with the subjective percept (rather than real stimulus) unlike the activity in V1 which represents both stimuli [59]. The manner to understand this is that quantum entanglement sequences starting from the magnetic body proceed down to sensory organs and select from V1, V2 and V3 only the second stimulus.

3. It is known that neural activity in parietal and frontal regions is involved with the change of the dominating stimulus and that the activity in visual areas is not enough for visual consciousness [62]. Thus the presence of neural representations of both stimuli in V1 but conscious experience of only one stimulus would support the view that neuronal activity is *not* enough to generate our conscious experience. If the hierarchy of entanglements proceeds from our magnetic body to frontal lobes and from there downwards it is easy to understand why the activity in frontal lobes is essential for selecting the consciously experienced stimulus. Obviously the sensory-motor loop would have counterpart in much longer length scales.

4. V1 seems to be necessary for visual consciousness. Pascual-Leone and Walsh have studied the visual hallucinations induced by transcranial magnetic stimulation [65]. The stimulation of V1 generates static and colored impressions whereas the stimulation of V5/MT generates moving non-colored phosphenes (in accordance with the fact that 'where' type information processing is color blind and 'what type' information processing at lowest levels is motion blind). This picture is consistent with the idea that the fundamental visual representations are realized at retinal magnetic bodies. The back-projections in question would be essential for the "qualiafication" of imagination during dreams and hallucinations.

5. The study also demonstrates that the stimulation of V1 *after*, rather than before, the stimulation of regions V5/MT sending feedback to V1 can prevent the generation of hallucination. Even more, [51] describes a case in which patient has lost visual consciousness when V1 is not intact. There is indeed a strong neural feedback to V1, V2 and V3 from the higher visual areas V5/MT and area V1 is activated simultaneously with MT in macaque. These findings are in conflict with what one might expect if sensory processing proceeds in strictly feed-forward manner. The necessity of V1 for our visual consciousness is obvious if entanglement sequences go through V1 down to the level of retinas. Feedback would also make possible "coloring" of the sensory map during ordinary wave-up experience. Perception would be creative act already at the level of sensory organs.

6. The timing of the interactions in the visual areas provides further hints about how sensory representations are constructed. According to [51] that early activation of V1 by magnocellular neurons in LGN occurs 20 ms earlier that the activation by parvocellular neurons. At this time also the feedback from V5/MT arrives to V1. This suggests that sensory map is constructed by making first a rough sketch using the sensory input from the magnocellular pathways (motion and position). For about 20 milliseconds later follows the coloring of the sensory map as well as the association of the higher level features to the map. This order is is consistent with the fact that highly developed parvocellular pathway is a newcomer in the evolution and that the information involved is not so vital for survival. Thus V1 would act as an effective 'active blackboard' as has been suggested [51] and by the sensory-motor analogy in TGD framework.

2.4.2 EEG and sensory canvas hypothesis

The general qualitative features of EEG seem to conform with sensory canvas hypothesis and it seems possible to make relatively concrete suggestions for EEG correlates of sensory qualia, cognition and long term memories.

Why the endogenous magnetic field corresponds to .2 Gauss?

For years I erratically believed that the magnitude of the magnetic field assignable to the biological body is $B_E = .5$ Gauss, the nominal value of the Earth's magnetic field. Probably I had made the calculational error at very early stage when taking Ca^{++} cyclotron frequency as a standard. I am grateful for Bulgarian physicist Rossen Kolarov for pointing to me that the precise magnitude of the magnetic field implying the observed 15 Hz cyclotron frequency for Ca^{++} is .2 Gauss and thus slightly smaller than the minimum value .3 Gauss of B_E. This value must be assigned to the magnetic body carrying dark matter rather than to the flux quanta of the Earth's magnetic field. This field value corresponds roughly to the magnitude of B_E at distance 1.4R, R the radius of Earth.

Dark matter hierarchy leads to a detailed quantitative view about quantum biology with several testable predictions [20]. Number theoretical arguments suggest a general formula for the allowed values of Planck constant [20] products and ratios of two integers. The values of integers for which the 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 $F_0 = 3, F_1 = 5, F_2 = 17$. The prediction is that also n-multiples of p-adic length scales are possible as preferred length scales. The unit of magnetic flux scales up as $h_0 \rightarrow h = nh_0$ in the transition increasing Planck constant: this is achieved by scalings $L(k) \rightarrow nL(k)$ and $B \rightarrow B/n$.

$B = .2$ Gauss would corresponds to a flux tube radius $L = \sqrt{5/2} \times L(169) \simeq 1.58L(169)$, which does not correspond to any p-adic length scale as such. $k = 168 = 2^3 \times 3 \times 7$ with $n = 5$ would predict the field strength correctly as $B_{end} = 2B_E/5$ and predict the radius of the flux tube to be $r = 18$ μm, size of a large neuron. However, $k = 169$ with flux $2h_5$ would be must more attractive option since it would give a direct connection with the Earth's magnetic field. Furthermore, the model for EEG forces to assume that also a field $B_{end}/2$ must be assumed and this gives the minimal flux h_5. Note that $n = 5$ is the minimal value of n making possible universal topological quantum computation with Beraha number $B_n = 4cos^2(\pi/n)$ equal to Golden Mean [33].

Evolution as emergence of lower EEG frequency scales: dark matter hierarchy

Sensory canvas hypothesis combined with the scaling law suggests an entire hierarchy of sensory canvases. One must however keep mind open for the possibility that the flux tubes of Earth's magnetic field define only single sensory magnetic canvas.

A firm prediction is that evolution should correspond to the emergence of higher level selves characterized by decreasing EEG frequency scales. There are two hierarchies involved. Dark matter hierarchy and p-adic length scale hierarchy and both presumably correspond to evolutionary hierarchies.

Dark matter hierarchy correspond to a hierarchy of values of Planck constant coming for the most general option as ratios and products of two integers. The model for the hierarchy of generalized EEGs [20] assigns to preferred levels of dark matter hierarchy a typical time scale identifiable as typical time span of memories. The hypothesis about evolution proceeding as the emergence of higher and higher levels of dark matter hierarchy at the level of personal consciousness is very natural.

Evolution as emergence of lower EEG frequency scales: p-adic length scale hierarchy

p-Adic length scale hierarchy defines a hierarchy at each level of dark matter hierarchy and one can ask whether also the emergence of increasingly longer p-adic length scales characterizes evolution.

1. Cerebellar, retinal, and cortical rhythms

The p-adic time scales assignable with the basic rhythms associated with cerebellum, retina, and cortex increase in this order and are consistent with the hypothesis that higher evolutionary levels corresponds to longer p-adic time scales.

1. The fact that the dominating rhythm in cerebellum is about 200 Hz supports the view that it corresponds to shorter p-adic length and time scale than cortex. The fact that cerebellum is responsible for the finer details of motor action is consistent with shorter p-adic time scale.

   If one assumes that 200 Hz rhythm is analogous to sensorimotor rhythm of 13 Hz (Na^+ cyclotron frequency) then scaling then the magnetic field at the field quanta involved should be $\simeq 16$ times stronger than B_{end}. Since B_{end} most naturally corresponds to the p-adic length scale $k = 169$ and magnetic flux $2h_5$, this field could correspond to $k = 169 - 8 = 161 = 7 \times 23$ (scaling down of thickness of flux sheets flux sheets) or $k = 169 - 4 = 165 = 5 \times 53$ (scaling down of the radius of the flux tube). The work of Gariaev [98] provides support for the hierarchy of magnetic flux sheets of various thicknesses associated with chromosomes and favors $k = 161$ option.

2. The micro-tremor of retina corresponds to 80 Hz frequency and would relate naturally to 40 Hz thalamocortical resonance frequency if the magnetic field in question corresponds to transversally scaled down magnetic flux sheets having $k = 167$ instead of $k = 169$. Note that $k = 167$ corresponds to the Gaussian Mersenne $(1 + i)^{167} - 1$.

3. Primary sensory areas are dominated by 40 Hz frequency. Lowest frequencies such as hippocampal theta are in turn associated with long term memory which corresponds to high level mental function distinguishing sharply between humans and other species.

2. Why the interpretation in terms of spin flip frequencies does not work?

The original interpretation of cerebellar rhythm was in terms of some magnetic spin flip frequency. Representative examples of spin flip frequencies near cerebellar 200 Hz are $f_s(Na) = 222$ Hz, $f_s(Al) = 218$ Hz and $f_s(Mn) = 208$ Hz, $f_s(Co) = 199$ Hz and $f_s(Sc) = 204$ Hz. Co is obviously the best candidate.

The spin flip frequencies in EEG range (see the table 4) are $f_s(Cl) = 82$ Hz and $f_s(Rb) = 81$ Hz (80 Hz micro-tremor in retina); $f_s(K) = 39$ Hz and $f_s(Y) = 41$ Hz (both very near to 40 Hz thalamocortical resonance frequency); $f_s(Ag) = 34.2$ Hz, $f_s(Rh) = 26.6$ Hz (27 Hz resonance frequency in dog's cortex); $f_s(Ir) = 17$ Hz (narrow band in EEG [44]), $f_s(Au) = 14$ Hz (the sleeping spindle frequency).

These interpretations are however excluded in the dark matter based view since the ions are assumed to be ordinary ions topologically condensed to dark matter space-time sheets defining λ^k-fold coverings of M^4 so that spin flip photons would be ordinary ones and their energies would be extremely low and much below the thermal threshold. Of course, one must be very cautious with this kind of statements since the ideas about dark matter are still just a colleciton of rules.

3. p-Adic length scale hierarchy as abstraction hierarchy

This picture suggest an abstraction hierarchy in which EEG frequency scale of projecting EEG MEs correlates with the abstractness of the feature associated with the point of sensory map. For instance, sensory qualia could correspond to gamma frequencies, in particular frequencies near 40 Hz; cognitive features to beta frequencies whereas alpha and theta and delta frequencies to the generation of the long term memories making possible the historical self. The frequencies involved with long term memory recall are expected to correspond to the time span of the memory characterized by the level of the dark matter hierarchy.

4. Objection against p-adic evolutionary hierarchy

If evolution corresponds to emergence of increasingly longer p-adic time scales in EEG, then the naive application of ontogeny recapitulates phylogeny principle (ORP) suggest that gamma, beta, alpha and theta bands should emerge in this order during the development. This is not the case.

1. According to [50], the wake-up EEG of infants before 3 months age consists of 'fast' background activity. At three months posterior delta rhythm appears at 3-4 Hz and gradually shifts to 6-7 Hz during the first life year. According to [52], binding related 40 Hz oscillations are evident at the age of 8 months. Also the contrast sensitivity of vision improves rapidly to adult level at this age: this conforms with the hypothesis that EEG is essential for the construction of the sensory representations.

2. According to [56], for infants the counterpart of the alpha band appearing in darkness is the occipital rhythmic activity in the range $5.2 - 9.6$ Hz with peak frequency at about 7 Hz and increases gradually. The frequency band $6.0 - 8.8$ Hz with gradually increasing peak frequency at about 7 Hz is activated during visual attention and seems to be the counterpart of sensory-motor rhythm of about 13 Hz of adults. It would be interesting to know whether the sensorimotor rhythm is eventually established via a continuous shift of this band or not.

A direct correlation between body size and frequency scale of the sensory-motor frequency band suggests itself. This might be understood if magnetic flux tubes in the somatosensory part of the sensory canvas get gradually stretched during the growth so that the increasing distances of the body extremities from head are coded by increasing magnetic transition frequencies.

This picture seems to contradict the idea about p-adic evolutionary hierarchy. In TGD framework one must however seriously consider the possibility that the lowest EEG bands relate with the higher level collective and multi-brained sensory representations. These higher level selves could be especially alert during sleep since the entire information processing capacity used for the sensory and motor activities during wake-up state would be freely available. This suggests also a resolution of the objection against p-adic evolutionary hierarchy.

The work of Jaynes inspires the idea about child as a small bicameral nursed by the higher collective levels of consciousness. The location of the sensory motor and alpha rhythms in theta band could indeed be seen as an indication for a kind of magnetic nursery provided higher level magnetic selves and their presence would not corresponds to the infant's consciousness but to the consciousness of the "magnetic nurse". Rather interestingly, according to Jaynes [67] sitting in mother's lap can induce EEG in infants not possessing stable EEG yet. An interesting question is whether mother's EEG shows a correlation with that of infant and whether it deviates from ordinary EEG in theta band.

The TGD based model of EEG to be discussed in detail later predicts that EEG consists of two copies so that ordinary alpha band has a scaled down copy around 5 Hz. The scaled down copy of EEG is predicted to dominate during sleep. The 7 Hz rhythm in the infant EEG could be interpreted as the scaled down counterpart of the sensorimotor rhythm identifiable in terms Na^+ cyclotron frequency. Infants would be in a state of consciousness analogous to sleep state as far EEG is considered: this of course conforms with the magnetic nursery hypothesis.

EEG rhythms in contrast to evoked and event related potentials

Evoked and event related potentials are believed to be associated with the neuronal activities generated by the sensory stimuli and it seems that they must be distinguished from the narrow frequency bands associated with the sensory and cognitive representations. Indeed, both evoked potentials associated with simple stimuli and event related potentials accompanying more complex stimuli have temporal structure which clearly reflects the propagation of nerve pulses along various parts of brain and one can assign to the peaks of the evoked potentials various a anatomical correlates in the neural pathways involved [49].

The time-scale systematics for the evoked and event related potentials conforms with the idea of self hierarchy. For instance, brain stem responds to simple auditory stimuli like clicks in time scale is 10 ms: the corresponding frequency is 100 Hz, which is the dominating EEG frequency in brain stem. For cerebellum the corresponding rhythm is about 200 Hz and cerebellum indeed takes care of micro-temporal regulation of motor actions. For higher regions of brain the time scale of event related potentials is typically about 100 ms: this correspond to the time scale of 10 Hz and time scale of memetic code. For instance, at V4 activity starts 100 ms after the onset of the visual stimulus and is peaked around 135 ms.

A good example of an event related potential (ERP) is P300, which is a large positive amplitude ERP following an improbable target in the sequence of repeated target stimuli: P300 occurs with the latency of 300 ms for young adults and for simple stimuli. P300 is preceded by a negative potential called N2 which presumably corresponds to the conscious detection of the target stimulus whereas P300 probably represents the use of this information to update the model about world. N2 contains also information about novelty of the stimulus and the difference of N2 for standard stimulus and novel stimulus is called mismatch negativity.

Coherence of EEG and sensory canvas hypothesis

If the EEG measured at skull relates closely to the sensory representations, it must inherit high coherence from the high coherence of the sensory landscape. Also fractal like hierarchy is predicted. At higher frequencies associated with sensory representations in shorter length scales, coherence should be restricted in shorter range. Indeed, according to [44], the coherence length for EEG at skull is present and measured by using 10 cm as a natural unit. This coherence could reflect the correlations between neural activities in various parts of brain but it is not at all obvious whether the timing of neural ionic currents can be so sharp that destructive interference cancelling the correlations EEG level does not occur.

According to [44], very complex structures of coherence in bands around 3, 5 and 7 Hz and 13, 15 and 17 Hz are definitely inconsistent with simple dipole models for the generation of EEG patterns. The findings are however consistent with the view that several distant regions of cortex can project features to the same point of a sensory map and that the coherence reflects the coherence of the sensory map. Coherence regions could naturally correspond to the objects of the perceptive field. The high coherence in the band $4-5$ Hz during mental calculations [44], which certainly represent abstract information processing and involve also long term memory in an essential manner, supports the view that abstract long term memories correspond to lowest EEG bands at 3, 5 and 7 Hz. According to [44], also increase of coherence between prefrontal and posterior cortical association areas have been reported during working memory retention in the range $4-7$ Hz.

The coherence lengths for EEG inside cortex are generally much shorter and complex patterns are encountered. Coherence length of order 2 cm is associated with cortical EEG structures which Freeman introduces as basic units of EEG activity [38] and calls mesoscopic level of sensory processing. Note that also retina has same size as the mesoscopic structures. Perhaps it is not accident that this length scale corresponds to the highest ionic cyclotron frequencies in Helium period.

EEG synchrony and negentropic entanglement

If one accepts the vision about life as something in the intersection of real and p-adic worlds 40 Hz EEG synchrony can be interpreted as a correlate for the generation of negentropic entanglement between cortical neurons. Before proposing this interpretation let us first describe the experimental findings of a finnish neuroscientist Antti Revonsuo [47].

1. *Findings*

The interpretation for 40 Hz EEG frequency inspired by the binding hypothesis is as a synchronizing frequency necessary for the generation of unified percepts. This hypothesis has been studied using auto-stereograms [47]. There was no detectable difference in the power spectrum at 36-44 Hz range in the situation when auto-stereogram was experienced as a set of random dots as compared to the situation when it was perceived as a coherent, symmetrical gestalt. The situation was same also in 8-13 Hz and 13-20 Hz beta bands. The finding is consistent with the place coding hypothesis.

On the other hand, when the conscious percept was transformed from a random set of points to a coherent gestalt, there was a detectable increase in 40 Hz power in the occipital and right posterior sites for EEG electrodes in a time window 500-300 ms before the unified percept was reported. There could be also some time lapse between the unified percept and the report about it but probably this cannot explain the entire lapse. No increase of power in beta bands was detected: this might be due to the fact that the widths of the measured bands are much wider than the widths of the narrow sub-bands reported masked by other EEG activity according to [44]. Note that in the model for a hierarchy of EEGs based on dark matter hierarchy beta band correspond to data communicated to the magnetic body [20].

That the change in activity is associated with the emergence of a new percept suggests that the temporary increase of the EEG power could be assigned to the communications of the forming percept to the magnetic body.

2. Interpretation in terms of generation of negentropic entanglement

A fresh view about what really happens during 40 Hz synchrony came with the realization that negentropic entanglement is possible in the intersection of real and p-adic worlds. The generation of negentropic entanglement between two subselves means that the corresponding mental images are fused [8, 27]. The process is experienced by the fusing subselves as an expansion of consciousness whereas consciousness is lost when when bound state entanglement is generated. Also the meditative states begin with enchanged 40 Hz activity and the interpretation would be same. Quite generally, the generation of negentropically entangled neuron groups could be a correlate for the emergence of a new idea or a new holistic pattern emerging from a chaos. Synchronous firing would be a natural correlate for the synergic state resulting in this manner. The paradoxical looking reduction of the oxiditative metabolism associated with 40 Hz firing could be seen as a signature of reduced dissipation when dissipating ensemble of neurons forms a single quantum coherent system.

What could then be the interpretation of the 300-500 ms time scale and synchronous firing in TGD framework?

1. If one assumes that only brain is involved, one must answer whether the new percept emerges after such a long time period. One would naively expect that negentropic entanglement immediately gives rise to the percept. Negentropic entanglement however means that a quantum superposition of several alternative percepts is involved. In the beginning the new percept is present with only small probability so that one would only know that the moment of heureka is quite near (this is indeed the experience that one has) and in the final situation it dominates but not completely since it requires conscious effort to preserve the percept.

2. Also magnetic body should be involved in TGD framework. The natural question is "Why this synchronous neuronal firing?". The natural answer would be that it allows to communicate the new percept as a consequence of a generation of negentropic entanglement to the magnetic body. The frequency scale of 40 Hz corresponds to a time scale of 25 milliseconds and corresponds to a length scale involved is about $.75 \times 10^7$ m, a good candidate for the size of the part of the magnetic body involved. This time scale is much shorter than 300-500 seconds. If the layer of the magnetic body in question corresponds to the fundamental 100 millisecond time scale assignable to electron as is natural in case of sensory percepts, the time lapse could be essentially due to the communication. If one takes the time scale literally the value of Planck constant which is about 3 to 5 larger than its standard value would suggest itself. Of course, the development of the percept from a fuzzy inkling to the final heureka could involve several communication loops between brain and magnetic body so that the interpretation as a lapse due the slowness of communications need not be inconsistent with the first interpretation.

3. The time scale 300-500 ms could characterize the duration of negentropic entanglement but this is not necessarily the case since negentropic entanglement would be un-necessary after the percept has been represented symbolically so that one knows what is lurking behind the chaos.

Narrow EEG bands and sensory canvas hypothesis

Sensory canvas hypothesis predicts the existence of narrow EEG bands corresponding to the magnetic transition frequencies varying in the range determined by the thickness range for the magnetic flux tubes involved with the sensory representation. The most natural candidates for the magnetic transition frequencies are cyclotron frequencies and their harmonics. There is indeed evidence for this kind of bands [44].

1. The best known band is alpha band around 11 Hz and has width of order 1 Hz. From this one can conclude that the relative variation of the magnetic field along magnetic flux tubes and thus magnetic flux tube area in the radial direction is roughly 10 per cent so that the

radius would vary about 3 per cent. The fact that alpha band at 11 Hz becomes active when eyes are closed is consistent with the interpretation that alpha band corresponds to cyclotron frequencies of bosonic ions and to the motor control by rather than sensory communications to the magnetic body. The activation of the alpha band is also associated with the generation of meditative and 'creative' states of mind. Hence one cannot exclude the possibility that alpha band activation corresponds to the projection of some information to the possible multi-brained sensory/cognitive representations associated with higher level collective selves.

2. Besides alpha band Nunez mentions also narrow sub-bands at 3, 5 and 7 Hz at delta and theta range, as well as sub-bands at 13, 15 and 17 Hz in beta band [44]. That beta disappears when eyes are closed conforms with the interpretation of these bands as being associated with sensory communications to the magnetic body. Hence these bands might be associated with the assignment of cognitive features to the points of the sensory canvas. Indeed, the evolutionary hierarchy sensory representations$\rightarrow$ cognitive representations$\rightarrow$ long term memories involving time like entanglement and making possible historical self, suggests this.

3. 40 Hz band has a width of about 8 Hz, contains several cyclotron frequencies, is associated with the primary sensory areas and disappears during sleep. This suggests that also this band is involved with the projection of the sensory qualia to the sensory canvas. The information about narrow sub-bands of EEG during hypnagogic states (the state between wake-up and sleep involving sensory hallucinations), during the schizophrenic hallucinations and hallucinations generated by sensory deprivation, and during lucid dreaming could provide interesting constraints on the possible sensory quale-EEG frequency correlations.

4. A well motivated guess is that 3, 5 and 7 Hz bands do not correspond directly to the sensory qualia experienced by our magnetic body. Hippocampal theta band (which actually extends from about 4 to 12 Hz) could contain these narrow bands and be involved with the assignment of abstract features, such as concepts and verbal associations and emotions, to the sensory map crucial for the memories. The fact that alpha and theta waves are important during this period suggests that alpha and theta frequencies are involved with the generation of episodal memories.

Whether the same frequency must be present during memory recall as during the generation of the memory, depends on the model of memory recall. According to the simplest model, memory recall means that an object in the sensory canvas of the geometric past is activated and temporal quantum entanglement mechanism allows us to share the experience. This does not require that the EEG frequency involved with sensory projection is generated in the brain which remembers. Of course, the formation of memory about recalled memory could generate this frequency.

2.4.3 How to test the sensory canvas hypothesis

In this subsection some tests for the new vision about sensory canvas hypothesis are proposed and some astrophysical phenomena possibly supporting the basic assumptions behind the new view are considered. The magnetospheric sensory representations associated with Mother Gaia, as opposed to the sensory representations realized at the personal magnetic body, are discussed in [22].

Some simple tests

One could try to disturb the magnetic flux tubes or MEs responsible for the projection of the visual map to the external world *outside* the body somehow. If the visual experience is modified dramatically, one has an experimental argument supporting the new view. One could perhaps induce also magnetic quantum phase transitions outside the body by stimulating the super-conductors at magnetic transition frequencies and perhaps generate in this manner visual hallucinations. One could generate weak magnetic fields of roughly the same strength as the fields associated with the magnetic canvas and thus superposing with them. Slow modulations of the magnetic fields in these flux tubes might be possible so that cyclotron frequency scale changes and the objects of the perceptive field would be experienced to either contract or expand. Unfortunately (from the point of view of empirical testing), if sensory images are of order ME wavelength $L = c/f$, the sensory images might be extremely stable against perturbations.

One could also study what happens for the vision if the magnetic materials in brain or retina are not present in normal amounts. Or what happens when there is external magnetic field perturbing the magnetic field of Earth inside retina or cortex so that the compass defining the inertial reference frame does not function properly. Does this lead to a sensations associated with dizziness? Could the removal of Earth's magnetic field induce this kind of sensations or affect the visual experience? Probably this is not the case. The general model for EEG predicts that the magnetic flux quanta carrying dark matter responsible for sensory representations and motor control are present even if Earth's magnetic field is cancelled.

Tests for place coding

The hypothesis that EEG frequencies in narrow EEG bands code for the distance of an object of perceptive field can be tested. If subject person directs attention to a moving object of the perceptive field, the peak frequencies inside the narrow EEG bands responsible for the place-coding should shift. The detection of EEG activity in V1 when percept changes in binocular rivalry would support the existence of strictly non-neural correlates of visual consciousness. Negative energy MEs are responsible for the entanglement, and one must ask what it is to detect negative energy MEs. MEs generate coherent light and phase conjugate laser waves at ELF frequencies are what comes in mind first. It is not at all obvious to me how one could observe these. The breakdown of second law in appropriate time scale might be one correlate for the presence of negative energy MEs.

How to test the hypothesis that primary sensory representations occur at the level of sensory organs?

That retinas are involved with the attention is known for some time: directing the attention to an object of the visual field does not necessarily imply directing the gaze to the object [55]. The amplification of the back-projections from frontal lobes to the part of retina in question is enough, and if the feedback exceeds a critical value the direction of the gaze is changed. This suggests that the mental image of the object of the perceptive field is realized at the retina and corresponding magnetic body and directing of attention to it feeds metabolic energy to this mental image. If the fundamental visual representation occurs at the level of retinas, the selection of the visual percept in the visual rivalry might be detectable at the level of retinas.

80 Hz frequency is known to be associated with retinas, and one can wonder whether this would determine the size of the magnetic body associated with retina (the size would slightly below Earth radius!). It would be worth of testing whether the pattern of 80 Hz activity associated with retinas correlates with the selection of the sensory percept say in the case of sensory rivalry: certainly this is not what standard neuroscience would suggest but would be worth of testing.

2.5 Support for the magnetic sensory canvas hypothesis

Magnetic sensory canvas hypothesis is certainly the craziest idea inspired by TGD inspired theory of consciousness. The effects of atmospheric and magnetospheric electromagnetic phenomena to conscious experience would support the sensory canvas hypothesis. If sensory organs are the seats of primary sensory qualia, the possibility that atmospheric phenomena could induce extrasensory percepts is excluded. Sensory percepts based on back-projection mechanism might be however possible.

2.5.1 Atmospheric and ionospheric phenomena and sensory canvas hypothesis

The sounds claimed to be generated by auroras and meteors and the correlation of UFO reports and ET experiences with tectonic activity provide some clues in the attempt to develop magnetic sensory canvas hypothesis. Also various anomalous visual percepts and OBE experiences provide challenges for the model.

The sounds generated by auroras

There are claims that auroras generate audible sounds [39] (for the quantum model of auroras see [23]). These sounds have not been detected by acoustic means. Of course, it might be only a matter of time when this is done.

A particular example of microwave hearing [42] could be in question. The microwave MEs generated in auroras could propagate like massless particles along ELF MEs to brain, and induce cortical perturbations modulated by ELF frequencies serving as modulating frequencies and determining the pitch of the sounds heard. The perturbations would be analogous to electric stimulation of cortex inducing sensory percepts by back-projection mechanism. The cortical perturbations would generate auditory sensations by the back-projection mechanism. Higher Schumann resonances are in the audible range and could also be mediated along the flux tubes from the magnetic body or magnetosphere to brain and induce audible sounds by the back-projection mechanism.

The TGD based model of hearing relies heavily on classical Z^0 fields and auditory canvas could be be actually Z^0 magnetic. Since all classical fields are expressible in terms of CP_2 coordinates, magnetic storms are expected to be accompanied by their Z^0 magnetic counterparts.

The sounds generated by meteors

so some further evidence for the sensory canvas hypothesis. Since 16th century it is known that also meteors produce audible sounds. What is mysterious that there is no time lag due to the propagation through the atmosphere. The explanation is that it is very low frequency em waves which propagate to Earth and generate sounds by interacting with the objects at the surface of Earth. Joined by the International Leonid Watch - Croatia (ILWC) project, a group of scientists presented the first instrumental detection of elusive electrophonic meteor sounds. In November 1998, the researchers from the Croatian Physical Society and the University of Kentucky organized an expedition to Mongolia to observe the anticipated Leonid meteor shower and shed some light on the phenomenon [37].

The complete data analysis revealed two electrophonic sounds that provided several important clues about the nature of this longstanding astronomical mystery. It became clear that sounds were created when the meteors were crossing night-time ionosphere (the heights involved are in 85-110 km). The electrophonic sounds seem to be produced inside the measuring apparatus suggesting that electromagnetic energy is transformed to sound at this stage. The existing theories cannot however completely explain the phenomenon. The energy of the meteor does not seem to be high enough to invoke the electric fields needed to explain the electronically recorded sounds: only one percent of the electric energy is estimated to be transformable to acoustic form but the required conversion ratio seems to be 100 percent and perhaps even higher than this. The frequencies are much lower than the expected range 20-20.000 Hz range for sferics, which by the way is the range of audible sounds, not an accident in TGD universe. The fundamental frequencies are in the region 37-44 Hz but are consistent with the psychophysical correlate of the sound (deep 'pop').

Magnetic mirrors as carriers of the electromagnetic perturbations might allow a better understanding of the phenomenon. What is intriguing that the frequencies are in the range 37-44 Hz: this frequency range is the same as associated with the average value of the thalamocortical resonance frequency of 40 Hz. This frequency range should be associated with the sensory representations on the magnetic canvas. It is known that sounds near 40 Hz induce strong effect in EEG. The first hypothesis is that the interaction of these em fields with brain generates the perceived sound. On the other hand, in TGD framework these sounds are represented ultimately in the magnetic sensory canvas: thus the intriguing possibility is that the consciously perceived sounds are in fact generated by the direct perturbations of the magnetic or Z^0 magnetic auditory canvas and are genuine ESP effects.

The recorded electrophonic sounds could be induced by electromagnetic perturbations propagating along magnetic mirrors at multiples of the fundamental frequency $f = c/L$ determined by the length L of the magnetic mirror and the mirrors might not only channel the electromagnetic energy very effectively but even act as resonators amplifying the em fields. In fact, in one of the models analyzed in [37], the electric fields on the surface of Earth must have the same strength as the electric fields created by the meteor in its immediate vicinity in order to explain the data! If the electric fields are channelled along the magnetic mirrors associated with the magnetic sensory canvases to the surface of Earth, the frequency spectrum is automatically in the 'thalamocortical' range instead of the expected $20-20.000$

Hz range for the sferics and one can understand why only few meteors generate electrophonic sounds. Notice that magnetic mirrors of length shorter than Earth's circumference would give rise to higher resonance frequencies than Schumann frequencies: the required length of the mirror would be roughly 1.26 Earth radii for 40 Hz frequency.

One can imagine tests for the sensory canvas hypothesis and for the possible ESP character of the heard sound (in the sense that the heard sound is induced cortically rather than received from environment).

1. One could construct acoustic amplifier in 37-44 Hz range so that human perceiver could hear both the direct ESP sound and the sound generated by the amplifier. This would mean hearing two 'pops', such that the interval between them is determined by the time used to the sensory processing and propagation of the sound from the external source. In fact, in the introduction of [37] it is mentioned that 'many witnesses heard sounds even before they heard the noise inside the house'. Assuming that the sounds are both heard and electronically detected, a neurophysiological model for the time lapse from the sensory input to the conscious percept would allow to test whether the consciously perceived sounds can have non-ESP origin. If the lag is too small, ESP interpretation is supported.

2. The human perceiver could use ear plugs. If 'pop' is heard also in this case, the only possible interpretation (excluding fraud) is that the sounds are generated either by the neuronal activity stimulated by the interaction of the ELF em perturbation with brain, that the sound is generated in body as physiophonic sound [41], or that a genuine ESP is in question. The phenomenon of physiophonic sound discovered by Antionio Meucci in 1842 means the amplification of external sounds or electromagnetic signals by musculature and their feed directly to the neural circuits (ears could be closed) and is a rather convincing explanation for the heard sounds. The possibility of fraud could be eliminated by excluding the possibility of the direct visual perception of the meteor and finding whether the heard sounds coincide with the electronically detected sounds.

UFOs, ETs and magnetic perturbations

Persinger has proposed a model explaining the encounters of extraterrestrials as hallucinations caused by the perturbations of Earth's magnetic field induced by the liberation of the tectonic energy at the lines of tectonic activity [70]. The model is based on well-established statistics about the effects of the perturbations of Earth's magnetic field on consciousness collected in mental hospitals. The lines of the tectonic activity are also accompanied by well established luminous phenomena which suggests that the model could be naturally combined with the explanation of UFOs as this kind of luminous phenomena.

The most obvious guess is that a beam of visible light or ions emerges from the region where the tectonic energy is liberated. If this beam somehow produces a localized ball lightning type phenomenon it could be interpreted as UFO. If the direction of the beam varies randomly the resulting UFO performs random butterfly like motion and in principle the velocity of motion can be super-luminal since a signal velocity is not in question. The motion would resemble that of a flicker's light spot in a roof. Many UFO candidates have indeed found to move in this manner and this is quite a challenge in the attempts to understand the technology used.

1. Why a light spot rather than beam of light is observed?

The challenge is to explain why a localized pseudo UFO rather than a beam of light is observed.

1. One could consider the possibility that a radial spray of electric flux emanates from the site of the tectonic activity and electrons accelerate in this field until they gain the energy needed to ionize the molecules of the atmosphere and produce visible light. The analog of vacuum discharge would be in question. The problem is that the drifting velocity is achieved very rapidly so that the model works only if the density of molecules of the atmosphere decreases sufficiently fast as function of height. This is not the case.

2. Suppose that the spot of tectonic activity emits dark microwave photons including frequencies $f > 5$ GHz. In this case visible light could result via the de-coherence of the dark microwave photons to ordinary photons. The fraction of ordinary visible photons in the beam would

behave as $1 - exp(-h/h_0)$ and at some critical height the beam would become visible as the visible photons scatter from the molecules of atmosphere.

3. Pseudo UFO could be a kind of a mini aurora produced by exactly the same mechanism as auroras. Similar mechanism could apply also to ball lightnings and other exotic luminous phenomena. The super-conducting magnetic flux tubes associated with the stream of magnetic flux assumed to emanate from the site of tectonic energy liberation would intersect with the magnetic flux tubes of Earth's magnetic field (or those emerging from the brain or body of the perceiver of ETs). This would lead to a reconnection process in which magnetic flux tubes having a local U-shape are generated. The inertia of the super-conducting ions (perhaps protons and electrons) would induce the leakage of the ions to the non-super-conducting atmospheric space-time sheet. This in turn would lead to a further ionization and the molecular electronic transitions would generate the visible light as in the case of auroras. Also electric fields could be involved as in the case of auroras. U-shaped structures would occur at definite height. By measuring the local electromagnetic fields one could perhaps test whether the orbit of the pseudo UFO correlates with the variation of the hypothesized stream of magnetic flux emerging from the site of the tectonic activity. The pseudo-UFO character could be tested by finding what kind of radar echoes the luminous region generates (if any).

2. What about ET reports?

The aurora mechanism could explain also the hallucinations as real encounters with other selves of the predicted self hierarchy rather than ETs. The tectonic activity could cause a similar perturbation of the personal sensory canvas and perhaps its temporal fusion with other sensory canvases, perhaps even with higher multi-brained sensory canvases possibly present. This would obviously induce genuine ESPs. The generalized motor response coming from the sensory canvas would be also involved but primary percept would occur before it. Brain would probably do its best to interpret the situation using concepts provided by the cultural background. Angels, spirits, demons, ETs, etc.. would be various narratives for the same phenomenon.

Also Schumann resonances are excited during tectonic activity and could correlate strongly with the experiences about encounters of ETs: this explanation is consistent also with option b). Similar mechanism might be behind hypnagogic experiences occurring at the boundary between wake and sleep. EEG is dominated by frequencies near the lowest Schumann frequency 7.8 Hz during hypnagogy and this might mean that the entanglement with other sensory canvases occurs with an enhanced probability.

Krishnamurti has told very movingly about experiences of literally being another one. Perhaps also other identification experiences, such as shamanic identification with animals, rely on the same mechanism. Also I have had strange hypnagogic experiences of being a totally different person for a moment. This picture would suggest that magnetic transition frequencies associated with the flux tubes of the magnetic sensory canvas emanating more or less vertically from the head code for the personal content of consciousness whereas Schumann frequencies relate with the transpersonal contribution to consciousness possibly present always and giving rise to a third person bird's eye of view about own person and amplified during hypnagogic experiences or by strong perturbations of Earth's magnetic field.

Anomalous visual percepts and sensory canvas hypothesis

Sensory canvas hypothesis means that at the level of magnetic body we see using ELF– rather than visible light. Of course, if primary sensory qualia are at the level of sensory receptors, this seeing has the character of imagination. Even in this case brain could use back-projection to the sensory receptors assign sensory qualia with the imagination like perception. This would occur during dreaming and what is regarded as hallucinations.

The model of EEG [20] however leads to the conclusion that the Josephson radiation from cell membrane corresponds to dark photons with EEG frequencies and bio-photon energies so that they can transform to bunches of EEG photons or to biophotons with ordinary value of Planck constant. This model predicts correctly the frequencies of maximal sensitivity for the four kinds of photoreceptors and a good guess is that this radiation could explain large number of various anomalies in which low frequency radiation has biological effects.

One can also consider the possibility of "vision" as a sensory experience of the magnetic body based solely on the ELF input from brain and body having no correlate with the visible light entering into the retina or even with neural activity. The de-coherence of (for instance) dark ELF photons with frequencies above alpha band level of the dark matter hierarchy to ordinary visible photons could be responsible for this vision.

Even genuinely three-dimensional vision in which own body is seen as it would be seen by the external world suggests itself. The dropping of ions from the atomic space-time sheets to the magnetic flux tubes so that they end up to high n cyclotron states decaying via the emission of photons at frequencies which are harmonics of the cyclotron frequency would generate the projector MEs needed for the sensory representation of the physical body or part of it as seen by the environment.

There is some evidence for this kind of anomalous vision.

1. Yogis have reported altered states of consciousness in which they see their own body three-dimensionally, that is simultaneously from all directions. This might have interpretation as ELF vision involving a feedback from magnetic sensory canvas to brain to "qualiafy" the percept. An alternative interpretation is that the visual experience is visual experience of some other self which is shared by quantum entanglement.

2. Becker tells in his book "Cross currents" [89] about a young cancer patient who told that he can see the interior of his own body. The patient could also locate the remnant of the tumor correctly. If sensory receptors are necessary for visual qualia, the needed data must be received from somewhere by brain, and be projected to the retinas like during dreaming. The simplest option is that body parts can in some sense "see" each other. In particular, brain can "see" body parts (note that bacteria possess a primitive IR vision based on micro-tubules). Bio-holography provides support for the body as a hologram. For instance, an electric stimulation of ear during Kirlian imaging of a finger tip creates a Kirlian photo from which it is possible to abstract a hologram of ear (see [46] and [16]). One can also imagine that magnetic body "sees" and the mechanism is the transformation of dark EEG photons to visible photons.

3. Also the OBE experiences, for instance those associated with NDEs, could have an analogous interpretation. The sensory input from eyes would be absent but brain would give feedback to visual receptors to "qualiafy" the input which it might receive from other levels of self hierarchy. If even the input from neural activity is absent during NDEs so that the visual experience should be determined by the background ELF component emanating from the brain and body. The third person perspective associated with OBEs might be always present but be masked by the strong sensory input or by the absence of feedback to visual receptors. It is possible to have experiences about contact with deceased by a therapy based on rhythmic eye movements [67, 58]. The function of eye movements might be to establish a feedback to certain brain regions serving as receivers of input from magnetic bodies of deceased or from magnetosphere. I have developed a detailed model for various kind OBE experiences in [26].

4. I have proposed thousand and one explanations for the beautiful flow visible when I close my eyes in a calm state of mind. During my "great experience" this background flow was accompanied by extremely vivid visual hallucinations. An additional item to the long list of explanations is following. The information characterizing the flow enters from or via brain to the visual receptors and is in this manner "qualiafied".

What has been said about magnetospheric third person aspect applies also to other senses. Interestingly, I often wake-up partially and realize that I hear my own snoring as an outsider (quite a dramatic experience!). Sometimes I have had an experience which might be interpreted by saying that the hearing in the first perspective is superposed with the hearing in the third person perspective. The third person hearing has a time lag so that a kind of double breathing results.

2.5.2 Taos hum

Taos hum is an experimentally well-established anomalous phenomenon which has escaped rational explanations (in the article [41] a thorough review about nocturnal taos hum is given and the following representation relies on this article). Very concisely, taos hum seems is apparently a subjective experience without identifiable objective counterpart and could thus provide an application for the sensory canvas hypothesis.

The TGD based model for EEG [20] is based on dark Josepson radiation generated by cell membrane Josephson junctions in the energy range of visible and UV light and covering a wide frequency range. The model explains biophotons and EEG photons as manifestations of one and same thing. Taos hum could be understood in terms of this kind of Josephson radiation at microwave frequencies generated by living matter during night-time and possibly providing some organisms with an active vision. The emission of negative energy dark photons could also make it possible for plants to suck metabolic energy from environment in the absence of solar radiation.

Basic facts

Taos hum is perceived in and around Taos, New Mexico but similar phenomena are experienced also in Northern America and Northern Europe. The hum is mostly heard during night time. Most people experience the hum as irritating and it causes nocturnal disturbances. From the tests based on psychophysical matching the frequency range of the hum has been deduced to be 40-80 Hz and whereas amplitude is around 60 dB. The hum is a regional phenomenon. The hum does not usually appear between sunrise and sunset. The pitch and intensity of the hum varies inside house and finds the largest magnifications on lower floors. Rooms modify the hum by adding distinctive harmonics to it. The pitch of the hum changes when one moves from outer wall to the interior rooms. Hallways and small alcoves raise the pitch considerably. The wavelengths involved vary between 3.9-7.8 meters for 40-80 Hz frequency range which suggests that resonance effects could be involved. It has been however impossible to identify any acoustic origin for the phenomenon. The presence of effectively acoustic effects suggests that gigantic amplification by the physical (and em!) body of the patient is involved.

Hum can involve also an experience about whirling or roaring wind, kind of vortex although nothing moves around, and coming from all directions. Also a strange amplification of distant sounds can be experienced. White light in the horizon in the direction where hum comes from can be also perceived. Experiences analogous to hum have been reported also in past, even in antique ('Aeolian wind'), but nowadays the number of victims of the hum has increased, which suggests a connection with the emergence of electronics and computers. The direction which hum is experienced to come from seems to be random.

The hum can be accompanied by irritating tactile sensations and neuralgic pain. The unfortunate individual who suffers of extreme HUM disturbances, seems to be controlled by very fundamental and autonomic response-reflexes when in its grips. Such sufferers may behave in semiconscious modes, modelling behavioral patterns seen only in animals. Typically the victim tends to get underground believing that this allows to get him rid of the hum. The victims of hum indeed tend to wake up with the realization that they have very strong and painful muscle tenure.

An important hint as regards to mechanism of hum is the fact that the temporal patterns of the shortwave radio static detectable by shortwave receivers correlate strongly with those associated with the hum. It is also known that the static has a biological origin: the warbling sounds characterizing the static resemble those produced by plants and galvanic skin response sensors. And most importantly, the statics is present during night time.

All attempts to detect the hum instrumentally and to identify its source have failed. This has inspired various kinds of conspiracy theories about the nature of the phenomenon, for instance, the proposal the strong ELF power feed by submarine radars alone could explain the phenomenon.

Phenomena possibly related to taos hum

It is appropriate to discuss first some phenomena possibly related to the taos hum before considering the model for the phenomenon itself.

1. *Microwave hearing*

During the collaboration with Joaquim Fernandez related to the construction of a a model for so called Fatima miracle [40] I learned about the phenomenon of microwave hearing [42] in which microwaves generate an audible sensation. There is evidence that microwave hearing does not involve ears as receivers of the primary signal [43] and that the sensation of hearing could result as back-projection from cortex to ears.

This, and the correlation with microwave static suggest that taos hum could be a particular case of microwave hearing. The model of sensory representations implies that brain acts as a sending microwave antenna: a natural implication is that brain can act also as a receiving microwave antenna. The size of the brain hemisphere corresponds to a microwave frequency of order 3 GHz and smaller structures inside brain correspond to higher radio frequencies. If primary sensory organs are the seats of the sensory qualia and that back-projections cannot induce physical pain, the presence of the painful tactile sensations means that microwaves must interact also with the sensory receptors at the skin.

2. Physiophonic effect

Physiophonic effect is a phenomenon accidentally discovered by Antonio Meucci in 1842, in which vocal signals are electrically transmitted directly into the neurology of listeners [41]. Physiophonic sound can be often amplified to an enormous volume. A possible interpretation is as externally stimulated internal sound but one can of course wonder whether the transduction to sound is necessary.

Since the body (especially collagen network) is liquid crystal allowing piezoelectric effect in which mechanical vibrations are transformed to electric signal, external sounds could be transformed to electric fields. On course, LC property implies that also genuine sound is generated so that both ELF em fields and ELF sounds can act as amplified signals. One can ask whether strong back-projection to the ears is generated so that sound percept results. This would imply oto-acoustic sounds directly detectable by microphones not found in the case of taos hum.

3. Microwave static and taos hum

It is known that the temporal patterns of the shortwave static detectable by shortwave receivers correlate strongly with those associated with the hum. It is also known that the static has a biological origin: the warbling sounds characterizing the static resemble those produced by plants and galvanic skin response sensors. And most importantly, the fact that the static is present during night time would explain why hum is experienced at night time.

Possible ingredients for the model for taos hum

The facts about the role of the musculature, shortwave radio noise, and the role of acoustic environment combined with the model of microwave hearing based on the notion of dark photons [19] pose strong constraints on the model of taos hum.

1. Taos hum as sensitivity to alien control commands

Magnetic bodies control biological body by sending control commands to brain and body where they are transformed to nerve pulse patterns and various physiological waves. Also the lower levels of self hierarchy should control the respective levels of the hierarchy, in particular muscle cells, in a similar manner. In the case of hum patient the normal control signal could be replaced by a control signal from some external biological source, say plants, and would be responsible for the muscular vibrations amplified to the hum. In the worst situation the behavior of hum patients reduces to simple reflex actions: these reflex actions would be initiated by fake control signals.

The fact that the taos hum begins after the sunset would conform with the interpretation as sucking of metabolic energy with energy quanta in visible and UV range. The loss of metabolic energy could explain why the experiences of patients are so unpleasant. Since motor action is based on negative energy signals affecting directly neuronal membranes by the same mechanisms as ordinary motor actions the signals would also induce reflex actions.

The situation would be due to the failure of the em (or rather, electro-weak) immune system of the patient. In order to understand what is involved a brief discussion of model of motor control based on charge entanglement induced by W MEs is necessary: a detailed model is discussed in [16, 19].

1. The exotic ionization of dark matter induced by W MEs generates dark plasma oscillations inducing electric fields which by many-sheeted variant of the Faraday law induce electric fields also at the space-time sheets where ordinary matter resides. Various ionic waves, in particular Ca^{2+} waves and nerve pulse are examples of the physiological responses resulting in this manner.

2. Dark plasma frequency corresponds to a microwave photon with energy above the thermal threshold and the system must be able to provide dark photons with this energy to generate plasma oscillation patterns serving as control commands.

The electro-weak immune system could fail in the following manner.

1. In the healthy situation em immune system takes care the the body is tuned to the personal dark plasma frequencies and does not respond to control commands from alien magnetic bodies associated with say plants.
2. In an un-healthy situation persons plasma oscillation frequencies are tuned to some frequencies in the microwave static and microwave static provides the energy needed to generate plasma wave patterns and thus to realize control commands from the alien magnetic bodies. The plasmoids would induce microwave hearing and generalized motor actions at cellular level exhausting the personal metabolic sources and leading to the painful experiences and fatigue.

2. Taos hum and microwave hearing

The identification of the audible sensation associated with taos hum is in terms of microwave hearing explains the failure of the attempts to identify the source for taos hum. Amplitude modulation by ELF frequencies naturally associated with motor control would give rise to sensation of sound.

Concerning the model for microwave hearing, a good guideline is that the effect is expected to be possible as quantum effect only if the energies of the microwave photons are above the thermal threshold. This would require dark microwave photons for which 5 GHz photons have energy above thermal threshold (6 cm wavelength). Same applies to other effects caused by dark microwave photons.

Microwave hearing itself would rely on hearing of dark microwave photons at visible and UV frequencies. These dark microwave photons could accompany the microwave signal automatically or could be generated by cells via a phase transition increasing the value of Planck constant.

3. Taos hum and microwave seeing

The de-coherence of microwave photons to ordinary photons would produce the biological effects. This could explain also the reported perception of white light as resulting from the de-coherence of the microwave photons at the upper end of the spectrum: 1 mm microwave wavelength would correspond to 2.5 eV photon energy.

The de-coherence of dark microwave static to ordinary visible photons could make possible microwave vision during night time. This could explain why the static emerges after the sunset. Plants could also generate negative energy dark microwave photons with energies in the frequency bands of visible photons involved with photosynthesis to satisfy their metabolic needs when they do not receive sunlight. One can of course wonder whether the quartz in the rock heated during day-time could generate dark microwave photons during night-time serving as a metabolic source.

3. Taos hum as a failure of the electromagnetic immune system

Taos hum starts immediately after the sunrise and stops after the sunset and seems to have a biological origin. The magnetic bodies of (say) plant cells could send dark energy photons at microwave frequencies above 5 GHz: one reason is that they become visible in this manner.

Negative energy W MEs in the same frequency range and responsible for quantum bio-control in the time scale of microwaves could be involved. Due to the failure of the electro-weak immune system the surrounding biosphere could induce generalized motor actions and these would exhaust the metabolic energy resources of the victim. This would explain why the hum is intolerable and the extreme fatigue caused by it.

The radio noise generated by computers and other sources of radio waves should not cause troubles if these radio waves correspond to ordinary photons. If not, then the microwaves in question could provide the energy needed to realize alien control commands based on ELF modulation.

4. An explanation for 40-80 Hz modulation

The model of biological evolution and evolution of nervous system based on dark matter hierarchy [20] leads to sa detailed identification of the values of Planck constant associated with EEG identified as of dark Josephson radiation with energies in visible and UV range and EEG frequencies. This level is involved with all life forms capable of genetic expression, in particular plants. Therefore the ELF modulation of microwave frequencies could be due to the control commands from the levels of the magnetic body normally meant to control the genetic expression of say plants. The modulation of the microwaves with EEG frequencies, in particular with the frequencies in the $37-44$ Hz thalamo-cortical resonance band, could force the patient to stay awake by not allowing the dominant EEG frequencies to drop down to theta and delta region of EEG as occurs during sleep.

5. Is stochastic resonance involved?

One could also ask whether the microwave static of victims of taos hum is anomalously amplified by some mechanism so that control commands from alien magnetic bodies can be realized. The transduction of weak microwave signals to mechanical oscillations by piezo-electric body liquid crystals, and the amplification of this signal in the presence of a metabolic energy feed to the musculature, could lead to this kind of situation.

Stochastic resonance with white noise generated by body provides one possible amplification mechanism. Micro-wave frequency would correspond to the amplified frequency. If so, one could perhaps understand why only some persons experience the hum and why the effect is strong at night time. White noise would be generated by body. White noise induces jumps between the states of the 2-state system with an average frequency f_K (Kramers frequency) which depends on the autocorrelation function of the white noise and the properties of the 2-state system [44]. If the Kramers frequency satisfies $f_R = 2f$, where f is the frequency of the signal, a resonant amplification occurs. The dependence $f_K \propto exp(-\Delta V/D)$, where $\Delta V > 0$ is the height of the potential barrier separating the states of the 2-state system, implies and exponential sensitivity of f_K on $1/D$, where D is the intensity of the white noise. Hence the failure of the em immune system could be due to the too intense white noise produced by the body of the victim or due a too low height of the the potential barrier.

6. Are electronic systems involved with the hum?

The fact that the number of victims of hum has rapidly increased during the era of radio communications and computers and suggests that both radio noise and computers might be actively involved with the hum. Also ELF noise from electronic systems might be important if these systems generate dark ELF photons.

Electronic instruments generate also frequencies in the range $40-80$ Hz, in particular the 50 Hz frequency associated with the household electricity. Also submarine radars generate very strong ELF signals. The liquid crystal character of human body implies that besides weak sound signals also these ELF signals can contribute to the signal amplified by musculature. If these signals correspond to the lowest level of dark matter hierarchy, they should not have biological effects but whether this is the case is not all clear.

The strong coupling between magnetic flux tube structures associated the with computer networks and sensory canvases might be created by the magnetic reconnection process during night time when the shape of the flux tube structures changes. Also whole-daily use of a computer could generate magnetic mirror bridges between the computer and user's musculature and allow computer to feed fake control signals to muscles.

Is hum possible in other sensory modalities?

The model of hum based on magnetic sensory canvas suggests that the effect is involved with all sensory modalities. Tactile sensations, in particular pain, are certainly involved. It was already mentioned that hum experiences can involve also perceptions of white light in the horizon in the direction from which hum came. In the model explaining the sensation of hum as being caused by the muscular sound, this sensation could result as a kind of cross-modal association accompanying very intense auditory sensation. In the model explaining the effect as ESP the presence light sensation could be understood as visual aspect of the ESP.

My personal experiences provide a candidate for the counterpart of taos hum in visual field. While closing eyes in a calm state of mind, I see a strange and complex flow consisting of small dots: for the first time I had this experience during my great experience roughly 15 years ago. The effect is easiest to achieve with lightly closed eyes but appears after some time also with tightly closed eyes. For lightly closed eyes the flow is more complex whereas for tightly closed eyes there is just a sink in the middle representing what I would call 'third eye', which is present practically always. Vortices and spiral vortices (compare with the whirling winds associated with hums) are typically involved and flow can have also weak coloring.

Could this flow be the visual counterpart of the taos hum? The very fact that the experience is pleasant and the appearance of diffuse white light during taos hum suggests that this interpretation need not be quite correct.

1. The effect is caused by the de-coherence of dark microwave photons or perhaps dark EEG photons above alpha band to visible photons (during calm states of mind alpha band is very strong).

2. This effect is strongest when the eyes are only lightly closed. Perhaps ELF em waves from some source could provide the input to the retina which is magnetic structure and generate the visual sensation somehow (note that rotating non-colored Benham top can generate sensations of color). The de-coherence of dark ELF photons to ordinary visible photons could be the mechanism.

3. I have proposed an interpretation for the flow in terms of the magnetic flux tube structure emerging from the retina. One can however wonder why just single central vortex rather than two? Could it be that pineal gland, which is also a magnetic structure and contains retinal pigments and is 'third eye' in rather literal sense, could be responsible for the 'third eye' component of the flow, and that during eyes lightly closed conditions turbulent retinal and single vortex like pineal contributions superpose? Could pineal vision be based on the de-coherence of EEG waves above alpha band to ordinary visible photons?

What is perhaps remarkable that the ability to have the flow experience has stabilized during last year or two, which is also the period during which various hum symptoms have developed. However, I experience the flow also when the computer is off: as a matter fact, I experienced the flow for 15 years ago when I did not work with computers.

Personal experiences about hum

While learning about taos hum, I suddenly realized that I am perhaps not an objective outsider at all! I cannot tolerate the humming noise of the refrigerator: in order to sleep at all I try to insulate myself from the kitchen by cloth (I do not have door between) and use pillows on my ears in order to get rid of this extremely irritating sound. Even this is not enough and I wake-up very often during night-time. I also used to have terrifying experiences in which the noise of the refrigerator started to increase in volume and my body started to float and was attracted by the refrigerator as if it were a conscious creature wanting to fuse with, or rather steal, my consciousness (by the way this suggests that magnetic selves strongly interacting with my magnetic body might be really involved). I can also hear sounds, such as cracks from wall, as amplified to completely abnormal intensity (in fact I have always had abnormally sensitive ears).

I suffer also from almost intolerable hum of my computer at day-time and only while learning about taos hum, I realized that similar mechanism might be at work also here (note however that taos hum is strongest during night time, between 9 P.M. and 9 A.M.). Remarkably, the hum amplifies when I become conscious of it: I can work long times without noticing its presence at all. Neither am I aware of the refrigerator at daytime. To complete the picture, two years ago I began to suffer from chronic pain in head, neck and back which are due to strong muscle tensions. These pains correlate very strongly with working at the computer terminal. I have believed that this is due to the bad working ergonomy and poor quality of eye glasses. However it turned out that this was not the reason of pains. I have even suffered from temporal dizziness when pains have been worst and even lost my consciousness once: strangely enough, I heard before the loss of consciousness a strange whirling wind to blow (sic!), and realized only later that weather had been completely calm.

It seems that all these symptoms fit with those of a hum patient. Now only the source of radio waves would be my own computer and would act also at daytime via direct radio wave magnetic mirror bridges connecting the oscillating circuits of the computer to my musculature. When I am not aware of the noise, my brain does not project sensory input from muscles to the auditory canvas and I am saved from the hum sensation. I however feel the pain coming from the body all the time.

On basis of what has been said, it would seem that there is high time to consider the possibility that the electric pollution of environment is gradually making our life increasingly intolerable. One cannot even exclude demon like conscious virus like entities generated by the electronics and computers and fighting for survival with us.

Bibliography

Books about TGD

[1] M. Pitkänen (2006), *Topological Geometrodynamics: Overview*. http://tgd.wippiespace.com/public_html/tgdview/tgdview.html.

[2] M. Pitkänen (2006), *Quantum Physics as Infinite-Dimensional Geometry*. http://tgd.wippiespace.com/public_html/tgdgeom/tgdgeom.html.

[3] M. Pitkänen (2006), *Physics in Many-Sheeted Space-Time*. http://tgd.wippiespace.com/public_html/tgdclass/tgdclass.html.

[4] M. Pitkänen (2006), *p-Adic length Scale Hypothesis and Dark Matter Hierarchy*. http://tgd.wippiespace.com/public_html/paddark/paddark.html.

[5] M. Pitkänen (2006), *Quantum TGD*. http://tgd.wippiespace.com/public_html/tgdquant/tgdquant.html.

[6] M. Pitkänen (2006), *TGD as a Generalized Number Theory*. http://tgd.wippiespace.com/public_html/tgdnumber/tgdnumber.html.

[7] M. Pitkänen (2006), *TGD and Fringe Physics*. http://tgd.wippiespace.com/public_html/freenergy/freenergy.html.

Books about TGD Inspired Theory of Consciousness and Quantum Biology

[8] M. Pitkänen (2006), *TGD Inspired Theory of Consciousness*. http://tgd.wippiespace.com/public_html/tgdconsc/tgdconsc.html.

[9] M. Pitkänen (2006), *Bio-Systems as Self-Organizing Quantum Systems*. http://tgd.wippiespace.com/public_html/bioselforg/bioselforg.html.

[10] M. Pitkänen (2006), *Quantum Hardware of Living Matter*. http://tgd.wippiespace.com/public_html/bioware/bioware.html.

[11] M. Pitkänen (2006), *Bio-Systems as Conscious Holograms*. http://tgd.wippiespace.com/public_html/hologram/hologram.html.

[12] M. Pitkänen (2006), *Genes and Memes*. http://tgd.wippiespace.com/public_html/genememe/genememe.html.

[13] M. Pitkänen (2006), *Magnetospheric Consciousness*. http://tgd.wippiespace.com/public_html/magnconsc/magnconsc.html.

[14] M. Pitkänen (2006), *Mathematical Aspects of Consciousness Theory*. http://tgd.wippiespace.com/public_html/mathconsc/mathconsc.html.

[15] M. Pitkänen (2006), *TGD and EEG*. http://tgd.wippiespace.com/public_html/tgdeeg/tgdeeg.html.

References to the chapters of the books about TGD

[16] The chapter *Fusion of p-Adic and Real Variants of Quantum TGD to a More General Theory* of [5].
http://tgd.wippiespace.com/public_html/tgdnumber/tgdnumber.html#mblocks.

[17] The chapter *Does TGD Predict the Spectrum of Planck Constants?* of [3].
http://tgd.wippiespace.com/public_html/tgdquant/tgdquant.html#Planck.

References to the chapters of the books about TGD Inspired Theory of Consciousness and Quantum Biology

[18] The chapter *Biological Realization of Self Hierarchy* of [9].
http://tgd.wippiespace.com/public_html/bioselforg/bioselforg.html#bioselfc.

[19] The chapter *Homeopathy in Many-Sheeted Space-Time* of [11].
http://tgd.wippiespace.com/public_html/hologram/hologram.html#homeoc.

[20] The chapter *Quantum Model for Paranormal Phenomena* of [8].
http://tgd.wippiespace.com/public_html/tgdconsc/tgdconsc.html#parac.

[21] The chapter *Crop Circles and Life at Parallel Space-Time Sheets* of [14].
http://tgd.wippiespace.com/public_html/magnconsc/magnconsc.html#crop2.

[22] The chapter *Crop Circles and Life at Parallel Space-Time Sheets* of [14].
http://tgd.wippiespace.com/public_html/magnconsc/magnconsc.html#crop1.

[23] The chapter *Dark Matter Hierarchy and Hierarchy of EEGs* of [13].
http://tgd.wippiespace.com/public_html/tgdeeg/tgdeeg.html#eegdark.

[24] The chapter *Magnetospheric Sensory Representations* of [14].
http://tgd.wippiespace.com/public_html/magnconsc/magnconsc.html#srepres.

[25] The chapter *Quantum Model of Memory* of [8].
http://tgd.wippiespace.com/public_html/tgdconsc/tgdconsc.html#memoryc.

[26] The chapter *TGD Based Model for OBEs* of [8].
http://tgd.wippiespace.com/public_html/tgdconsc/tgdconsc.html#OBE.

[27] The chapter *p-Adic Physics as Physics of Cognition and Intention* of [8].
http://tgd.wippiespace.com/public_html/tgdconsc/tgdconsc.html#cognic.

[28] The chapter *Bio-Systems as Super-Conductors: part II* of [10].
http://tgd.wippiespace.com/public_html/bioware/bioware.html#superc2.

[29] The chapter *Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin* of [11].
http://tgd.wippiespace.com/public_html/hologram/hologram.html#metab.

[30] The chapter *General Theory of Qualia* of [11].
http://tgd.wippiespace.com/public_html/hologram/hologram.html#qualia.

[31] The chapter *Negentropy Maximization Principle* of [8].
http://tgd.wippiespace.com/public_html/tgdconsc/tgdconsc.html#nmpc.

[32] The chapter *Topological Quantum Computation in TGD Universe* of [12].
http://tgd.wippiespace.com/public_html/genememe/genememe.html#tqc.

[33] The chapter *Bio-Systems as Conscious Holograms* of [11].
http://tgd.wippiespace.com/public_html/hologram/hologram.html#hologram.

[34] The chapter *Quantum Model of EEG* of [13].
http://tgd.wippiespace.com/public_html/tgdeeg/tgdeeg.html#eegII.

Cosmology and astrophysics

[35] P. E. Freeman *et al* (2006), *Examining the Effect of the Map-making Algorithm on Observed Power Asymmetry in WMAP Data.* The Astrophysical Journal, 638:1-19, February 10. astro-ph/0510406.

[36] J. D. Barrow and J. K. Webb (2005), *Inconstant Constants: Do the inner workings of nature change with time?.* Scientific American, June issue. http://www.sciam.com/article.cfm?chanID=sa006&colID=1&articleID=0005BFE6-2965-128A-A96583414B7F0000.

[37] G. Zgrablic *et al*(2001), *Instrumental recording of electrophonic sounds from Leonid fireballs.* To be published in Journal of Geophysical Research. http://fizika.org/ilwcro/results/. See also news release in same URL address.

[38] A. Saleh (2001), *Capturing the Earth's songs.* ABC Science Online. http://www.abc.net.au/science/news/stories/s237849.htm.

[39] T. L. Hansen (2001), *The northern lights-what are they?.* http://geo.phys.uit.no/articl/theaurora.html.

Fringe physics

[40] F. Armada and J. Fernandez (1982), *Extraterrestrial Intervention in Fatima –the Apparitions and the UFO phenomena.* Amadora, Livraria Bertrand.
Ibid. (1995), *The Fatima Apparitions and the UFO Phenomenon.* Lisboa, Editorial Estampa.
Ibid. (2002), *Fatima – behind the Secret.* Lisboa, Âncora Editora.

Biology related references

[41] G. Vassilatos (2001), *Nocturnal Disturbances and the Infrasonic "HUM".* http://www.borderlands.com/journal/nux.htm.

[42] J. C. Lin, S. Sales-Cunha, J. Battocletti, A. Sances, (1980), *The Microwave Auditive phenomenon.* proceedings of the IEEE, vol. 68, #1.

[43] C. E. Ingalls (2002), *Sensation of Hearing in Electromagnetic Fields.* http://www.angelfire.com/or/mctrl/ingalls.htm.

[44] M. W. Ho (1993), *The Rainbow and the Worm.* World Scientific, Singapore.

[45] P. P. Gariaev *et al*(2002), *The spectroscopy of bio-photons in non-local genetic regulation.* Journal of Non-Locality and Remote Mental Interactions, Vol 1, Nr 3. http://www.emergentmind.org/gariaevI3.htm.

[46] M. Shaduri. & G.Tshitshinadze (1999), *On the problem of application of Bioenergography in medicine.* Georgian Engineering News 2, 109-112. See also http://www.bioholography.org.

[47] Callahan, P. S. (1977). *Moth and Candle: the Candle Flame as a Sexual Mimic of the Coded Infrared Wavelengths from a Moth Sex Scent.* Applied Optics. 16(12) 3089-3097.

[48] R. Sheldrake (1995), *A New Science of Life: The Hypothesis of Morphic Resonance.* Inner Traditions Intl Ltd.

Neuroscience

[49] T. W. Picton (2001), *What is encephalogram?*. http://www.rotman-baycrest.on.ca/content/science/eegsub.html.

[50] I. Petersen and O. Eeg-Olofsson (1971), *The development of the electroencephalogram in normal children from the age of 1 through 15 years*. Neuropaediatrie, 2.

[51] J. Bullier (2001), *Feedback Connections and Conscious Vision.*To appear in forthcoming issue of *Trends in Cell Biology*. http://www.trends.com.

[52] G. Csibra *et al*(2000), *Gamma oscillations and object processing in the infant brain*. Science, Nov. 24;290(5496):1582-5.

[53] A. Revonsuo (1998), *Is synchronization the direct neural correlate of visual consciousness?*. http://www.phil.vt.edu/ASSC/engel/revonsuo1.html.

[54] P. L. Nunez (2000), *Toward a Quantitative Description of Large Scale Neocortical Dynamic Function and EEG*. Behavioral and Brain Sciences, 23, (3): XX.

[55] T. Moore and K. Amstrong (2003), *Selective gating of visual signals by micro-stimulation of frontal cortex*. Nature 421, 370 - 373. http://www.nature.com/.

[56] T. A. Stroganova *et al*(1999), *EEG alpha rhythm in infants*. Clin. Neurophysiol. Jun; 110(6):997-1012.

[57] T. H. Bullock *et al* (1995), *Temporal fluctuations in coherence of brain waves*. http://cogprints.soton.ac.uk/documents/disk0/00/00/01/11/cog00000111-00/Temp_fluc_coherence.htm.

Consciousness related references

[58] F. Shapiro (1995), *Eye moment densensitization and reprocessing: Principles, processes and procedures*. New York, NY: Guilford.

[59] E. D. Lumer and G. Rees (1999), *Covariation of activity in visual and prefrontal cortex associated with subjective visual perception*. Neurobiology, Vol. 96, Issue 4, 1669-1673, February 16, 1999.

[60] J.K. O'Regan and A. Noe (2000), *A sensorimotor account of vision and visual consciousness*. submitted 14 July 2000, as revision of manuscript under review in Behavioral and Brain Sciences. http://nivea.psycho.univ-paris5.fr.

[61] S. Klein (2002), *Libet's Research on Timing of Conscious Intention to Act: A Commentary* of Stanley Klein, Consciousness and Cognition 11, 273-279. http://cornea.berkeley.edu/pubs/ccog_2002_0580-Klein-Commentary.pdf.

[62] G. Rees (2001). *Neuroimaging of visual awareness in patients and normal subjects*. To appear in *Current Opinion In Neurobiology* 11(2), 2001.

[63] B. Libet, E. W. Wright Jr., B. Feinstein, and D. K. Pearl (1979), *Subjective referral of the timing for a conscious sensory experience* Brain, 102, 193-224.

[64] B. Libet(1982), E. W. Wright, C. A. Gleason (1982), *Readiness potentials preceding unrestricted spontaneous and preplanned voluntary acts*. Electroencephalography and Clinical Psychology 54, 322-325.
See also the article *Libet's Research on Timing of Conscious Intention to Act: A Commentary* of Stanley Klein. http://cornea.berkeley.edu/pubs/ccog_2002_0580-Klein-Commentary.pdf.

[65] A. Pascual-Leone and V. Walsh (2001). *Fast back projections from the motion to the primary visual area necessary for visual awareness*. Science, 292, 510-512.

[66] M. Perus (2001), *Neural correlates of vision and attention.* `http://ai.fri.uni-lj.si/xaigor/articles/perus2.doc`.

[67] A. L. Botkin (2000), *The Induction of After-Dearth Communications Utilizing Eye-Movement Desensitization and Reprocessing: A New Discovery.* Journal of Near-Death Studies, vol 18, no 3, p. 181.

[68] R. O. Becker (1990), *Cross Currents.* Penguin Putnam Inc., New York.

[69] Julian Jaynes (1982), *The origin of consciousness in the breakdown of the bicameral mind.* Princeton University Press.

[70] M. Persinger (1999), *The tectonic strain theory as an explanation for UFO phenomena.* `http://www.laurentian.ca/www/neurosci/tectonicedit.htm`.
M. Persinger (1987) *Neuropsychological Bases of God Beliefs.* Praeger Publishers.
M. A. Persinger and S. Krippner (1989), *Dream ESP experiments and geomagnetic activity.* The Journal of the American Society for Psychical Research, Vol. 83.

Chapter 3

Quantum Model for Bio-Superconductivity

/Users/mattipitkanen/Desktop/tgd/bibliot/

3.1 Introduction

The model for EEG and ZEG, as well as their variants with E in the middle replaced by K or something else, follows neatly from the general model of high T_c superconductivity [29, 23]. A fractal hierarchy of EEGs and ZEGs is predicted labelled by p-adic length scales and an integer characterizing the value of $\hbar$ at various levels of dark matter hierarchy. To make the representation self-contained this model is discussed in detail before proceeding to the models of EEG and ZEG.

3.1.1 General mechanisms of bio-superconductivity

The many-sheeted space-time concept provides a very general mechanism of superconductivity based on the 'dropping' of charged particles from atomic space-time sheets to larger space-time sheets. The first guess was that larger space-time sheets are very dry, cool and silent so that the necessary conditions for the formation of high T_c macroscopic quantum phases are met.

The possibility of large $\hbar$ quantum coherent phases makes however the assumption about thermal isolation between space-time sheets un-necessary. At larger space-time sheet the interactions of the charged particles with classical em fields generated by various wormhole contacts feeding gauge fluxes to and from the space-time sheet in question give rise to the necessary gap energy. The simplest model for Cooper pair is space-time sheet containing charged particles having attractive Coulombic interaction with the quarks and antiquarks associated with the throats of the wormhole contacts.

Wormhole contacts can be interpreted as Higgs type fields [23] and photon massivation could be understood in terms of a coherent state of charged wormhole contacts. The coherent states of charged wormhole contacts and of Cooper pairs do not imply non-conservation of energy, charge, and fermion number in zero energy ontology [16].

A crucial element is quantum criticality predicting a new kind of superconductivity explaining the strange features of high T_c super-conductivity. There are two kinds of Cooper pairs, exotic Cooper pairs and counterparts of ordinary BCS type Cooper pairs. Both correspond to a large value of Planck constant. Exotic Cooper pairs are quantum critical meaning that they can decay to ordinary electrons. Below temperature $T_{c_1} > T_c$ only exotic Cooper pairs with spin are present and their finite lifetime implies that super-conductivity is broken to ordinary conductivity satisfying scaling laws characteristic for criticality. At T_c spinless BCS type Cooper pairs become stable and exotic Cooper pairs can decay to them and vice versa. An open question is whether the BCS type Cooper pairs can be present also in the interior of cell.

These two superconducting phases compete in certain narrow interval around critical temperature for which body temperature of endotherms is a good candidate in the case of living matter. Also high T_c superfluidity of bosonic atoms dropped to space-time sheets of electronic Cooper pairs becomes possible besides ionic super conductivity. Even dark neutrino superconductivity can be considered below the weak length scale of scaled down weak bosons.

Magnetic flux tubes and sheets are especially interesting candidates for supra current carries. In this case the Cooper pairs must have spin one and this is indeed possible for exotic Cooper pairs. The fact that the critical magnetic fields can be very weak or large values of $\hbar$ is in accordance with the idea that various almost topological quantum numbers characterizing induced magnetic fields provide a storage mechanism of bio-information.

This mechanism is extremely general and in principle works for electrons, protons, ions, charged molecules and even exotic neutrinos and an entire zoo of high T_c bio-superconductors, super-fluids and Bose-Einstein condensates is predicted. Of course, there are restrictions due to the thermal stability it room temperature and it seems that only electron, neutrino, and proton Cooper pairs are possible at room temperature besides Bose-Einstein condensates of all bosonic ions and their exotic counterparts resulting when some nuclear color bonds become charged [18].

3.1.2 Hierarchies of preferred p-adic length scales and values 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.

The hypothesis that Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1 + i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241..\}$ (the number theoretical miracle is that all the four p-adic length scales sith $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm) define scaled up copies of electro-weak and QCD type physics with ordinary value of $\hbar$ and that these physics are induced by dark variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$, and the resulting picture finds support from the ensuing models for biological evolution and for EEG [20]. This hypothesis - to be referred to as Mersenne hypothesis - replaces the earlier rather ad hoc proposal $r = \hbar/\hbar_0 = 2^{11k}$ for the preferred values of Planck constant.

3.1.3 Fractal hierarchy of magnetic flux sheets and the hierarchy of genomes

The notion of magnetic body is central in the TGD inspired theory of living matter. Every system possesses magnetic body and there are strong reasons to believe that the magnetic body associated with human body is of order Earth size and that there could be an entire hierarchy of these bodies with even much larger sizes. Therefore the question arises what one can assume about these magnetic bodies. The quantization of magnetic flux suggests an answer to this question.

1. The quantization condition for magnetic flux reads in the most general form as $\oint (p - eA) \cdot dl = n\hbar$. If supra currents flowing at the boundaries of the flux tube are absent one obtains $e \int B \cdot dS = n\hbar$, which requires that the scaling of the Planck constant scales up the flux tube thickness by r^2 and scaling of B by $1/r$. If one assumes that the radii of flux tubes do not depend on the value of r, magnetic flux is compensated by the contribution of the supra current flowing around the flux tube: $\oint (p - eA) \cdot dl = 0$. The supra currents would be present inside living organism but in the faraway region where flux quanta from organism fuse together, the quantization conditions $e \int B \cdot dS = n\hbar$ would be satisfied.

2. From the point of view of EEG especially interesting are the flux sheets which have thickness $L(151) = 10$ nm (the thickness of cell membrane) carrying magnetic field having strength of endogenous magnetic field. In absence of supra currents these flux sheets have very large total transversal length proportional to r^2. The condition that the values of cycloctron energies are above thermal energy implies that the value of r is of order 2^{k_d}, $k_d = 44$. Strongly folded flux sheets of this thickness might be associated with living matter and connect their DNAs to single

coherent structure. One can of course assume the presence of supra currents but outside the organism the flux sheet should fuse to form very long flux sheets.

3. Suppose that the magnetic flux flows in head to tail direction so that the magnetic flux arrives to the human body through a layer of cortical neurons. Assume that the flux sheets traverse through the uppermost layer of neurons and also lower layers and that DNA of each neuronal nuclei define a transversal sections organized along flux sheet like text lines of a book page. The total length of DNA in single human cell is about one meter. It seems that single organism cannot provide the needed total length of DNA if DNA dominates the contribution. This if of course not at all necessarily since supra currents are possible and outside the organism the flux sheets can fuse together. This implies however correlations between genomes of different cells and even different organisms.

These observations inspire the notion of super- and hyper genes. As a matter fact, entire hierarchy of genomes is predicted. Super genes consist of genes in different cell nuclei arranged to threads along magnetic flux sheets like text lines on the page of book whereas hyper genes traverse through genomes of different organisms. Super and hyper genes provide an enormous representative capacity and together with the dark matter hierarchy allows to resolve the paradox created by the observation that human genome does not differ appreciably in size from that of wheat.

3.1.4 Bose-Einstein condensates at magnetic flux quanta in astrophysical length scales

The model for the topological condensation at magnetic flux quanta of endogenous magnetic field $B_{end} = .2$ Gauss is based on the dark matter hierarchy with levels characterized by the values of Planck constant. The hypothesis for the preferred values of Planck constans allows to build quantitative model for the Bose-Einstein condensation at magnetic flux quanta assuming that the value of B_{end} scales like $1/\hbar$. A justification for this hypothesis comes form flux quantization conditions and from the similar scaling of Josephson frequencies [20].

1. There are several levels of dynamics. In topological condensation the internal dynamics of ions is unaffected and $\hbar$ has the ordinary value. For instance, the formation of Cooper pairs involves dynamics at $k_d = 24 = 151 - 127$ level of dark matter hierarchy if one assumes that electrons and Cooper pairs have size given by the cell membrane thickess $L(151)$. Also the dynamics of ionic Cooper pairs remains unaffected in the topological condensation to magnetic flux quanta obeying $k_d > 24$ dynamics.

2. Cyclotron energies scale as as $\hbar$ so that for a sufficiently high value of k_d thermal stability of cyclotron states at room temperature is achieved for a fixed value of B. Same applies to spin flip transitions in the recent scenario. The model for EEG based on dark matter hierarchy [20] involves the hypothesis that EEG quanta correspond to Josephson radiation with energies in the visible and UV range and that they produce in the decay to ordinary photons either bunches of EEG photons or visible/UV photons. This identification allows to deduce the value of k_d when the frequency of the dark photon is fixed. The Mersenne hypothesis for the preferred p-adic length scales and values of Planck constants leads to very precise predictions.

3. Cyclotron energies $E = (\hbar/2\pi) \times ZeB/Am_p$ are scaled up by a factor $r = 2^{k_d}$ from their ordinary values and for 10 Hz cyclotron frequency are in the range of energies of visible light for $k_d = 46$.

3.2 General TGD based view about super-conductivity

Today super-conductivity includes besides the traditional low temperature super-conductors many other non-orthodox ones [43]. These unorthodox super-conductors carry various attributes such as cuprate, organic, dichalcogenide, heavy fermion, bismute oxide, ruthenate, antiferromagnetic and ferromagnetic. Mario Rabinowitz has proposed a simple phenomenological theory of superfluidity and super-conductivity which helps non-specialist to get a rough quantitative overall view about super-conductivity [43].

3.2.1 Basic phenomenology of super-conductivity

The following provides the first attempt by a non-professional to form an overall view about super-conductivity.

Basic phenomenology of super-conductivity

The transition to super-conductivity occurs at critical temperature T_c and involves a complete loss of electrical resistance. Super-conductors expel magnetic fields (Meissner effect) and when the external magnetic field exceeds a critical value H_c super-conductivity is lost either completely or partially. In the transition to super-conductivity specific heat has singularity. For long time magnetism and super-conductivity were regarded as mutually exclusive phenomena but the discovery of ferromagnetic super-conductors [47, 41] has demonstrated that reality is much more subtle.

The BCS theory developed by Bardeen, Cooper, and Schrieffer in 1957 provides a satisfactory model for low T_c super-conductivity in terms of Cooper pairs. The interactions of electrons with the crystal lattice induce electron-electron interaction binding electrons to Cooper pairs at sufficiently low temperatures. The electrons of Cooper pair are at the top of Fermi sphere (otherwise they cannot interact to form bound states) and have opposite center of mass momenta and spins. The binding creates energy gap E_g determining the critical temperature T_c. The singularity of the specific heat in the transition to super-conductivity can be understood as being due to the loss of thermally excitable degrees of freedom at critical temperature so that heat capacity is reduced exponentially. BCS theory has been successful in explaining the properties of low temperature super conductors but the high temperature super-conductors discovered in 1986 and other non-orthodox superconductors discovered later remain a challenge for theorists.

The reasons why magnetic fields tend to destroy super-conductivity is easy to understand. Lorentz force induces opposite forces to the electrons of Cooper pair since the momenta are opposite. Magnetic field tends also to turn the spins in the same direction. The super-conductivity is destroyed in fields for which the interaction energy of magnetic moment of electron with field is of the same order of magnitude as gap energy $E_g \sim T_c$: $e\hbar H_c/2m \sim T_c$.

If spins are parallel, the situation changes since only Lorentz force tends to destroy the Cooper pair. In high T_c super-conductors this is indeed the case: electrons are in spin triplet state ($S = 1$) and the net orbital angular momentum of Cooper pair is $L = 2$. The fact that orbital state is not $L = 0$ state makes high T_c super-conductors much more fragile to the destructive effect of impurities than conventional super-conductors (due to the magnetic exchange force between electrons responsible for magnetism). Also the Cooper pairs of ^3He superfluid are in spin triplet state but have $S = 0$.

The observation that spin triplet Cooper pairs might be possible in ferro-magnets stimulates the question whether ferromagnetism and super-conductivity might tolerate each other after all, and the answer is affirmative [41]. The article [47] provides an enjoyable summary of experimental discoveries.

Basic parameters of super-conductors from universality?

Super conductors are characterized by certain basic parameters such as critical temperature T_c and critical magnetic field H_c, densities n_c and n of Cooper pairs and conduction electrons, gap energy E_g, correlation length ξ and magnetic penetration length λ. The super-conductors are highly complex systems and calculation of these parameters from BCS theory is either difficult or impossible.

It has been suggested [43] that these parameters might be more or less universal so that they would not depend on the specific properties of the interaction responsible for the formation of Cooper pairs. The motivation comes from the fact that the properties of ordinary Bose-Einstein condensates do not depend on the details of interactions. This raises the hope that these parameters might be expressible in terms of some basic parameters such as T_c and the density of conduction electrons allowing to deduce Fermi energy E_F and Fermi momentum k_F if Fermi surface is sphere. In [43] formulas for the basic parameters are indeed suggested based on this of argumentation assuming that Cooper pairs form a Bose-Einstein condensate.

1. The most important parameters are critical temperature T_c and critical magnetic field H_c in principle expressible in terms of gap energy. In [43] the expression for T_c is deduced from the condition that the de Broglie wavelength λ must satisfy in supra phase the condition

$$\lambda \geq 2d = 2(\frac{n_c}{g})^{-1/D} \quad (3.2.1)$$

guaranteeing the quantum overlap of Cooper pairs. Here n_c is the density of Bose-Einstein condensate of Cooper pairs and g is the number of spin states and D the dimension of the condensate. This condition follows also from the requirement that the number of particles per energy level is larger than one (Bose-Einstein condensation).

Identifying this expression with the de Broglie wavelength $\lambda = \hbar/\sqrt{2mE}$ at thermal energy $E = (D/2)T_c$, where D is the number of degrees of freedom, one obtains

$$T_c \leq \frac{h^2}{4Dm}(\frac{n_c}{g})^{2/D} \quad . \quad (3.2.2)$$

m denotes the effective mass of super current carrier and for electron it can be even 100 times the bare mass of electron. The reason is that the electron moves is somewhat like a person trying to move in a dense crowd of people, and is accompanied by a cloud of charge carriers increasing its effective inertia. In this equation one can consider the possibility that Planck constant is not the ordinary one. This obviously increases the critical temperature unless n_c is scaled down in same proportion in the phase transition to large $\hbar$ phase.

2. The density of n_c Cooper pairs can be estimated as the number of fermions in Fermi shell at E_F having width Δk deducible from kT_c. For $D = 3$-dimensional spherical Fermi surface one has

$$\begin{aligned} n_c &= \frac{1}{2}\frac{4\pi k_F^2 \Delta k}{\frac{4}{3}\pi k_F^3} n \ , \\ kT_c &= E_F - E(k_F - \Delta k) \simeq \frac{h^2 k_F \Delta k}{m} \quad . \end{aligned} \quad (3.2.3)$$

Analogous expressions can be deduced in $D = 2$- and $D = 1$-dimensional cases and one has

$$n_c(D) = \frac{D}{2}\frac{T_c}{E_F} n(D) \quad . \quad (3.2.4)$$

The dimensionless coefficient is expressible solely in terms of n and effective mass m. In [43] it is demonstrated that the inequality 3.2.2 replaced with equality when combined with 3.2.4 gives a satisfactory fit for 16 super-conductors used as a sample.

Note that the Planck constant appearing in E_F and T_c in Eq. 3.2.4 must correspond to ordinary Planck constant $\hbar_0$. This implies that equations 3.2.2 and 3.2.4 are consistent within orders of magnitudes. For $D = 2$, which corresponds to high T_c superconductivity, the substitution of n_c from Eq. 3.2.4 to Eq. 3.2.2 gives a consistency condition from which n_c disappears completely. The condition reads as

$$n\lambda_F^2 = \pi = 4g \quad .$$

Obviously the equation is not completely consistent.

3. The magnetic penetration length λ is expressible in terms of density n_c of Cooper pairs as

$$\lambda^{-2} = \frac{4\pi e^2 n_c}{m_e} \ . \tag{3.2.5}$$

The ratio $\kappa \equiv \frac{\lambda}{\xi}$ determines the type of the super conductor. For $\kappa < \frac{1}{\sqrt{2}}$ one has type I super conductor with defects having negative surface energy. For $\kappa \geq \frac{1}{\sqrt{2}}$ one has type II super conductor and defects have positive surface energy. Super-conductors of type I this results in complex stripe like flux patterns maximizing their area near criticality. The super-conductors of type II have $\kappa > 1/\sqrt{2}$ and the surface energy is positive so that the flux penetrates as flux quanta minimizing their area at lower critical value H_{c_1} of magnetic field and completely at higher critical value H_{c_2} of magnetic field. The flux quanta contain a core of size ξ carrying quantized magnetic flux.

4. Quantum coherence length ξ can be roughly interpreted as the size of the Cooper pair or as the size of the region where it is sensible to speak about the phase of wave function of Cooper pair. For larger separations the phases of wave functions are un-correlated. The values of ξ vary in the range $10^3 - 10^4$ Angstrom for low T_c super-conductors and in the range $5 - 20$ Angstrom for high T_c super-conductors (assuming that they correspond to ordinary $\hbar$!) the ratio of these coherence lengths varies in the range $[50 - 2000]$, with upper bound corresponding to $n_F = 2^{11}$ for $\hbar$. This would give range $1-2$ microns for the coherence lengths of high T_c super-conductors with lowest values of coherence lengths corresponding to the highest values of coherence lengths for low temperatures super conductors.

Uncertainty Principle $\delta E \delta t = \hbar/2$ using $\delta E = E_g \equiv 2\Delta$, $\delta t = \xi/v_F$, gives an order of magnitude estimate for ξ differing only by a numerical factor from the result of a rigorous calculation given by

$$\xi = \frac{4\hbar v_F}{E_g} \ . \tag{3.2.6}$$

E_g is apart from a numerical constant equal to T_c: $E_g = nT_c$. Using the expression for v_F and T_c in terms of the density of electrons, one can express also ξ in terms of density of electrons.

For instance, BCS theory predicts $n = 3.52$ for metallic super-conductors and $n = 8$ holds true for cuprates [43]. For cuprates one obtains $\xi = 2n^{-1/3}$ [43]. This expression can be criticized since cuprates are Mott insulators and it is not at all clear whether a description as Fermi gas makes sense. The fact that high T_c super-conductivity involves breakdown of anti-ferromagnetic order might justify the use of Fermi gas description for conducting holes resulting in the doping.

For large $\hbar$ the value of ξ would scale up dramatically if deduced theoretically from experimental data using this kind of expression. If the estimates for ξ are deduced from v_F and T_c purely calculationally as seems to be the case, the actual coherence lengths would be scaled up by a factor $\hbar/\hbar_0 = n_F$ if high T_c super-conductors correspond to large $\hbar$ phase. As also found that this would also allow to understand the high critical temperature.

3.2.2 Universality of the parameters in TGD framework

Universality idea conforms with quantum criticality of TGD Universe. The possibility to express everything in terms of density of critical temperature coding for the dynamics of Cooper pair formation and the density charge carriers would make it also easy to understand how p-adic scalings and transitions to large $\hbar$ phase affect the basic parameters. The possible problem is that the replacement of inequality of Eq. 3.2.2 with equality need not be sensible for large $\hbar$ phases. It will be found that in many-sheeted space-time T_c does not directly correspond to the gap energy and the universality of the critical temperature follows from the p-adic length scale hypothesis.

The effect of p-adic scaling on the parameters of super-conductors

p-Adic fractality expresses as $n \propto 1/L^3(k)$ would allow to deduce the behavior of the various parameters as function of the p-adic length scale and naive scaling laws would result. For instance, E_g and T_c would scale as $1/L^2(k)$ if one assumes that the density n of particles at larger space-time sheets scales p-adically as $1/L^3(k)$. The basic implication would be that the density of Cooper pairs and thus also T_c would be reduced very rapidly as a function of the p-adic length scale. Without thermal isolation between these space-time sheets and hight temperature space-time sheets there would not be much hopes about high T_c super-conductivity.

In the scaling of Planck constant basic length scales scale up and the overlap criterion for super-conductivity becomes easy to satisfy unless the density of electrons is reduced too dramatically. As found, also the critical temperature scales up so that there are excellent hopes of obtain high T_c super-conductor in this manner. The claimed short correlation lengths are not a problem since they are calculational quantities.

It is of interest to study the behavior of the various parameters in the transition to the possibly existing large $\hbar$ variant of super-conducting electrons. Also small scalings of $\hbar$ are possible and the considerations to follow generalize trivially to this case. Under what conditions the behavior of the various parameters in the transition to large $\hbar$ phase is dictated by simple scaling laws?

1. Scaling of T_c and E_g

T_c and E_g remain invariant if E_g corresponds to a purely classical interaction energy remaining invariant under the scaling of $\hbar$. This is not the case for BCS super-conductors for which the gap energy E_g has the following expression.

$$\begin{aligned} E_g &= \hbar\omega_c exp(-1/X) \ , \\ X &= n(E_F)U_0 = \frac{3}{2}N(E_F)\frac{U_0}{E_F} \ , \\ n(E_F) &= \frac{3}{2}\frac{N(E_F)}{E_F} \ . \\ \omega_c &= \omega_D = (6\pi^2)^{1/3}c_s n_n^{1/3} \ . \end{aligned} \tag{3.2.7}$$

Here ω_c is the width of energy region near E_F for which "phonon" exchange interaction is effective. n_n denotes the density of nuclei and c_s denotes sound velocity.

$N(E_F)$ is the total number of electrons at the super-conducting space-time sheet. U_0 would be the parameter characterizing the interaction strength of of electrons of Cooper pair and should not depend on $\hbar$. For a structure of size $L \sim 1\ \mu$ m one would have $X \sim n_a 10^{12}\frac{U_0}{E_F}$, n_a being the number of exotic electrons per atom, so that rather weak interaction energy U_0 can give rise to $E_g \sim \omega_c$.

The expression of ω_c reduces to Debye frequency ω_D in BCS theory of ordinary super conductivity. If c_s is proportional to thermal velocity $\sqrt{T_c/m}$ at criticality and if n_n remains invariant in the scaling of $\hbar$, Debye energy scales up as $\hbar$. This can imply that $E_g > E_F$ condition making scaling non-sensible unless one has $E_g \ll E_F$ holding true for low T_c super-conductors. This kind of situation would *not* require large $\hbar$ phase for electrons. What would be needed that nuclei and phonon space-time sheets correspond to large $\hbar$ phase.

What one can hope is that E_g scales as $\hbar$ so that high T_c superconductor would result and the scaled up T_c would be above room temperature for $T_c > .15$ K. If electron is in ordinary phase X is automatically invariant in the scaling of $\hbar$. If not, the invariance reduces to the invariance of U_0 and E_F under the scaling of $\hbar$. If n scales like $1/\hbar^D$, E_F and thus X remain invariant. U_0 as a simplified parametrization for the interaction potential expressible as a tree level Feynman diagram is expected to be in a good approximation independent of $\hbar$.

It will be found that in high T_c super-conductors, which seem to be quantum critical, a high T_c variant of phonon mediated superconductivity and exotic superconductivity could be competing. This would suggest that the phonon mediated superconductivity corresponds to a large $\hbar$ phase for nuclei scaling ω_D and T_c by a factor $r = \hbar/\hbar_0$.

Since the total number $N(E_F)$ of electrons at larger space-time sheet behaves as $N(E_F) \propto E_F^{D/2}$, where D is the effective dimension of the system, the quantity $1/X \propto E_F/n(E_F)$ appearing in the expressions of the gap energy behaves as $1/X \propto E_F^{-D/2+1}$. This means that at the limit of vanishing electron density $D = 3$ gap energy goes exponentially to zero, for $D = 2$ it is constant, and for $D = 1$ it goes zero at the limit of small electron number so that the formula for gap energy reduces to $E_g \simeq \omega_c$. These observations suggests that the super-conductivity in question should be 2- or 1-dimensional phenomenon as in case of magnetic walls and flux tubes.

2. Scaling of ξ and λ

If n_c for high T_c super-conductor scales as $1/\hbar^D$ one would have $\lambda \propto \hbar^{D/2}$. High T_c property however suggests that the scaling is weaker. ξ would scale as $\hbar$ for given v_F and T_c. For $D = 2$ case the this would suggest that high T_c super-conductors are of type I rather than type II as they would be for ordinary $\hbar$. This conforms with the quantum criticality which would be counterpart of critical behavior of super-conductors of type I in nearly critical magnetic field.

3. Scaling of H_c and B

The critical magnetization is given by

$$H_c(T) = \frac{\Phi_0}{\sqrt{8}\pi\xi(T)\lambda(T)} , \qquad (3.2.8)$$

where Φ_0 is the flux quantum of magnetic field proportional to $\hbar$. For $D = 2$ and $n_c \propto \hbar^{-2}$ $H_c(T)$ would not depend on the value of $\hbar$. For the more physical dependence $n_c \propto \hbar^{-2+\epsilon}$ one would have $H_c(T) \propto \hbar^{-\epsilon}$. Hence the strength of the critical magnetization would be reduced by a factor $2^{-11\epsilon}$ in the transition to the large $\hbar$ phase with $n_F = 2^{-11}$.

Magnetic flux quantization condition is replaced by

$$\int 2eBdS = n\hbar 2\pi . \qquad (3.2.9)$$

B denotes the magnetic field inside super-conductor different from its value outside the super-conductor. By the quantization of flux for the non-super-conducting core of radius ξ in the case of super-conductors of type II $eB = \hbar/\xi^2$ holds true so that B would become very strong since the thickness of flux tube would remain unchanged in the scaling.

3.2.3 Quantum criticality and super-conductivity

The notion of quantum criticality has been already discussed in introduction. An interesting prediction of the quantum criticality of entire Universe also gives naturally rise to a hierarchy of macroscopic quantum phases since the quantum fluctuations at criticality at a given level can give rise to higher level macroscopic quantum phases at the next level. A metaphor for this is a fractal cusp catastrophe for which the lines corresponding to the boundaries of cusp region reveal new cusp catastrophes corresponding to quantum critical systems characterized by an increasing length scale of quantum fluctuations.

Dark matter hierarchy could correspond to this kind of hierarchy of phases and long ranged quantum slow fluctuations would correspond to space-time sheets with increasing values of $\hbar$ and size. Evolution as the emergence of modules from which higher structures serving as modules at the next level would correspond to this hierarchy. Mandelbrot fractal with inversion analogous to a transformation permuting the interior and exterior of sphere with zooming revealing new worlds in Mandelbrot fractal replaced with its inverse would be a good metaphor for what quantum criticality would mean in TGD framework.

How the quantum criticality of superconductors relates to TGD quantum criticality

There is empirical support that super-conductivity in high T_c super-conductors and ferromagnetic systems [47, 44] is made possible by quantum criticality [42]. In the experimental situation quantum criticality means that at sufficiently low temperatures quantum rather than thermal fluctuations are able to induce phase transitions. Quantum criticality manifests itself as fractality and simple scaling laws for various physical observables like resistance in a finite temperature range and also above the critical temperature. This distinguishes sharply between quantum critical super conductivity from

BCS type super-conductivity. Quantum critical super-conductivity also exists in a finite temperature range and involves the competition between two phases.

The absolute quantum criticality of the TGD Universe maps to the quantum criticality of subsystems, which is broken by finite temperature effects bringing dissipation and freezing of quantum fluctuations above length and time scales determined by the temperature so that scaling laws hold true only in a finite temperature range.

Reader has probably already asked what quantum criticality precisely means. What are the phases which compete? An interesting hypothesis is that quantum criticality actually corresponds to criticality with respect to the phase transition changing the value of Planck constant so that the competing phases would correspond to different values of $\hbar$. In the case of high T_c super-conductors (anti-ferromagnets) the fluctuations can be assigned to the magnetic flux tubes of the dipole field patterns generated by rows of holes with same spin direction assignable to the stripes. Below T_c fluctuations induce reconnections of the flux tubes and a formation of very long flux tubes and make possible for the supra currents to flow in long length scales below T_c. Percolation type phenomenon is in question. The fluctuations of the flux tubes below $T_{c1} > T_c$ induce transversal phonons generating the energy gap for $S = 1$ Cooper pairs. $S = 0$ Cooper pairs are predicted to stabilize below T_c.

Scaling up of de Broglie wave lengths and criterion for quantum overlap

Compton lengths and de Broglie wavelengths are scaled up by an integer n, whose preferred values correspond to $n_F = 2^k \prod_s F_s$, where $F_s = 2^{2^s} + 1$ are distinct Fermat primes. In particular, $n_F = 2^{k11}$ seem to be favored in living matter. The scaling up means that the overlap condition $\lambda \geq 2d$ for the formation of Bose-Einstein condensate can be satisfied and the formation of Cooper pairs becomes possible. Thus a hierarchy of large $\hbar$ super-conductivities would be associated with to the dark variants of ordinary particles having essentially same masses as the ordinary particles.

Unless one assumes fractionization, the invariance of $E_F \propto \hbar_{eff}^2 n^{2/3}$ in $\hbar$ increasing transition would require that the density of Cooper pairs in large $\hbar$ phase is scaled down by an appropriate factor. This means that supra current intensities, which are certainly measurable quantities, are also scaled down. Of course, it could happen that E_F is scaled up and this would conform with the scaling of the gap energy.

Quantum critical super-conductors in TGD framework

For quantum critical super-conductivity in heavy fermions systems, a small variation of pressure near quantum criticality can destroy ferromagnetic (anti-ferromagnetic) order so that Curie (Neel) temperature goes to zero. The prevailing spin fluctuation theory [40] assumes that these transitions are induced by long ranged and slow spin fluctuations at critical pressure P_c. These fluctuations make and break Cooper pairs so that the idea of super-conductivity restricted around critical point is indeed conceivable.

Heavy fermion systems, such as cerium-indium alloy $CeIn_3$ are very sensitive to pressures and a tiny variation of density can drastically modify the low temperature properties of the systems. Also other systems of this kind, such as $CeCu_2Ge_2$, $CeIn_3$, $CePd_2Si_2$ are known [47, 41]. In these cases super-conductivity appears around anti-ferromagnetic quantum critical point.

The last experimental breakthrough in quantum critical super-conductivity was made in Grenoble [44]. URhGe alloy becomes super-conducting at $T_c = .280$ K, loses its super-conductivity at $H_c = 2$ Tesla, and becomes again super-conducting at $H_c = 12$ Tesla and loses its super-conductivity again at $H = 13$ Tesla. The interpretation is in terms of a phase transition changing the magnetic order inducing the long range spin fluctuations.

TGD based models of atomic nucleus [18] and condensed matter [19] assume that weak gauge bosons with Compton length of order atomic radius play an essential role in the nuclear and condensed matter physics. The assumption that condensed matter nuclei possess anomalous weak charges explains the repulsive core of potential in van der Waals equation and the very low compressibility of condensed matter phase as well as various anomalous properties of water phase, provide a mechanism of cold fusion and sono-fusion, etc. [19, 16]. The pressure sensitivity of these systems would directly reflect the physics of exotic quarks and electro-weak gauge bosons. A possible mechanism behind the phase transition to super-conductivity could be the scaling up of the sizes of the space-time sheets of nuclei.

Also the electrons of Cooper pair (and only these) could make a transition to large $\hbar$ phase. This transition would induce quantum overlap having geometric overlap as a space-time correlate. The formation of join along boundaries bonds between neighboring atoms would be part of the mechanism. For instance, the criticality condition $4n^2\alpha = 1$ for BE condensate of n Cooper pairs would give $n = 6$ for the size of a higher level quantum unit possibly formed formed from Cooper pairs. If one does not assume invariance of energies obtained by fractionization of principal quantum number, this transition has dramatic effects on the spectrum of atomic binding energies scaling as $1/\hbar^2$ and practically universal spectrum of atomic energies would result [16] not depending much on nuclear charge. It seems that this prediction is non-physical.

Quantum critical super-conductors resemble superconductors of type I with $\lambda \ll \xi$ for which defects near thermodynamical criticality are complex structures looking locally like stripes of thickness λ. These structures are however dynamical in super-conducting phase. Quite generally, long range quantum fluctuations due to the presence of two competing phases would manifest as complex dynamical structures consisting of stripes and their boundaries. These patterns are dynamical rather than static as in the case of ordinary spin glass phase so that quantum spin glass or 4-D spin glass is a more appropriate term. The breaking of classical non-determinism for vacuum extremals indeed makes possible space-time correlates for quantum non-determinism and this makes TGD Universe a 4-dimensional quantum spin glass.

Could quantum criticality make possible new kinds of high T_c super-conductors?

The transition to large $\hbar = r\hbar_0$ phase increases various length scales by r and makes possible long range correlations even at high temperatures. Hence the question is whether large $\hbar$ phase could correspond to ordinary high T_c super-conductivity. If this were the case in the case of ordinary high T_c super-conductors, the actual value of coherence length ξ would vary in the range $5-20$ Angstrom scaled up by a factor r. For effectively D-dimensional super-conductor The density of Cooper pairs would be scaled down by an immensely small factor $1/r^D$ from its value deduced from Fermi energy.

Large $\hbar$ phase for some nuclei might be involved and make possible large space-time sheets of size at least of order of ξ at which conduction electrons forming Cooper pairs would topologically condense like quarks around hadronic space-time sheets (in [19] a model of water as a partially dark matter with one fourth of hydrogen ions in large $\hbar$ phase is developed).

Consider for a moment the science fictive possibility that super conducting electrons for some quantum critical super-conductors to be discovered or already discovered correspond to large $\hbar$ phase with $\hbar = r\hbar_0$ keeping in mind that this affects only quantum corrections in perturbative approach but not the lowest order classical predictions of quantum theory. For $r \simeq n2^{k11}$ with $(n,k) = (1,1)$ the size of magnetic body would be $L(149) = 5$ nm, the thickness of the lipid layer of cell membrane. For $(n,k) = (1,2)$ the size would be $L(171) = 10$ μm, cell size. If the density of Cooper pairs is of same order of magnitude as in case of ordinary super conductors, the critical temperature is scaled up by 2^{k11}. Already for $k = 1$ the critical temperature of 1 K would be scaled up to $4n^2 \times 10^6$ K if n_c is not changed. This assumption is not consistent with the assumption that Fermi energy remains non-relativistic. For $n = 1$ $T_c = 400$ K would be achieved for $n_c \to 10^{-6}n_c$, which looks rather reasonable since Fermi energy transforms as $E_F \to 8\times 10^3 E_F$ and remains non-relativistic. H_c would scale down as $1/\hbar$ and for $H_c = .1$ Tesla the scaled down critical field would be $H_c = .5\times 10^{-4}$ Tesla, which corresponds to the nominal value of the Earth's magnetic field.

Quantum critical super-conductors become especially interesting if one accepts the identification of living matter as ordinary matter quantum controlled by macroscopically quantum coherent dark matter. One of the basic hypothesis of TGD inspired theory of living matter is that the magnetic flux tubes of the Earth's magnetic field carry a super-conducting phase and the spin triplet Cooper pairs of electrons in large $\hbar$ phase might realize this dream. That the value of Earth's magnetic field is near to its critical value could have also biological implications.

3.2.4 Space-time description of the mechanisms of super-conductivity

The application of ideas about dark matter to nuclear physics and condensed matter suggests that dark color and weak forces should be an essential element of the chemistry and condensed matter physics. The continual discovery of new super-conductors, in particular of quantum critical superconductors, suggests that super-conductivity is not well understood. Hence super-conductivity provides an obvious test for these ideas. In particular, the idea that wormhole contacts regarded as parton pairs living at two space-time sheets simultaneously, provides an attractive universal mechanism for the formation of Cooper pairs and is not so far-fetched as it might sound first.

Leading questions

It is good to begin with a series of leading questions. The first group of questions is inspired by experimental facts about super-conductors combined with TGD context.

1. The work of Rabinowitch [43] suggests that that the basic parameters of super-conductors might be rather universal and depend on T_c and conduction electron density only and be to a high degree independent of the mechanism of super-conductivity. This is in a sharp contrast to the complexity of even BCS model with its somewhat misty description of the phonon exchange mechanism.
   Questions: Could there exist a simple universal description of various kinds of super-conductivities?

2. The new super-conductors possess relatively complex chemistry and lattice structure.
   Questions: Could it be that complex chemistry and lattice structure makes possible something very simple describable in terms of quantum criticality. Could it be that the transversal oscillations magnetic flux tubes allow to understand the formation of Cooper pairs at T_{c1} and their reconnections generating very long flux tubes the emergence of supra currents at T_c?

3. The effective masses of electrons in ferromagnetic super-conductors are in the range of 10-100 electron masses [47] and this forces to question the idea that ordinary Cooper pairs are current carriers.
   Questions: Can one consider the possibility that the p-adic length scale of say electron can vary so that the actual mass of electron could be large in condensed matter systems? For quarks and neutrinos this seems to be the case [18, 17]. Could it be that the Gaussian Mersennes $(1+i)^k-1$, $k = 151, 157, 163, 167$ spanning the p-adic lengthscale range 10 nm-2.5 μm very relevant from the point of view of biology correspond to p-adic length especially relevant for super-conductivity?

Second group of questions is inspired by quantum classical correspondence.

1. Quantum classical correspondence in its strongest form requires that bound state formation involves the generation of join along boundaries bonds between bound particles. The weaker form of the principle requires that the particles are topologically condensed at same space-time sheet. In the case of Cooper pairs in ordinary superconductors the length of join along boundaries bonds between electrons should be of order $10^3 - 10^4$ Angstroms. This looks rather strange and it seems that the latter option is more sensible.
   Questions: Could quantum classical correspondence help to identify the mechanism giving rise to Cooper pairs?

2. Quantum classical correspondence forces to ask for the space-time correlates for the existing quantum description of phonons.
   Questions: Can one assign space-time sheets with phonons or should one identify them as oscillations of say space-time sheets at which atoms are condensed? Or should the microscopic description of phonons in atomic length scales rely on the oscillations of wormhole contacts connecting atomic space-time sheets to these larger space-time sheets? The identification of phonons as wormhole contacts would be completely analogous to the similar identification of gauge bosons except that phonons would appear at higher levels of the hierarchy of space-time sheets and would be emergent in this sense. As a matter fact, even gauge bosons as pairs of fermion and antifermion are emergent structures in TGD framework and this plays fundamental role in the construction of QFT limit of TGD in which bosonic part of action is generated radiatively so that all coupling constants follow as predictions [27, 19]. Could Bose-Einstein condensates of wormhole contacts be relevant for the description of super-conductors or more general macroscopic quantum phases?

The third group of questions is inspired by the new physics predicted or by TGD.

1. TGD predicts a hierarchy of macroscopic quantum phases with large Planck constant.
   Questions: Could large values of Planck constant make possible exotic electronic super-conductivities? Could even nuclei possess large $\hbar$ (super-fluidity)?

2. TGD predicts that classical color force and its quantal counterpart are present in all length scales.
   Questions: Could color force, say color magnetic force which play some role in the formation of Cooper pair. The simplest model of pair is as a space-time sheet with size of order ξ so that the electrons could be "outside" the background space-time. Could the Coulomb interaction energy of electrons with positively charged wormhole throats carrying parton numbers and feeding em gauge flux to the large space-time sheet be responsible for the gap energy? Could wormhole throats carry also quark quantum numbers. In the case of single electron condensed to single space-time sheet the em flux could be indeed feeded by a pair of $u\overline{u}$ and $\overline{d}d$ type wormhole contacts to a larger space-time sheet. Could the wormhole contacts have a net color? Could the electron space-time sheets of the Cooper pair be connected by long color flux tubes to give color singlets so that dark color force would be ultimately responsible for the stability of Cooper pair?

3. Suppose that one takes seriously the ideas about the possibility of dark weak interactions with the Compton scale of weak bosons scaled up to say atomic length scale so that weak bosons are effectively massless below this length scale [19].
   Questions: Could the dark weak length scale which is of order atomic size replace lattice constant in the expression of sound velocity? What is the space-time correlate for sound velocity?

Photon massivation, coherent states of Cooper pairs, and wormhole contacts

The existence of wormhole contacts is one of the most stunning predictions of TGD. First I realized that wormhole contacts can be regarded as parton-antiparton pairs with parton and antiparton assignable to the light-like causal horizons accompanying wormhole contacts. Then came the idea that Higgs particle could be identified as a wormhole contact. It was soon followed by the identification all bosonic states as wormhole contacts [23]. Finally I understood that this applies also to their super-symmetric partners, which can be also fermion [19]. Fermions and their super-partners would in turn correspond to wormhole throats resulting in the topological condensation of small deformations of CP_2 type vacuum extremals with Euclidian signature of metric to the background space-time sheet. This framework opens the doors for more concrete models of also super-conductivity involving the effective massivation of photons as one important aspect in the case of ordinary super-conductors.

There are two types of wormhole contacts. Those of first type correspond to elementary bosons. Wormhole contacts of second kind are generated in the topological condensation of space-time sheets carrying matter and form a hierarchy. Classical radiation fields realized in TGD framework as oscillations of space-time sheets would generate wormhole contacts as the oscillating space-time sheet develops contacts with parallel space-time sheets (recall that the distance between space-time sheets is of order CP_2 size). This realizes the correspondence between fields and quanta geometrically. Phonons could also correspond to wormhole contacts of this kind since they mediate acoustic oscillations between space-time sheets and the description of the phonon mediated interaction between electrons in terms of wormhole contacts might be useful also in the case of super-conductivity. Bose-Einstein condensates of wormhole contacts might be highly relevant for the formation of macroscopic quantum phases. The formation of a coherent state of wormhole contacts would be the counterpart for the vacuum expectation value of Higgs.

The notions of coherent states of Cooper pairs and of charged Higgs challenge the conservation of electromagnetic charge. The following argument however suggests that coherent states of wormhole contacts form only a part of the description of ordinary super-conductivity. The basic observation is that wormhole contacts with vanishing fermion number define space-time correlates for Higgs type particle with fermion and antifermion numbers at light-like throats of the contact.

The ideas that a genuine Higgs type photon massivation is involved with super-conductivity and that coherent states of Cooper pairs really make sense are somewhat questionable since the conservation of charge and fermion number is lost for coherent states. A further questionable feature is that a quantum superposition of many-particle states with widely different masses would be in question. These interpretational problems can be resolved elegantly in zero energy ontology [16] in which the total conserved quantum numbers of quantum state are vanishing. In this picture the energy, fermion number, and total charge of any positive energy state are compensated by opposite quantum numbers of the negative energy state in geometric future. This makes possible to speak about superpositions of Cooper pairs and charged Higgs bosons separately in positive energy sector.

If this picture is taken seriously, super-conductivity can be seen as providing a direct support for both the hierarchy of scaled variants of standard model physics and for the zero energy ontology.

Space-time correlate for quantum critical superconductivity

The explicit model for high T_c super-conductivity relies on quantum criticality involving long ranged quantum fluctuations inducing reconnection of flux tubes of local (color) magnetic fields associated with parallel spins associated with stripes to form long flux tubes serving as wires along which Cooper pairs flow. Essentially percolation [46] type phenomenon would be in question. The role of the doping by holes is to make room for Cooper pairs to propagate by the reconnection mechanism: otherwise Fermi statistics would prevent the propagation. Too much doping reduces the number of current carriers, too little doping leaves too little room so that there exists some optimal doping. In the case of high T_c super-conductors quantum criticality corresponds to a quite wide temperature range, which provides support for the quantum criticality of TGD Universe. The probability $p(T)$ for the formation of reconnections is what matters and exceeds the critical value at T_c.

3.2.5 Super-conductivity at magnetic flux tubes

Super-conductivity at the magnetic flux tubes of magnetic flux quanta is one the basic hypothesis of the TGD based model of living matter. There is also evidence for magnetically mediated super-conductivity in extremely pure samples [50]. The magnetic coupling was only observed at lattice densities close to the critical density at which long-range magnetic order is suppressed. Quantum criticality that long flux tubes serve as pathways along which Cooper pairs can propagate. In anti-ferromagnetic phase these pathways are short-circuited to closed flux tubes of local magnetic fields.

Almost the same model as in the case of high T_c and quantum critical super-conductivity applies to the magnetic flux tubes. Now the flux quantum contains BE condensate of exotic Cooper pairs interacting with wormhole contacts feeding the gauge flux of Cooper pairs from the magnetic flux quantum to a larger space-time sheet. The interaction of spin 1 Cooper pairs with the magnetic field of flux quantum orients their spins in the same direction. Large value of $\hbar$ guarantees thermal stability even in the case that different space-time sheets are not thermally isolated.

The understanding of gap energy is not obvious. The transversal oscillations of magnetic flux tubes generated by spin flips of electrons define the most plausible candidate for the counterpart of phonons. In this framework phonon like states identified as wormhole contacts would be created by the oscillations of flux tubes and would be a secondary phenomenon.

Large values of $\hbar$ allow to consider not only the Cooper pairs of electrons but also of protons and fermionic ions. Since the critical temperature for the formation of Cooper pairs is inversely proportional to the mass of the charge carrier, the replacement of electron with proton or ion would require a scaling of $\hbar$. If T_{c1} is proportional to $\hbar^2$, this requires scaling by $(m_p/m_e)^{1/2}$. For $T_{c1} \propto \hbar$ scaling by $m_p/m_e \simeq 2^{11}$ is required. This inspired idea that powers of 2^{11} could define favored values of $\hbar/\hbar_0$. This hypothesis is however rather adhoc and turned out to be too restrictive.

Besides Cooper pairs also Bose-Einstein condensates of bosonic ions are possible in large $\hbar$ phase and would give rise to super-conductivity. TGD inspired nuclear physics predicts the existence of exotic bosonic counterparts of fermionic nuclei with given (A, Z) [36].

Superconductors at the flux quanta of the Earth's magnetic field

Magnetic flux tubes and magnetic walls are the most natural candidates for super-conducting structures with spin triplet Cooper pairs. Indeed, experimental evidence relating to the interaction of ELF em radiation with living matter suggests that bio-super-conductors are effectively 1- or 2-dimensional. $D \leq 2$-dimensionality is guaranteed by the presence of the flux tubes or flux walls of, say, the magnetic field of Earth in which charge carries form bound states and the system is equivalent with a harmonic oscillator in transversal degrees of freedom.

The effect of Earth's magnetic field is completely negligible at the atomic space-time sheets and cannot make super conductor 1-dimensional. At cellular sized space-time sheets magnetic field makes possible transversal the confinement of the electron Cooper pairs in harmonic oscillator states but does not explain energy gap which should be at the top of 1-D Fermi surface. The critical temperature extremely low for ordinary value of $\hbar$ and either thermal isolation between space-time sheets or large value of $\hbar$ can save the situation.

An essential element of the picture is that topological quantization of the magnetic flux tubes occurs. In fact, the flux tubes of Earth's magnetic field have thickness of order cell size from the quantization of magnetic flux. The observations about the effects of ELF em fields on bio-matter [79, 80] suggest that similar mechanism is at work also for ions and in fact give very strong support for bio-super conductivity based on the proposed mechanism.

Energy gaps for superconducting magnetic flux tubes and walls

Besides the formation of Cooper pairs also the Bose-Einstein condensation of charge carriers to the ground state is needed in order to have a supra current. The stability of Bose-Einstein condensate requires an energy gap $E_{g,BE}$ which must be larger than the temperature at the magnetic flux tube.

Several energies must be considered in order to understand $E_{g,BE}$.

1. The Coulombic binding energy of Cooper pairs with the wormhole contacts feeding the em flux from magnetic flux tube to a larger space-time sheet defines an energy gap which is expected to be of order $E_{g,BE} = \alpha/L(k)$ giving $E_g \sim 10^{-3}$ eV for $L(167) = 2.5$ μm giving a rough estimate for the thickness of the magnetic flux tube of the Earth's magnetic field $B = .5 \times 10^{-4}$ Tesla.

2. In longitudinal degrees of freedom of the flux tube Cooper pairs can be described as particles in a one-dimensional box and the gap is characterized by the length L of the magnetic flux tube and the value of $\hbar$. In longitudinal degrees of freedom the difference between $n = 2$ and $n = 1$ states is given by $E_0(k_2) = 3h^2/4m_eL^2(k_2)$. Translational energy gap $E_g = 3E_0(k_2) = 3h^2/4m_eL^2(k_2)$ is smaller than the effective energy gap $E_0(k_1) - E_0(k_2) = h^2/4m_eL^2(k_1) - h^2/4m_eL^2(k_2)$ for $k_1 > k_2 + 2$ and identical with it for $k_1 = k_2 + 2$. For $L(k_2 = 151)$ the zero point kinetic energy is given by $E_0(151) = 20.8$ meV so that $E_{g,BE}$ corresponds roughly to a temperature of 180 K. For magnetic walls the corresponding temperature would be scaled by a factor of two to 360 K and is above room temperature.

3. Second troublesome energy gap relates to the interaction energy with the magnetic field. The magnetic interaction energy E_m of Cooper pair with the magnetic field consists of cyclotron term $E_c = n\hbar eB/m_e$ and spin-interaction term which is present only for spin triplet case and is given by $E_s = \pm\hbar eB/m_e$ depending on the orientation of the net spin with magnetic field. In the magnetic field $B_{end} = 2B_E/5 = .2$ Gauss ($B_E = .5$ Gauss is the nominal value of the Earth's magnetic field) explaining the effects of ELF em fields on vertebrate brain, this energy scale is $\sim 10^{-9}$ eV for $\hbar_0$ and $\sim 1.6 \times 10^{-5}$ eV for $\hbar = 2^{14} \times \hbar_0$.

The smallness of translational and magnetic energy gaps in the case of Cooper pairs at Earth's magnetic field could be seen as a serious obstacle.

1. Thermal isolation between different space-time sheets provides one possible resolution of the problem. The stability of the Bose-Einstein condensation is guaranteed by the thermal isolation of space-time if the temperature at the magnetic flux tube is below E_m. This can be achieved in all length scales if the temperature scales as the zero point kinetic energy in transversal degrees of freedom since it scales in the same manner as magnetic interaction energy.

2. The transition to large $\hbar$ phase could provide a more elegant way out of the difficulty. The criterion for a sequence of transitions to a large $\hbar$ phase could be easily satisfied if there is a large number of charge Cooper pairs at the magnetic flux tube. Kinetic energy gap remains invariant if the length of the flux tube scales as $\hbar$. If the magnetic flux is quantized as a multiple of $\hbar$ and flux tube thickness scales as $\hbar^2$, B must scale as $1/\hbar$ so that also magnetic energy remains invariant under the scaling. This would allow to have stability without assuming low temperature at magnetic flux tubes.

3.3 TGD based model for high T_c super conductors

High T_c superconductors are quantum critical and involve in an essential magnetic structures, they provide an attractive application of the general vision for the model of super-conductivity based on magnetic flux tubes.

3.3.1 Some properties of high T_c super conductors

Quite generally, high T_c super-conductors are cuprates with CuO layers carrying the supra current. The highest known critical temperature for high T_c superconductors is 164 K and is achieved under huge pressure of 3.1×10^5 atm for LaBaCuO. High T_c super-conductors are known to be super conductors of type II.

This is however a theoretical deduction following from the assumption that the value of Planck constant is ordinary. For $\hbar = 2^{14}\hbar_0$ (say) ξ would be scaled up accordingly and type I super-conductor would be in question. These super-conductors are characterized by very complex patterns of penetrating magnetic field near criticality since the surface area of the magnetic defects is maximized. For high T_c super-conductors the ferromagnetic phase could be regarded as an analogous to defect and would indeed have very complex structure. Since quantum criticality would be in question the stripe structure would fluctuate with time too in accordance with 4-D spin glass character.

The mechanism of high T_c super conductivity is still poorly understood [45, 51].

1. It is agreed that electronic Cooper pairs are charge carriers. It is widely accepted that electrons are in relative d-wave state rather than in s-wave (see [57] and the references mentioned in [45]). Cooper pairs are believed to be in spin triplet state and electrons combine to form $L = 2$ angular momentum state. The usual phonon exchange mechanism does not generate the attractive interaction between the members of the Cooper pair having spin. There is also a considerable evidence for BCS type Cooper pairs and two kinds of Cooper pairs could be present.

2. High T_c super conductors have spin glass like character [37]. High T_c superconductors have anomalous properties also above T_c suggesting quantum criticality implying fractal scaling of various observable quantities such as resistivity. At high temperatures cuprates are antiferromagnets and Mott insulators meaning freezing of the electrons. Superconductivity and conductivity are believed to occur along dynamical stripes which are antiferromagnetic defects.

3. These findings encourage to consider the interpretation in terms of quantum criticality in which some new form of super conductivity which is not based on quasiparticles is involved. This superconductivity would be assignable with the quantum fluctuations destroying antiferromagnetic order and replacing it with magnetically disordered phase possibly allowing phonon induced super-conductivity.

4. The doping of the super-conductor with electron holes is essential for high T_c superconductivity, and there is a critical doping fraction $p = .14$ at which T_c is highest. The interpretation is that holes make possible for the Cooper pairs to propagate. There is considerable evidence that holes gather on one-dimensional stripes with thickness of order few atom sizes and lengths in the range 1-10 nm [51], which are fluctuating in time scale of 10^{-12} seconds. These stripes are also present in non-superconducting state but in this case they do not fluctuate appreciably. The most plausible TGD based interpretation is in terms of fluctuations of magnetic flux tubes allowing for the formation of long connected flux tubes making super-conductivity possible. The fact that the fluctuations would be oscillations analogous to acoustic wave and might explain the BCS type aspects of high T_c super-conductivity.

5. T_c is inversely proportional to the distance L between the stripes. A possible interpretation would be that full super-conductivity requires delocalization of electrons also with respect to stripes so that T_c would be proportional to the hopping probability of electron between neighboring stripes expected to be proportional to $1/L$ [51].

From free fermion gas to Fermi liquids to quantum critical systems

The article of Jan Zaanen [59] gives an excellent non-technical discussion of various features of high T_c super-conductors distinguishing them from BCS super-conductors. After having constructed a color flux tube model of Cooper pairs I found it especially amusing to learn that the analogy of high T_c super-conductivity as a quantum critical phenomenon involving formation of dynamical stripes to QCD in the vicinity of the transition to the confined phase leading to the generation of string like hadronic objects was emphasized also by Zaanen.

BCS super-conductor behaves in a good approximation like quantum gas of non-interacting electrons. This approximation works well for long ranged interactions and the reason is Fermi statistics plus the fact that Fermi energy is much larger than Coulomb interaction energy at atomic length scales.

For strongly interacting fermions the description as Fermi liquid (a notion introduced by Landau) has been dominating phenomenological approach. ^{3}He provides a basic example of Fermi liquid and already here a paradox is encountered since low temperature collective physics is that of Fermi gas without interactions with effective masses of atoms about 6 times heavier than those of real atoms whereas short distance physics is that of a classical fluid at high temperatures meaning a highly correlated collective behavior.

It should be noticed that many-sheeted space-time provides a possible explanation of the paradox. Space-time sheets containing join along boundaries blocks of ^3He atoms behave like gas whereas the ^3He atoms inside these blocks form a liquid. An interesting question is whether the ^3He atoms combine to form larger units with same spin as ^3He atom or whether the increase of effective mass by a factor of order six means that $\hbar$ as a unit of spin is increased by this factor forcing the basic units to consist of Bose-Einstein condensate of 3 Cooper pairs.

High T_c super conductors are neither Fermi gases nor Fermi liquids. Cuprate superconductors correspond at high temperatures to doped Mott insulators for which Coulomb interactions dominate meaning that electrons are localized and frozen. Electron spin can however move and the system can be regarded as an anti-ferromagnet. CuO planes are separated by highly oxidic layers and become super-conducting when doped. The charge transfer between the two kinds of layers is what controls the degree of doping. Doping induces somehow a delocalization of charge carriers accompanied by a local melting of anti-ferromagnet.

Collective behavior emerges for high enough doping. Highest T_c results with 15 per cent doping by holes. Current flows along electron stripes. Stripes themselves are dynamical and this is essential for both conductivity and superconductivity. For completely static stripes super-conductivity disappears and quasi-insulating electron crystal results.

Dynamical stripes appear in mesoscopic time and length scales corresponding to 1-10 nm length scale and picosecond time scale. The stripes are in a well-defined sense dual to the magnetized stripe like structures in type I super-conductor near criticality, which suggests analog of type I super-conductivity. The stripes are anti-ferromagnetic defects at which neighboring spins fail to be antiparallel. It has been found that stripes are a very general phenomenon appearing in insulators, metals, and super-conducting compounds [56].

Quantum criticality is present also above T_c

Also the physics of Mott insulators above T_c reflects quantum criticality. Typically scaling laws hold true for observables. In particular, resistivity increases linearly rather than transforming from T^2 behavior to constant as would be implied by quasi-particles as current carriers. The appearance of so called pseudo-gap [38] at $T_{c1} > T_c$ conforms with this interpretation. In particular, the pseudo-gap is non-vanishing already at T_{c_1} and stays constant rather than starting from zero as for quasi-particles.

Results from optical measurements and neutron scattering

Optical measurements and neutron scattering have provided especially valuable microscopic information about high T_c superconductors allowing to fix the details of TGD based quantitative model.

Optical measurements of copper oxides in non-super-conducting state have demonstrated that optical conductivity $\sigma(\omega)$ is surprisingly featureless as a function of photon frequency. Below the critical temperature there is however a sharp absorption onset at energy of about 50 meV [54]. The origin of this special feature has been a longstanding puzzle. It has been proposed that this absorption onset corresponds to a direct generation of an electron-hole pair. Momentum conservation implies that the threshold for this process is $E_g + E$, where E is the energy of the 'gluon' which binds electrons of Cooper pair together. In the case of ordinary super-conductivity E would be phonon energy.

Soon after measurements, it was proposed that in absence of lattice excitations photon must generate two electron-hole pairs such that electrons possess opposite momenta [54]. Hence the energy of the photon would be $2E_g$. Calculations however predicted soft rather than sharp onset of absorption since pairs of electron-hole pairs have continuous energy spectrum. There is something wrong with this picture.

Second peculiar characteristic [53, 48, 49] of high T_c super conductors is resonant neutron scattering at excitation energy $E_w = 41$ meV of super conductor. This scattering occurs only below the critical temperature, in spin-flip channel and for a favored momentum exchange $(\pi/a, \pi/a))$, where a denotes the size of the lattice cube [53, 48, 49]. The transferred energy is concentrated in a remarkably narrow range around E_w rather than forming a continuum.

In [55] is is suggested that e-e resonance with spin one gives rise to this excitation. This resonance is assumed to play the same role as phonon in the ordinary super conductivity and e-e resonance is treated like phonon. It is found that one can understand the dependence of the second derivative of the photon conductivity $\sigma(\omega)$ on frequency and that consistency with neutron scattering data is achieved. The second derivative of $\sigma(\omega)$ peaks near 68 meV and assuming $E = E_g + E_w$ they found nearly perfect match using $E_g = 27$ meV. This would suggest that the energy of the excitations generating the binding between the members of the Cooper pair is indeed 41 meV, that two electron-hole pairs and excitation of the super conductor are generated in photon absorption above threshold, and that the gap energy of the Cooper pair is 27 meV. Of course, the theory of Carbotte *et al* does not force the 'gluon' to be triplet excitation of electron pair. Also other possibilities can be considered. What comes in mind are spin flip waves of the spin lattice associated with stripe behaving as spin 1 waves.

In TGD framework more exotic options become possible. The transversal fluctuations of stripes- or rather of the magnetic flux tubes associated with the stripes- could define spin 1 excitations analogous to the excitations of a string like objects. Gauge bosons are identified as wormhole contacts in quantum TGD and massive gauge boson like state containing electron-positron pair or quark-antiquark pair could be considered.

3.3.2 TGD inspired vision about high T_c superconductivity

The following general view about high T_c super-conductivity as quantum critical phenomenon suggests itself. It must be emphasized that this option is one of the many that one can imagine and distinguished only by the fact that it is the minimal option.

The interpretation of critical temperatures

The two critical temperatures T_c and $T_{c_1} > T_c$ are interpreted as critical temperatures. The recent observation that there exists a spectroscopic signature of high T_c super-conductivity, which prevails up to T_{c_1} [52], supports the interpretation that Cooper pairs exist already below T_{c1} but that for some reason they cannot form a coherent super-conducting state.

One can imagine several alternative TGD based models but for the minimal option is the following one.

1. T_{c_1} would be the temperature for the formation of two-phase system consisting of ordinary electrons and of Cooper pairs with a large value of Planck constant explaining the high critical temperature.

2. Magnetic flux tubes are assumed to be carriers of supra currents. These flux tubes are very short in in anti-ferromagnetic phase. The holes form stripes making them positively charged so that they attract electrons. If the spins of holes tend to form parallel sequences along stripes, they generate dipole magnetic fields in scales of order stripe length at least. The corresponding magnetic flux tubes are assumed to be carriers of electrons and Cooper pairs. The flux tube structures would be closed so that the supra currents associated with these flux tubes would be trapped in closed loops above T_c.

3. Below T_{c1} transversal fluctuations of the flux tubes structures occur and can induce reconnections giving rise to longer flux tubes. Reconnection can occur in two manners. Recall that upwards going outer flux tubes of the dipole field turn downwards and eventually fuse with the dipole core. If the two dipoles have opposite directions the outer flux tube of the first (second) dipole can reconnect with the inward going part of the flux tube of second (first) dipole. If the dipoles have same direction, the outer flux tubes of the dipoles reconnect with each other. Same applies to the inwards going parts of the flux tubes and the dipoles fuse to a single deformed dipole if all flux tubes reconnect. This alternative looks more plausible. The reconnection process is in general only partial since dipole field consists of several flux tubes.

4. The reconnections for the flux tubes of neighboring almost dipole fields occur with some probability $p(T)$ and make possible finite conductivity. At T_c the system the fluctuations of the flux tubes become large and also $p(T, L)$, where L is the distance between stripes, becomes large and the reconnection leads to a formation of long flux tubes of length of order coherence length at least and macroscopic supra currents can flow. One also expects that the reconnection occurs for practically all flux tubes of the dipole field. Essentially a percolation type phenomenon [46] would be in question. Scaling invariance suggests $p_c(T, L) = p_c(TL/\hbar)$, where L is the distance between stripes, and would predict the observed $T_c \propto \hbar/L$ behavior. Large value of $\hbar$ would explain the high value of T_c.

This model relates in an interesting manner to the vision of Zaanen [39] expressed in terms of the highway metaphor visualizing stripes as quantum highways along which Cooper pairs can move. In antiferromagnetic phase the traffic is completely jammed. The doping inducing electron holes allows to circumvent traffic jam due to the Fermi statistics generates stripes along which the traffic flows in the sense of ordinary conductivity. In TGD framework highways are replaced with flux tubes and the topology of the network of highways fluctuates due to the possibility of reconnections. At quantum criticality the reconnections create long flux tubes making possible the flow of supra currents.

The interpretation of fluctuating stripes in terms of 1-D phonons

In TGD framework the phase transition to high T_c super-conductivity would have as a correlate fluctuating stripes to which supra currents are assigned. Note that the fluctuations occur also for $T > T_c$ but their amplitude is smaller. Stripes would be parallel to the dark magnetic flux tubes along which dark electron current flows above T_c. The fluctuations of magnetic flux tubes whose amplitude increases as T_c is approached induce transverse oscillations of the atoms of stripes representing 1-D transverse phonons.

The transverse fluctuations of stripes have naturally spin one character in accordance with the experimental facts. They allow identification as the excitations having 41 meV energy and would propagate in the preferred diagonal direction $(\pi/a, \pi/a)$. Dark Cooper pairs would have a gap energy of 27 meV. Neutron scattering resonance could be understood as a generation of these 1-D phonons and photon absorption a creation of this kind of phonon and breaking of dark Cooper pair. The transverse oscillations could give rise to the gap energy of the Cooper pair below T_{c1} and for the formation of long flux tubes below T_c but one can consider also other mechanisms based on the new physics predicted by TGD.

Various lattice effects such as superconductivity-induced phonon shifts and broadenings, isotope effects in T_c, the penetration depth, infrared and photoemission spectra have been observed in the cuprates [58]. The simplest interpretation is that ordinary phonons are replaced by 1-D phonons defined by the transversal excitations of stripes but do not give rise to the binding of the electrons of the Cooper pair but to to reconnection of flux tubes.

Explanation for the spectral signatures of high T_c superconductor

The model should explain various spectral signatures of high T_c super-conductors. It seems that this is possible at qualitative level at least.

1. Below the critical temperature there is a sharp absorption onset at energy of about $E_a = 50$ meV.

2. Second characteristic [53, 48, 49] of high T_c super conductors is resonant neutron scattering at excitation energy $E_w = 41$ meV of super conductor also visible only below the critical temperature.

3. The second derivative of $\sigma(\omega)$ peaks near 68 meV and assuming $E = E_g + E_w$ they found nearly perfect match using $E_g = 27$ meV for the energy gap.

$E_g = 27$ meV has a natural interpretation as energy gap of spin 1 Cooper pair. $E_w = 41$ meV can be assigned to the transversal oscillations of magnetic flux tubes inducing 1-D transversal photons which possibly give rise to the energy gap. $E_a = 50$ meV can be understood if also $S = 0$ Cooper pair for which electrons of the pair reside dominantly at the "outer" dipole flux tube and inner dipole core. The presence of this pair might explain the BCS type aspects of high T_c super-conductivity. This identification would predict the gap energy of $S = 0$ Cooper pair to be $E_g(S = 0) = 9$ meV. Since the critical absorption onset is observed only below T_c these Cooper pairs would become thermally stable at T_c and the formation of long flux tubes should somehow stabilize them. For very long flux tubes the distance of a point of "outer" flux tube from the nearby point "inner" flux tube becomes very long along dipole flux tube. Hence the transformation of $S = 0$ pairs to $S = 1$ pairs is not possible anymore and $S = 0$ pairs are stabilized.

Model for Cooper pairs

The TGD inspired model for Cooper pairs of high T_c super-conductor involves several new physics aspects: large $\hbar$ phases, the notion of magnetic flux tubes. One can also consider the possibility that color force predicted by TGD to be present in all length scales is present.

1. One can consider two options for the topological quantization of the dipole field. It could decompose to a flux tube pattern with a discrete rotational symmetry Z_n around dipole axis or to flux sheets identified as walls of finite thickness invariant under rotations around dipole axis. Besides this there is also inner the flux tube corresponding to the dipole core. For the flux sheet option one can speak about eigenstates of L_z. For flux tube option the representations of Z_n define the counterparts of the angular momentum eigenstates with a cutoff in L_z analogous to a momentum cutoff in lattice. The discretized counterparts of spherical harmonics make sense. The counterparts of the relative angular momentum eigenstates for Cooper pair must be defined in terms of tensor products of these rather than using spherical harmonics assignable with the relative coordinate $r_1 - r_2$. The reconnection mechanism makes sense only for the flux tube option so that it is the only possibility in the recent context.

2. Exotic Cooper pair is modeled as a pair of large $\hbar$ electrons with zoomed up size at space-time representing the dipole field pattern associated with a sequence of holes with same spin. If the members of the pair are at diametrically opposite flux tubes or at the "inner" flux tube (dipole core) magnetic fluxes flow in same direction for electrons and spin 1 Cooper pair is favored. If they reside at the "inner" flux tube and outer flux tube, spin zero state is favored. This raises the question whether also $S = 0$ variant of the Cooper pair could be present.

3. Large $\hbar$ is needed to explain high critical temperature. By the general argument the transition to large $\hbar$ phase occurs in order to reduce the value of the gauge coupling strength - now fine structure constant- and thus guarantee the convergence of the perturbation theory. The generation or positive net charge along stripes indeed means strong electromagnetic interactions at stripe.

Color force in condensed matter length scales is a new physics aspect which cannot be excluded in the case that transverse oscillations of flux tubes do not bind the electrons to form a Cooper pair. Classically color forces accompany any non-vacuum extremal of Kähler action since a non-vanishing induced Kähler field is accompanied by a classical color gauge field with Abelian holonomy. Induced Kähler field is always non-vanishing when the dimension of the CP_2 projection of the space-time surface is higher than 2. One can imagine too alternative scenarios.

1. Electromagnetic flux tubes for which induced Kähler field is non-vanishing carry also classical color fields. Cooper pairs could be color singlet bound states of color octet excitations of electrons

(more generally leptons) predicted by TGD and explaining quite impressive number of anomalies [25]. These states are necessarily dark since the decay widths of gauge bosons do not allow new light fermions coupling to them. The size of these states is of order electron size scale $L(127)$ for the standard value of Planck constant. For the non-standard value of Planck constant it would be scaled up correspondingly. For $r = \hbar/\hbar_0 = 2^{14}$ the size would be around 3.3 Angströms and for $r = 2^{24}$ of order 10 nm. Color binding could be responsible for the formation of the energy gap in this case and would distinguish between ordinary two-electron states and Cooper pair. The state with minimum color magnetic energy corresponds to spin triplet state for two color octed fermions whereas for colored fermion and antifermion it corresponds to spin singlet (pion like state in hadron physics).

2. A more complex variant of this picture served as the original model for Cooper pairs. Electrons at given space-time sheet feed their gauge flux to large space-time sheet via wormhole contacts. If the wormhole throats carry quantum numbers of quark and antiquark one can say that in the simplest situation the electron space-time sheet is color singlet state formed by quark and antiquark associated with the upper throats of the wormhole contacts carrying quantum numbers of u quark and $\overline{d}$ quark. It can also happen that the electronic space-time sheets are not color singlet but color octet in which case the situation is analogous to that above. Color force would bind the two electronic space-time sheets to form a Cooper pair. The neighboring electrons in stripe possess parallel spins and could form a pair transforming to a large $\hbar$ Cooper pair bound by color force. The Coulombic binding energy of the charged particles with the quarks and antiquarks assignable to the two wormhole throats feeding the em gauge flux to Y^4 and color interaction would be responsible for the energy gap.

Estimate for the gap energy

If transverse oscillations are responsible for the binding of the Cooper pairs, one expects similar expression for the gap energy as in the case of BCS type super conductors. The 3-D formula for the gap energy reads as

$$\begin{aligned}
E_g &= \hbar\omega_D exp(-1/X) \ , \\
\omega_D &= (6\pi^2)^{1/3} c_s n^{1/3} \\
X &= n(E_F)U_0 = \frac{3}{2}N(E_F)\frac{U_0}{E_F} \ , \\
n(E_F) &= \frac{3}{2}\frac{N(E_F)}{E_F} \ .
\end{aligned} \tag{3.3.1}$$

X depends on the details of the binding mechanism for Cooper pairs and U_0 parameterizes these details.

Since only stripes contribute to high T_c super-conductivity it is natural to replace 3-dimensional formula for Debye frequency in 1-dimensional case with

$$\begin{aligned}
E_g &= \hbar\omega exp(-1/X) \ , \\
\omega &= kc_s n \ .
\end{aligned} \tag{3.3.2}$$

where n is the 1-dimensional density of Cooper pairs and k a numerical constant. X would now correspond to the binding dynamics at the surface of 1-D counterpart of Fermi sphere associated with the stripe.

There is objection against this formula. The large number of holes for stripes suggests that the counterpart of Fermi sphere need not make sense, and one can wonder whether it could be more advantageous to talk about the counterpart of Fermi sphere for holes and treat Cooper pair as a pair of vacancies for this "Fermi sphere". High T_c super conductivity would be 1-D conventional super-conductivity for bound states of vacancies. This would require the replacement of n with the linear density of holes along stripes, which is essentially that of nuclei.

From the known data one can make a rough estimate for the parameter X. If $E_w = hf = 41$ meV is assigned with transverse oscillations the standard value of Planck constant would give $f = f_0 = 9.8 \times 10^{12}$ Hz. In the general case one has $f = f_0/r$. If one takes the 10^{-12} second length scale of the transversal fluctuations at a face value one obtains $r = 10$ as a first guess. $E_g = 27$ meV gives the estimate

$$exp(-1/X) = \frac{E_g}{E_w} \tag{3.3.3}$$

giving $X = 2.39$.

The interpretation in terms of transversal oscillations suggests the dispersion relation

$$f = \frac{c_s}{L} \ .$$

L is the length of the approximately straight portion of the flux tube. The length of the "outer" flux tube of the dipole field is expected be longer than that of stripe. For $L = x$ nm and $f_D \sim 10^{12}$ Hz one would obtain $c_s = 10^3 x$ m/s.

Estimate for the critical temperatures and for $\hbar$

One can obtain a rough estimate for the critical temperature T_{c1} by following simple argument.

1. The formula for the critical temperature proposed in the previous section generalize in 1-dimensional case to the following formula

$$T_{c1} \leq \frac{h^2}{8m_e}(\frac{n_c}{g})^2 \ . \tag{3.3.4}$$

   g is the number of spin degrees of freedom for Cooper pair and n_c the 1-D density of Cooper pairs. The effective one-dimensionality allows only single $L = 2$ state localized along the stripe.The $g = 3$ holds true for $S = 1$.

2. By parameterizing n_c as $n_c = (1 - p_h)/a$, $a = x$ Angstrom, and substituting the values of various parameters, one obtains

$$T_{c1} \simeq \frac{r^2(1-p_h)^2}{9x^2} \times 6.3 \ meV \ . \tag{3.3.5}$$

3. An estimate for p_h follows from the doping fraction p_d and the fraction p_s of parallel atomic rows giving rise to stripes one can deduce the fraction of holes for a given stripe as

$$p_h = \frac{p_d}{p_s} \ . \tag{3.3.6}$$

   One must of course have $p_d \leq p_s$. For instance, for $p_s = 1/5$ and $p_d = 15$ per cent one obtains $p_h = 75$ per cent so that a length of four atomic units along row contains one Cooper pair on the average. For $T_{c1} = 23$ meV (230 K) this would give the rough estimate $r = 23.3$: $r = 24$ satisfies the Fermat polygon constraint. Contrary to the first guess inspired by the model of bio-superconductivity the value of $\hbar$ would not be very much higher than its standard value. Notice however that the proportionality $T_c \propto r^2$ makes it difficult to explain T_{c1} using the standard value of $\hbar$.

4. One $p_h \propto 1/L$ whereas scale invariance for reconnection probability ($p = p(x = TL/\hbar)$) predicts $T_c = x_c\hbar/L = x_c p_s \hbar/a$. This implies

$$\frac{T_c}{T_{c1}} = 32\pi^2 \frac{m_e a}{\hbar_0} x^2 g^2 \frac{p_s}{(1-(p_d/p_s)^2)^2} \frac{x_c}{r} \quad . \tag{3.3.7}$$

   This prediction allows to test the proposed admittedly somewhat ad hoc formula. For $p_d << p_s$ T_c/T_{c1} does behaves as $1/L$. One can deduce the value of x_c from the empirical data.

5. Note that if the reconnection probability p is a universal function of x as quantum criticality suggests and thus also x_c is universal, a rather modest increase of $\hbar$ could allow to raise T_c to room temperature range.

The value of $\hbar$ is predicted to be inversely proportional to the density of the Cooper pairs at the flux tube. The large value of $\hbar$ needed in the modeling of living system as magnetic flux tube super-conductor could be interpreted in terms of phase transitions which scale up both the length of flux tubes and the distance between the Cooper pairs so that the ratio rn_c remains unchanged.

Coherence lengths

The coherence length for high T_c super conductors is reported to be 5-20 Angstroms. The naive interpretation would be as the size of Cooper pair. There is however a loophole involved. The estimate for coherence length in terms of gap energy is given by $\xi = \frac{4\hbar v_F}{E_g}$. If the coherence length is estimated from the gap energy, as it seems to be the case, then the scaling up of the Planck constant would increase coherence length by a factor $r = \hbar/\hbar_0$. $r = 24$ would give coherence lengths in the range $12 - 48$ nm.

The interpretation of the coherence length would be in terms of the length of the connected flux tube structure associated with the row of holes with the same spin direction which can be considerably longer than the row itself. As a matter fact r would characterize the ratio of size scales of the "magnetic body" of the row and of row itself. The coherence lengths could relate to the p-adic length scales $L(k)$ in the range $k = 151, 152, .., 155$ varying in the range $(10, 40])$ nm. $k = 151$ correspond to thickness cell membrane.

Why copper and what about other elements?

The properties of copper are somehow crucial for high T_c superconductivity since cuprates are the only known high T_c superconductors. Copper corresponds to $3d^{10}4s$ ground state configuration with one valence electron. This encourages the question whether the doping by holes needed to achieve superconductivity induces the phase transition transforming the electrons to dark Cooper pairs.

More generally, elements having one electron in s state plus full electronic shells are good candidates for doped high T_c superconductors. If the atom in question is also a boson the formation of atomic Bose-Einstein condensates at Cooper pair space-time sheets is favored. Superfluid would be in question. Thus elements with odd value of A and Z possessing full shells plus single s wave valence electron are of special interest. The six stable elements satisfying these conditions are ^{5}Li, ^{39}K, ^{63}Cu, ^{85}Rb, ^{133}Cs, and ^{197}Au.

3.3.3 Speculations

21-Micrometer mystery

21 micrometer radiation from certain red giant stars have perplexed astronomers for more than a decade [60]. Emission forms a wide band (with width about 4 micrometers) in the infrared spectrum, which suggests that it comes form a large complex molecule or a solid or simple molecules found around starts. Small molecules are ruled out since they produce narrow emission lines. The feature can be only observed in very precise evolutionary state, in the transition between red giant phase and planetary nebular state, in which star blows off dust that is rich in carbon compounds. There is no generally accepted explanation for 21-micrometer radiation.

One can consider several explanations based on p-adic length scale hypothesis and some explanations might relate to the wormhole based super-conductivity.

1. 21 micrometers corresponds to the photon energy of 59 meV which is quite near to the zero point point kinetic energy 61.5 meV of proton Cooper pair at $k = 139$ space-time sheet estimated from the formula

$$\Delta E(2m_p, 139) = \frac{1}{2}\frac{\pi^2}{(2m_p)L(139)^2} = \frac{1}{8}\Delta E(m_p, 137) \simeq 61.5\ meV \ .$$

   Here the binding energy of the Cooper pair tending to reduce this estimate is neglected, and this estimate makes sense only apart from a numerical factor of order unity. This energy is liberated when a Cooper pair of protons at $k = 139$ space-time sheet drops to the magnetic flux tube of Earth's magnetic field (or some other sufficiently large space-time sheet). This energy is rather near to the threshold value about 55 meV of the membrane potential.

2. 21 micrometer radiation could also result when electrons at $k = 151$ space-time sheet drop to a large enough space-time sheet and liberate their zero point kinetic energy. Scaling argument gives for the zero point kinetic energy of electron at $k = 151$ space-time sheet the value $\Delta(e, 151) \simeq$ 57.5 meV which is also quite near to the observed value. If electron is bound to wormhole with quantum numbers of $\overline{d}$ Coulombic binding energy changes the situation.

3. A possible explanation is as a radiation associated with the transition to high T_c super conducting phase. There are two sources of photons. Radiation could perhaps result from the de-excitations of wormhole BE condensate by photon emission. $\lambda = 20.5$ micrometers is precisely what one expects if the space-time sheet corresponds to $p \simeq 2^k$, $k = 173$ and assumes that excitation energies are given as multiples of $E_w(k) = 2\pi/L(k)$. This predicts excitation energy $E_w(173) \simeq$ 61.5 meV. Unfortunately, this radiation should correspond to a sharp emission line and cannot explain the wide spectrum.

Are living systems high T_c superconductors?

The idea about cells and axons as superconductors has been one of the main driving forces in development of the vision about many-sheeted space-time. Despite this the realization that the supra currents in high T_c superconductors flow along structure similar to axon and having same crucial length scales came as a surprise. Axonal radius which is typically of order $r = .5\ \mu$m. $r = 151 - 127 = 24$ favored by Mersenne hypothesis would predict $r = .4\ \mu$m. The fact that water is liquid could explain why the radius differs from that predicted in case of high T_c superconductors.

Interestingly, Cu is one of the biologically most important trace elements [34]. For instance, copper is found in a variety of enzymes, including the copper centers of cytochrome c-oxidase, the Cu-Zn containing enzyme superoxide dismutase, and copper is the central metal in the oxygen carrying pigment hemocyanin. The blood of the horseshoe crab, Limulus polyphemus uses copper rather than iron for oxygen transport. Hence there are excellent reasons to ask whether living matter might be able to build high T_c superconductors based on copper oxide.

Neuronal axon as a geometric model for current carrying "rivers"

Neuronal axons, which are bounded by cell membranes of thickness $L(151)$ consisting of two lipid layers of thickness $L(149)$ are good candidates for high T_c superconductors in living matter.

These flux tubes with radius .4 μm would define "rivers" along which conduction electrons and various kinds of Cooper pairs flow. Scaled up electrons have size $L(k_{eff} = 151)$ corresponding to 10 nm, the thickness of the lipid layer of cell membrane. Also the quantum fluctuating stripes of length 1-10 nm observed in high T_c super conductors might relate to the scaled up electrons with Compton length 10 nm, perhaps actually representing zoomed up electrons!

The original assumption that exotic *resp.* BCS type Cooper pairs reside at boundaries *resp.* interior of the super-conducting rivulet. It would however seem that the most natural option is that the hollow cylindrical shells carry all supra currents and there are no Cooper pairs in the interior. If exotic Cooper pairs reside only at the boundary of the rivulet or the Cooper pairs at boundary remain critical against exotic-BCS transition also below T_c, the time dependent fluctuations of the shapes of stripes accompanying high T_c super-conductivity can be understood as being induced by the fluctuations of membrane like structures. Quantum criticality at some part of the boundary is necessary in order to transform ordinary electron currents to super currents at the ends of rivulets. In biology this quantum criticality would correspond to that of cell membrane.

3.4 Models for ionic superconductivity and topological condensation at the magnetic flux quanta of endogenous magnetic field

In this section the model for ionic superconductivity is constructed as a straightforward generalization of the model of high T_c electronic superconductivity. There is however a loophole involved. TGD based model of atomic nucleus predicts that fermionic ions can have bosonic chemical equivalents for which one of the color bonds connecting nucleons to nuclear string is charged. Dark fermionic ions like Na^+, K^+, and Cl^- could be actually exotic ions of this kind having different mass number and be able to form Bose-Einstein condensates. This is required by the recent model for nerve pulse [17]. The prediction can be tested.

The new model for the topological condensation at magnetic flux quanta of endogenous magnetic field differs radically from the earlier model and allows to understand that effects of ELF em fields on brain. Bose-Einstein condensates of bosonic ions are predicted to be of special importance for the functioning of living systems. Also a quantitative understanding of the effects of Schumann resonances and EEG emerges.

3.4.1 Model for ionic superconductivity

Exactly the same mechanisms are expected to work also in the case of ions and the only differences come from the different mass and charge of ion.

1. Magnetic flux tubes are carriers of supra currents and magnetic fields favor the formation of spin 1 Cooper pairs which are parallel and have also spins parallel to the flux tubes. In living matter the flux tubes could be dark magnetic flux tubes connecting different biomolecules. For instance, DNA as topological quantum computer model [28] assumes that flux tubes connect nucleotides of DNA with the lipid layers of nuclear or cell membrane.

2. Mersenne hypothesis discussed in the introduction is assumed and makes possible precise quantitative predictions using scaling arguments. With the motivation coming from the model of cell membrane as Josephson junction it is also assumed that magnetic field scales as $1/\hbar$ and that the supra currents at the boundaries of flux tubes guarantee that the quantization condition $\oint(p - eA) \cdot dl = 0$ is satisfied. This allows the flux tubes to have a fixed transversal size (cell membrane thickness) irrespective of the value of Planck constant. An attractive hypothesis is that the $B_{end} = 0.2$ Gauss and its $1/\hbar$ scaled variants define preferred values of magnetic field.

3. In the case of ionic super-conductivity there is no antiferromagnetic lattice present. Therefore there is no obvious reason for having higher critical temperature $T_{c,1}$. Percolation type mechanism is possible if a recombination of shorter magnetic flux tubes to form longer ones takes place at critical temperature. According to the model of DNA as topological quantum computer recombination of the flux tubes is a basic mechanism of information processing mechanism in living matter so that percolation type criticality might be present.

4. For large values of $\hbar$ the gap for magnetic cyclotron energies implies that proton Cooper pairs condense to the ground state in the degrees of freedom transversal to the flux tube in which harmonic oscillator states provide a good approximate model. In the longitudinal degrees of freedom one has effectively particle in box. The corresponding energy gap $E = \pi^2\hbar^2/2m_pL^2$ is below thermal energy at room temperature for flux tube lengths L of order $L(139)$ for ordinary value of $\hbar$. For electron this length scale is by a factor $m_p/m_e \simeq 2^{11}$ longer and corresponds to about 100 nm. The value of flux tube length however scales as $\hbar$ if one assumes that energy does

not change in the scaling of $\hbar$. Hence arbitrarily long flux tube lengths are possible. For ion with mass number A the minum value of $\hbar$ allowing given flux tube length L scales as $\hbar \propto AL$.

5. In the case of bosonic ions there is no need for Cooper pairs and super-conductivity would be due to the Bose-Eintein condensation of ions. TGD based nuclear physics also predicts exotic ions, which are chemically like their fermionic counterparts but are actually bosons. This is made possible by the possibility of the color flux tubes connecting nucleons to nuclear string to carry charges $1, 0, -1$.

6. Whether the Cooper pairs of fermionic ions can be thermally stable is far from obvious. The model for electronic super-conductivity would suggest transversal fluctuations of the flux tube as the mediator of the attractive interaction winning Coulomb repulsion and making possible the formation of the Cooper pairs.

   One might hope that the ions are trapped to the neighboring nodes of the transversal standing wave type oscillations and in this manner form correlated pairs. The size of the Cooper pairs would correspond to a multiple of wavelength for the transversal oscillations in this case. The approximation of the magnetic flux tube as string would suggest that waves are of form $sin(\omega t)sin(kz)$, $k = \omega$. The frequencies $\omega = n\pi/L$ would be allowed for a flux tube of length L.

   Perhaps it would be more appropriate to say that one has Bose-Einstein condensate of transverse phonons making possible the Bose-Einstein condensate of Cooper pairs. It is quite possible that metabolic energy must be pumped to the Bose-Einstein condensate of transverse oscillations in order to not lose the ionic super-conductivity.

3.4.2 Super conductors of exotic bosonic counterparts of fermionic ions

If ion is boson, no Cooper pairs is needed in order to have a super conductor, and Ca^{++} and Mg^{++} ions at dark magnetic flux tubes with large value of Planck constant could give rise to high T_c superconductors in this manner. Fermionic ions (Na^+, K^+,Cl^-,..) would not define supra currents. The explanation of the effects of ELF em fields on vertebrate brain however suggests cyclotron Bose-Einstein condensates of also ions behaving chemically like fermionic ions. Also the model of nerve pulse requires Josephson currents of ions which are chemical equivalents of fermionic ions.

TGD based nuclear physics [36] allows this kind of ions. The model indeed predicts the possibility of exotic nuclei for which one or more color bonds connecting nucleons to the nuclear string are charged. These exotic nuclei with electronic states identical to those of genuine ions could save the situation. The table below describes how cyclotron frequencies for $B = .2$ Gauss of the most important ions are modified in the simplest replacements with exotic ions. For instance, the notation Mg_{-}^{++} tells that there is double electronic ionization and electron shell of Argon as usual but that one color bond is negatively charged.

$$\begin{array}{llll} Ion & f_c/Hz & Pseudo-ion & f_c/Hz \\ ^{23}Na^+ & 13.1 & ^{19}Ne_+ & 15.7 \\ ^{23}Na^+ & 13.1 & ^{24}Mg_-^{++} & 12.5 \\ ^{39}K^+ & 7.7 & ^{40}A_+ & 7.5 \\ ^{39}K^+ & 7.7 & ^{40}Ca_-^{++} & 7.5 \\ ^{35}Cl^- & 8.6 & ^{40}A_- & 7.5 \end{array} \quad (3.4.1)$$

$f_c(K+)$ and $f_c(Cl^-)$ are replaced with the frequency 7.5 Hz and one can do only using the cyclotron frequencies $f(Ca^{++})/2 = 7.5$ Hz, $f_c(Mg^{++}) = 12.5$ Hz, and $f(Ca^{++}) = 15$ Hz. The nominal values of the lowest Schumann frequencies are 7.8 Hz and 14.3 Hz. All ions with relevance for nerve pulse and EEG could be bosonic ions or bosonic pseudo-ions. I do not know how well the needed ionization mechanisms are understood in the standard framework.

3.4.3 More quantitative picture about Bose-Einstein condensates

Cyclotron frequencies of biologically important ions in the endogenous magnetic field $B_{end} = 0.2$ Gauss are involved with the effects of ELF em fields on vertebrate brain and are also central in the model of EEG [20]. This motivates a more detailed study of these frequencies. Also the cyclotron frequencies of biologically important molecules are interesting.

Bose-Einstein condensates of bosonic ionized atoms

The number of elements for which ions are bosons is not very large. The following table lists the cyclotron frequencies of bosonic ions which are biologically important for $B_{end} = .2 \times 10^{-4}$ Tesla.

Ion	f_1/Hz	E_1/eV
$^6Li^+$	50.1	3.3
$^{24}Mg^{2+}$	25.0	1.65
$^{16}O^{2-}$	37.6	2.48
$^{32}S^{2-}$	18.8	1.24
$^{40}Ca^{2+}$	15.0	.99
$^{55}Mn^{2+}$	11.4	.75
$^{56}Fe^{2+}$	10.8	.71
$^{59}Co^{2+}$	10.0	.66
$^{64}Zn^{2+}$	9.4	.62
$^{80}Se^{2-}$	7.6	.5

Table 1. The first columns give the cyclotron frequencies and cyclotron energies for biologically relevant bosonic ions in $B_{end} = .2 \times 10^{-4}$ Tesla. The third column gives cyclotron energy.

The table inspires some comments.

1. For Li$^+$ the dominating isotope ^{7}Li$^+$ is fermion. ^{6}Li$^+$ is boson and its abundance is 5 per cent. Li$^+$ ions are used as medications in mania and represents mood stabilizer [62]. A possible explanation is that the cyclotron oscillations of Bose-Einstein condensate of ^{6}Li$^+$ ions serve as a biological clock helping to stabilize the mood. The cyclotron frequency is however 50 Hz and higher than thalamocortical resonance frequency having nominal value 40 Hz.

   An alternative explanation for the effect of Li^+ is based on the observation that $^7Li_+$ has cyclotron frequency equal to 42.9 Hz for $B_{end} = .2 \times 10^{-4}$ Tesla, which is at the upper limit of the 40 Hz resonance band. The presence of lithium ions or their Cooper pairs could enhance thalamocortical resonance.

   These hypothesis could be tested by looking whether the use of pure $A = 6$ ($A = 7$) isotope of Li$^+$ amplifies the beneficial effect and the use of $A = 7$ ($A = 6$) isotope nullifies it.

2. For Mg^{2+} cyclotron energy corresponds to the energy of photon of green light. Chlorophyll is not able to convert nutrients to sugar without magnesium, which suggests that cyclotron transitions of Mg BE condensate are at least partially responsible for the green color of plants. Mg BE condensate could control the coherent occurrence of photosynthesis in the size scale of plant.

3. For oxygen ion the cyclotron frequency is 37.6 Hz and rather near to ~ 40 Hz thalamocortical resonance frequency, which suggests that the cyclotron transitions of oxygen ions might play key role in inducing coherent firing of neurons at this frequency. This would mean that oxygen would be much more than a mere provider of metabolic energy. Note also that $\Delta n = 3$ cyclotron transition of Na$^+$ ion corresponds to frequency 39 Hz and might be involved with the synchronous firing.

4. Ca^{2+} ions play a unique role in the functioning of living matter. In particular, calcium waves appearing in a wide range of time scales are known to serve a crucial role in nervous system [108]. Ca^{2+} corresponds to .99 eV cyclotron energy scale, which is twice the energy of metabolic energy quantum. Hence one can ask whether the cyclotron transitions of Ca^{2+} BE condensate could induce a collective emission of metabolic energy quanta and in this manner induce coherent metabolic activity in the scale of entire body.

5. The cyclotron frequencies Mn, Fe, Co, Cu, and Zn are in alpha band and corresponding cyclotron energies are somewhat above metabolic energy quantum. These energy quanta could drive protons from larger space-time sheet to $k = 137$ atomic space-time sheet. 10 Hz frequency is known to define an important biological clock and Co ions could be essential for the functioning

of this clock. $n=3$ multiple of Co^{2+} cyclotron frequency corresponds to the 30 Hz threshold of gamma band known to be important for cognition. Also $3f_c(Fe^{2+})=32.2$ Hz and $3f_c(Mn^{2+})=34.2$ belong to gamma band. The presence of Bose-Einstein condensates of these ions in length scale of $5L(212)=141$ km could mean that these bio-rhythms are shared by different organisms inside regions of this size.

6. The fact that the cyclotron frequency of Se^{2-} ion, which is known to be a biologically important trace element, corresponds to the nominal value of the metabolic energy quantum, raises the question whether Selenium BE condensate might act as a metabolic synchronizer.

Cyclotron frequencies and Schumann frequencies

Even in the case that Cooper pairs of fermionic ions are not thermally stable, the cyclotron transitions of fermionic ions like K^+, Cl^-, and Na^+ are expected to be important. In the following table cyclotron frequencies and energies of some fermionic ions are given. Notice that the cyclotron energy of K^+ ion corresponds to metabolic energy quantum. Quite generally fermionic ions cannot be involved with the generation of Josephson part of EEG.

Ion	f/Hz	E_c/eV
$^7Li_+$	42.9	
F^-	15.8	1.04
Na^+	13	.86
Al^+	11.1	.73
Cl^-	8.5	.56
K^+	7.5	.50
Cu^+	4.8	333.9
Ag^+	2.8	.18
I^+	2.4	.16
Au^+	1.5	.10

Table 2. The first columns give cyclotron frequencies and corresponding cyclotron energies for some ions in $B_{end}=.2\times 10^{-4}$ Tesla for some fermionic ions.

The first thing to notice is the close relationship of cyclotron frequencies with the lowest resonance frequencies in the spectrum of geo-electromagnetic field starting from 5 Hz, so called Schumann frequencies [61], are $7.8, 14, 20, 26, 33, 39$ and 45 Hz. 5 Hz corresponds roughly to the threshold 4 Hz of theta frequency range below which EEG spectrum lies during sleep which suggests that wake-up state involves the coupling of brain with geo-electro-magnetic activity. 7.8 Hz corresponds to the threshold for alpha waves associated with wake-up state without cognition; 14 Hz corresponds to threshold of 13 Hz for beta waves accompanying cognitive activities, and 33 Hz is quite near to the threshold 30 Hz for gamma waves known to be important in the temporal coding of sensory data.

Consider now examples of cyclotron frequencies keeping in mind that Schumann frequencies vary typically within 1 Hz interval around their mean values [61].

1. As already noticed, the frequencies, which are multiples of 15 Hz can be assigned to Ca^{2+} ion. The excitations $n=3,5,7,..$ correspond to the frequencies $45, 75, 105, ...$ Hz. All these frequencies have been observed. The two lowest frequencies correspond to Schumann frequencies 14 and 45 Hz with accuracy of 1 Hz.

2. Na_+ has $A=23$ and gives $f=13$ Hz. This is the lower bound for the frequency of beta EEG waves which are associated with conscious cognition. This would suggest that the presence of em field of 13 Hz frequency correlates with large fluxes of Na_+ ions through the axonal cell membrane during nerve pulse generation. This could result from increased amplitude of Na_+ Josephson current facilitating the emission of nerve pulses at the second half of the EEG cycle. Silencing of mind by meditation or closing eyes reduces amplitudes associated with EEG frequencies below 13 Hz and conscious cognition disappears.

   $n=3$ excitation of Na_+ corresponds to 39 Hz, which is one of the Schumann frequencies and quite near to the 40 Hz resonant frequency associated with the thalamocortical circuit. This could correspond to jumping of Na_+ ions from ground state to $n = 3$ state or vice versa. $n = 5$ quantum jumps correspond to 65 Hz which is average EEG frequency during REM sleep! Thus 13, 39 and 65 Hz frequencies correspond to the basic signatures of conscious cognition. The two lowest transition frequencies correspond to Schumann frequencies 14 and 45 Hz within accuracy of 1 Hz.

3. K_+ has $A = 39$ and gives $f = 7.5$ Hz, which is theta frequency rather near to the lowest Schumann resonance frequency 7.8 Hz. K_+ ion flux could correlate with em fields in the range of the alpha frequencies creating cyclotron resonance. Theta activity dominates during sleep and Adey's observations [79] demonstrate that 7 Hz ELF field increases reaction times. Second and third transition frequencies are within 1.5 Hz Schumann frequencies 20 and 37.5 Hz.

4. Cl_- ion has $A = 35$ and gives $f = 8.5$ Hz. Chloride ion has inhibitory effect. $n = 3, 7, ..$ excitations correspond to 25.5, 42.5 Hz,... Rather interestingly, frequencies rather near to 40 Hz associated with thalamo-cortical loops appear as excitations for all ions relevant to nerve pulse activity. Note that 39 Hz is also Schumann frequency. Two lowest transition frequencies of Cl_- are quite near to Schumann frequencies 7.8 and 25 Hz.

5. Fe^{2+} has $A = 56$ and corresponds to 10.7 Hz. $3f_c(Fe^{2+}) = 32.2$ Hz is rather near to Schumann frequency 33 Hz whereas Co^{2+} corresponds to 10 Hz in excellent accuracy. Co has especially large nuclear magnetic moment and serves as a natural magnet. Fe^{2+} and/or Co^{2+} could be present in magnetic sensory organ possessed also by humans making it possible to navigate using magnetic fields. Yarrow suggests that Co makes B_{12} magnetic vitamin [79] so that it can serve as fundamental biological clock at frequency very precisely equal to 10 Hz. Co is carried by B_{12} vitamin and is known to be important for normal consciousness: among other things the lack of B_{12} causes fatigue, blurred vision and cognitive problems.

6. Mg^{2+} has A=24 and $f = 25$ Hz which is near to Schumann frequency: $n = 3$ corresponds 75 Hz. Charged polypeptides could also form BE condensates and be involved with cyclotron mechanism: they are rather heavy and their cyclotron frequencies are in Hz range. Negatively charged organic molecules are indeed known to be present in neurons.

To sum up, surprisingly many magnetic transition frequencies are near to Schumann frequencies which suggests strong resonant interaction between brain and geo-electromagnetic fields.

What about proton's cyclotron frequency?

There are good reasons to expect that the cyclotron frequency of proton and its odd harmonics play an important role in brain functioning. The cyclotron frequency of proton in $B_{end} = .2$ Gauss is $f(p) = 300$ Hz. The frequency associated with $n = 3$ transition would be $3f(p) = 900$ Hz. Third harmonics of cyclotron frequencies of many ions with f_c in alpha band belong to gamma band known to relate to cognition. Perhaps this is true also in the case of proton.

The duration of single bit of the memetic codeword consisting of 127 bits and having total duration defined by the p-adic timescale $T^{(2)}_{M_{127}} = .1$ seconds corresponds to the frequency $f_m = 1027$ Hz. This frequency is by 10 per cent higher than the cyclotron frequency of proton for $B_{end} = .2$ Gauss. If magnetic homeostasis is realized, as will be discussed later, and if it allows 10 per cent variation of the strength of magnetic field as the width 1 Hz of alpha band suggests, it is possible to realize this frequency as proton's cyclotron transition frequency.

The frequency of neuronal synchronization, which is obviously associated with cognitive processing, is $\simeq 1$ kHz and might well be identifiable with f_m. The maximum rate of neuronal firing is slightly below kHz: this rate however corresponds to the rate of quantum jumps rather than oscillation frequency at space-time level.

Bose-Einstein condensates of bosonic molecular ions

Also biologically relevant bosonic molecular ions such SO_4^{2-}, CO_3^{2-}, NO_3^-, NO_2^- could form Bose-Einstein condensates. The cyclotron frequencies for bosonic molecular ions satisfying the thermal stability condition $A \leq 233 \times Z$ at room temperature are typically in theta and delta band and above $f_{min} = 1.29$ Hz.

DNA is negatively charged and an interesting question is whether DNA satisfies the stability condition. The molecular weights of DNA nucleotides A,T,C,G are 132,126,96,149. The molecular weight of deoxyribose sugar attached to the nucleotide is 100 and that of phosphate group PO_4^{2-} is 95. Altogether this makes molecular weights 327, 321, 291, 344. Since phosphate group is doubly charged this structure has cyclotron energy which is higher than thermal energy. Also DNA sequences satisfy the thermal stability condition. The presence of DNA Bose-Einstein condensates at magnetic flux quanta could mean that DNA can be transferred between different organisms along these space-time sheets and that DNAs of different organisms of same species could form quantum coherent systems inside regions where magnetic field can be regarded as a constant.

Bibliography

Books about TGD

[1] M. Pitkänen (2006), *Topological Geometrodynamics: Overview.* http://tgd.wippiespace.com/public_html/tgdview/tgdview.html.

[2] M. Pitkänen (2006), *Quantum Physics as Infinite-Dimensional Geometry.* http://tgd.wippiespace.com/public_html/tgdgeom/tgdgeom.html.

[3] M. Pitkänen (2006), *Physics in Many-Sheeted Space-Time.* http://tgd.wippiespace.com/public_html/tgdclass/tgdclass.html.

[4] M. Pitkänen (2006), *p-Adic length Scale Hypothesis and Dark Matter Hierarchy.* http://tgd.wippiespace.com/public_html/paddark/paddark.html.

[5] M. Pitkänen (2006), *Quantum TGD.* http://tgd.wippiespace.com/public_html/tgdquant/tgdquant.html.

[6] M. Pitkänen (2006), *TGD as a Generalized Number Theory.* http://tgd.wippiespace.com/public_html/tgdnumber/tgdnumber.html.

[7] M. Pitkänen (2006), *TGD and Fringe Physics.* http://tgd.wippiespace.com/public_html/freenergy/freenergy.html.

Books about TGD Inspired Theory of Consciousness and Quantum Biology

[8] M. Pitkänen (2006), *TGD Inspired Theory of Consciousness.* http://tgd.wippiespace.com/public_html/tgdconsc/tgdconsc.html.

[9] M. Pitkänen (2006), *Bio-Systems as Self-Organizing Quantum Systems.* http://tgd.wippiespace.com/public_html/bioselforg/bioselforg.html.

[10] M. Pitkänen (2006), *Quantum Hardware of Living Matter.* http://tgd.wippiespace.com/public_html/bioware/bioware.html.

[11] M. Pitkänen (2006), *Bio-Systems as Conscious Holograms.* http://tgd.wippiespace.com/public_html/hologram/hologram.html.

[12] M. Pitkänen (2006), *Genes and Memes.* http://tgd.wippiespace.com/public_html/genememe/genememe.html.

[13] M. Pitkänen (2006), *Magnetospheric Consciousness.* http://tgd.wippiespace.com/public_html/magnconsc/magnconsc.html.

[14] M. Pitkänen (2006), *Mathematical Aspects of Consciousness Theory.* http://tgd.wippiespace.com/public_html/mathconsc/mathconsc.html.

[15] M. Pitkänen (2006), *TGD and EEG.* http://tgd.wippiespace.com/public_html/tgdeeg/tgdeeg.html.

References to the chapters of the books about TGD

[16] The chapter *Dark Forces and Living Matter* of [6]. http://tgd.wippiespace.com/public_html/paddark/paddark.html#darkforces.

[17] The chapter *p-Adic Particle Massivation: Hadron Masses* of [6]. http://tgd.wippiespace.com/public_html/paddark/paddark.html#mass3.

[18] The chapter *p-Adic Particle Massivation: Elementary particle Masses* of [6]. http://tgd.wippiespace.com/public_html/paddark/paddark.html#mass2.

[19] The chapter *Does the QFT Limit of TGD Have Space-Time Super-Symmetry?* of [3]. http://tgd.wippiespace.com/public_html/tgdquant/tgdquant.html#susy.

[20] The chapter *Construction of Quantum Theory: S-matrix* of [3]. http://tgd.wippiespace.com/public_html/tgdquant/tgdquant.html#towards.

[21] M. Pitkänen (2006), *Physics in Many-Sheeted Space-Time*. http://tgd.wippiespace.com/public_html/tgdclass/tgdclass.html.

[22] The chapter *Dark Nuclear Physics and Condensed Matter* of [6]. http://tgd.wippiespace.com/public_html/paddark/paddark.html#exonuclear.

[23] The chapter *Massless States and Particle Massivation* of [6]. http://tgd.wippiespace.com/public_html/paddark/paddark.html#mless.

[24] The chapter *TGD and Nuclear Physics* of [6]. http://tgd.wippiespace.com/public_html/paddark/paddark.html#padnucl.

[25] The chapter *The Recent Status of Leptohadron Hypothesis* of [6]. http://tgd.wippiespace.com/public_html/paddark/paddark.html#leptc.

[26] The chapter *Nuclear String Model* of [6]. http://tgd.wippiespace.com/public_html/paddark/paddark.html#nuclstring.

[27] The chapter *Quantum Field Theory Limit of TGD from Bosonic Emergence* of [3]. http://tgd.wippiespace.com/public_html/tgdquant/tgdquant.html#emergence.

References to the chapters of the books about TGD Inspired Theory of Consciousness and Quantum Biology

[28] The chapter *Quantum Model for Nerve Pulse* of [13]. http://tgd.wippiespace.com/public_html//tgdeeg/tgdeeg/tgdeeg.html#pulse.

[29] The chapter *Dark Matter Hierarchy and Hierarchy of EEGs* of [13]. http://tgd.wippiespace.com/public_html/tgdeeg/tgdeeg.html#eegdark.

[30] The chapter *Bio-Systems as Super-Conductors: part II* of [10]. http://tgd.wippiespace.com/public_html/bioware/bioware.html#superc2.

[31] The chapter *Bio-Systems as Super-Conductors: part I* of [10]. http://tgd.wippiespace.com/public_html/bioware/bioware.html#superc1.

[32] The chapter *DNA as Topological Quantum Computer* of [12]. http://tgd.wippiespace.com/public_html/genememe/genememe.html#dnatqc.

Articles related to TGD

[33] M. Pitkänen (2007), *Further Progress in Nuclear String Hypothesis*, http://tgd.wippiespace.com/public_html/articles/nuclstring.pdf.

Condensed matter physics

[34] *Copper*. http://en.wikipedia.org/wiki/Copper.

[35] J. Zaanen (2005), *Why high Tc is exciting?*. http://www.lorentz.leidenuniv.nl/research/jan_hitc.pdf.

[36] A. Hellemans (1999), *Labs Hold the Key to the 21-Micrometer Mystery*. Science, Vol. 284, Iss. 5417, p. 1113. http://adsabs.harvard.edu/abs/1999Sci...284.1113H

[37] I. Morgenstern (1990), article *Spin-Glass behavior of high T_c super conductors* in the book *Earlier and Recent Aspects of Super Conductivity* (eds. J. G. Bednorz and K. A. Muller), Springer Verlag.

[38] M. Buchanan (2001), *Mind the pseudogap*. Nature, vol 408, January 4. http://www.physique.usherbrooke.ca/taillefer/Projets/Nature-409008.pdf.

[39] J. Zaanen (2007), *Watching Rush Hour in the World of Electrons*. Science vol 315. www.sciencemag.org. http://www.ilorentz.org/~jan/perspstripes.pdf.

[40] M. Springford (ed) (1997), *Electron: A Centennary Volume*. Cambridge University Press.

[41] D. Aoki *et al* (2001), *Coexistence of super-conductivity and ferromagnetism in URhGe* (restricted access), Nature 413 613-616.
S. S. Saxena *et al* (2000),*Super-conductivity at the border of itinerant electron ferromagnetism in* UGe_2 (restricted access) Nature 406, 587-592.
C. Pfleiderer *et al* (2001), *Coexistence of super-conductivity and ferromagnetism in d band metal* $ZrZn_2$ (restricted access), Nature 412 58-61.

[42] S. Sachdev (1999) *Quantum phase transitions (summary)*. Physics World April pp. 33-38.

[43] M. Rabinowitz (2001), *Phenomenological Theory of Superfluidity and Super-conductivity*. http://arxiv.org/ftp/cond-mat/papers/0104/0104059.pdf.

[44] F. Levy, I. Sheikin, B. Grenier, and A. D. Huxley (2005), *Magnetic Field-Induced Superconductivity in the Ferromagnet URhGe*. Science 26, August, 1343-1346.
See also P. Rogers (2005), *Critical breakthrough*. Physics Web. http://physicsweb.org/articles/news/9/8/17.

[45] J. Orenstein, *Electrons pair themselves*. Nature 401.

[46] *Percolation*. http://en.wikipedia.org/wiki/Percolation.

[47] J. Flouquet and A. Boudin (2002), *Ferromagnetic super-conductors*. Physics Web, http://physicsweb.org/articles/world/15/1/9.

[48] H.A. Moock *et al* (1993), Phys. Rev. Lett. 70, 3490.

[49] H. S. Fong *et al* (1995), Phys. Rev. Lett. 75, 316.

[50] N. D. Mathur *et al* (1998), Nature 394, 39.
See also *Magnetic superglue promotes super-conductivity*. Physics Web. http://physicsweb.org/articles/news/2/7/3.

[51] J. Zaanen (2006), *Superconductivity: Quantum Stripe Search*. Nature vol 440, 27 April. http://www.lorentz.leidenuniv.nl/~jan/nature03/qustripes06.pdf.

[52] *Scientists Detect 'Fingerprint' of High-temperature Superconductivity Above Transition Temperature*. http://www.sciencedaily.com/releases/2009/08/090827141338.htm.

[53] J. Rossat-Mignot *et al* (1994), Physica (Amsterdam) 235 C, 59.

[54] J. Orenstein *et al* (1990), in *Electronic properties of high T_c super conductors* (ed. H. Kuzmany) 254-259. Springer, Berlin.

[55] J. Carbotte, E. Schachinger, D. N. Basov (1999), Nature 401, p. 354-356.

[56] V. J. Emery, S. A. Kivelson,, and J. M. Tranquada (1999), *Stripe phases in high-temperature superconductors*. Perspective, Vol. 96, Issue 16, 8814-8817, August 3. `http://www.pnas.org/cgi/reprint/96/16/8814.pdf`.

[57] D. A. Wollman *et al* (1993), *Experimental determinination of the super-conducting pairing state in YBCO from the phase coherence of YBCO-Pb dc SQUIDs*. Phys. Rev. Lett. B 71, 2134-2137.

[58] *High temperature and other unconventional superconductors*. `http://www.fkf.mpg.de/metzner/research/hightc/hightc.html`.

[59] J. Zaanen (2005), *Why high Tc is exciting?*. `http://www.lorentz.leidenuniv.nl/research/jan_hitc.pdf`.

[60] A. Hellemans (1999), *Labs Hold the Key to the 21-Micrometer Mystery*. Science, Vol. 284, Iss. 5417, p. 1113. `http://adsabs.harvard.edu/abs/1999Sci...284.1113H`

[61] D. D. Sentman (1995), *Schumann Resonances*. in *Handgbook of Atmospheric Electrodynamics*. (ed. Volland), Vol. 1, 267-295, Boca Raton: CRC Press, 1995.

Neuroscience

[62] National Institute of Mental Health, *Bipolar Disorder*. `http://www.nimh.nih.gov/publicat/bipolar.cfm#readNow`.

[63] L. F. Jaffe (2001), *Calcium Waves*.`http://waves.mbl.edu/calcium.waves.html`.
Calcium waves. `http://waves.mbl.edu/calcium.waves.html`.

Consciousness related references

[64] D. Yarrow (1990), *Spin the tale of the dragon*. review article on biomagnetism, `http://www.ratical.org/reatvlle/RofD2.html`.

[65] C. F. Blackman (1994), "Effect of Electrical and Magnetic Fields on the Nervous System" in *The Vulnerable Brain and Enviromental Risks, Vol. 3, Toxins in Air and Water* (eds. R. L. Isaacson and K. F. Jensen). Plenum Press, New York, pp. 331-355.

Chapter 4

Quantum Model for Hearing

4.1 Introduction

The quantum model of hearing has evolved through several twists and turns. For years this model seemed to be one of the stable portions of TGD inspired theory of qualia and, what was remarkable, allowed rather precise quantitative predictions. The model relied crucially on TGD based new physics: in particular, the roles of long ranged dark weak force and of neutrinos was central. Long ranged weak force predicted by TGD explains nicely the parity breaking effects in living matter but the idea that neutrinos could be central for cognition looks outlandish in the context provided by the text book myth about elusive neutrino travelling light years through condensed matter without any interactions.

The emergence of zero energy ontology, the explanation of dark matter in terms of a hierachy 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. This also modified dramatically the speculative ideas about the role of neutrinos in hearing.

Also in the recent view long range weak forces 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 wheras 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.

4.1.1 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 [28]. 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 (CDs). 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 [68],

and 160 Hz to cerebrellar synchrony [72]. 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-CDs 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 [17] remain to be disentangled.

3. The understanding of the Negentropy Maximization Principle [27] 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 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 [17]. 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) [55] 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.

4.1.2 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.

4.1.3 Model for hearing

The model for hearing follows as a special case from the general model for sensory receptor and representations.

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 the magnetic body rather than biological body. Hearing would be 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 a quale of the magnetic body resolves this mystery.

2. Equilibrioception (perception of the position and orientation of head) is very closely related to hearing as far as sensory receptors are considered: the basic difference is that the motion of hair cells is periodic for the sound perception and constant shift for equilibrioception. In this case the most important sensory data is geometric and the challenge is to build a model for magnetic body and for how the sensory data is communicated to the magnetic body.

3. At the quantative 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.

4. The frequency 2 kHz scale represents the lower bound for the frequencies representable in terms of cyclotron frequencies assignable to the CD of d quark. The CD of u quark allows to reduce the lower cutoff to 320 Hz and the CD of electron reduces the lower scale to 20 Hz representing the lower bound for the range of audible frequencies. The coding by the rate of nerve pulses can also resolve this problem as long as the rate of pulses is so high that the pulses sequences is experienced as a sound with a well-define pitch (the lower bound is about 28 Hz and higher than 20 Hz). The ultimate representation of the pitch would be always at the magnetic body.

5. 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.

6. 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.

4.2 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 elecromagnetic 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 [17].

4.2.1 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 [96] 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 prequisite 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 visiona 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 [45] 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 correponding 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 [45]

$$\gamma = 3J - \frac{p}{2}Z^0 \quad , \quad Q_Z = I_L^3 - pQ_{em} \quad , \quad p = sin^2(\theta_W) \tag{4.2.1}$$

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 implys $\hbar \sim 10^{13}\hbar_0$ 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 sourse- 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.

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

$$f_\nu = \frac{m_e}{m_\nu}\frac{1}{2sin^2(\theta_W)}f_e \ .$$

   From $f_e \simeq .57\times$ MHz and $p = sin^2(\theta_W) = .23$ one obtains $E_\nu = 1.7\times 10^{-2}$ eV, which is rouhgly 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 conlude that the value of Weinberg angle in the phase near vacuum extremal must be $p = .0295$ if one wants to reproduces 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

$$E = \sqrt{g_Z Q_Z B_Z 2\pi} \simeq .48 \ \ eV$$

   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

$$E = \sqrt{n}r^{1/2}\sqrt{g_Z Q_Z B_Z 2\pi} \simeq r^{1/2}\times .48 \ \ eV \ \ , \ \ r = \sqrt{\hbar/\hbar_0} \ .$$

   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 expecation vanishes so that this interpretation might make sense.

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 restoing 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 [109] 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 neuron (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 [106]. 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

$$\begin{aligned}
(\frac{Z-N}{4}-pZ)Z^0+q_{em}\gamma &= Q_{eff}\gamma \ , \\
Q_{eff} &= -\frac{Z-N}{2p}+2Z+q_{em} \ .
\end{aligned} \tag{4.2.2}$$

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.

$E(Ion)/eV$	$V=-40\ mV$	$V=-60\ mV$	$V=-70\ mV$
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 $V = -40$ mV corresponds to the resting state for photoreceptors and $V = -70$ mV to the resting state of a typical neuron.

4.2.2 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 [109, 118]. 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 [109] 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 [105]. 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^+ a 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 [105], 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 suggests 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^{++}
$E_J(.04\ mV, p = .23)/eV$	1.01	1.40	1.51	1.76
$E_J(.065\ V, p = .23)/eV$	1.64	2.29	2.69	2.73
$E_J(40\ mV, p = .0295)/eV$	1.60	2.00	2.23	1.68
$E_J(50\ mV, p = .0295)/eV$	2.00	2.49	2.79	2.10
$E_J(55\ mV, p = .0295)/eV$	2.20	2.74	3.07	2.31
$E_J(65\ mV, p = .0295)/eV$	2.60	3.25	3.64	2.73
$E_J(70\ mV, p = .0295)/eV$	2.80	3.50	3.92	2.94
$E_J(75\ mV, p = .0295)/eV$	3.00	3.75	4.20	3.15
$E_J(80\ mV, p = .0295)/eV$	3.20	4.00	4.48	3.36
$E_J(90\ mV, p = .0295)/eV$	3.60	4.50	5.04	3.78
$E_J(95\ mV, p = .0295)/eV$	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.

4.3 TGD based model for qualia and sensory receptors

The construction of model for hearing in TGD framework involves so many speculative elements that only the condition of universality of the model so that it applies to all sensory qualia gives hopes of constructing something which might be taken seriously.

4.3.1 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 corresponds 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 Käjhler 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 would 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 boots 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 a 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. One 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 frequence. 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 restrictes 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 [17] 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.

4.3.2 Qualia and DNA as topological quantum computer hypothesis

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 [28].

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 beween positive energy parts of the states associated with the sub-CD assigbnable 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 [28]. 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 [72]). 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 tne 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 [21]. 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 preocess 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 separtion 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 neutron.... 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 havelong 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.

4.3.3 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-qiuark 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.

4.3.4 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 [17]. 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 an 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 3×4 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 [66] 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 suggests 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: nocireceptors, 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.

4.4 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.

4.4.1 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 frquencies 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

$$r(q) = \frac{Q_{eff}(q)}{Q_{em}(q)} = \frac{\epsilon(q)}{2pQ_{em}(q)} + 1 \ , \ \epsilon(u) = -1 \ , \epsilon(d) = 1$$

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 he standard option would require both d quark and electron. Gor $d$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.

4. Besides cyclotron frequencies also the harmonics of the fundamental frequencies assignable to quark and electron CDs 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.

4.4.2 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 motor neurons at the ends of motor pathways wherefrom they would progate 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 [68]. 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 iseems 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 suggests that sensory data should be communicated from the cell membrane along the passive DNA strand. The simplest hypotesis 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 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

   $$\oint (p - ZeA)dl = n\hbar \ , \tag{4.4.1}$$

   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

   $$N = \frac{2m}{RZ^2e^2} \tag{4.4.2}$$

   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

   $$N_i = \frac{2m_i v_i}{RZ_i \sum_k Z_k v_k e^2} \ . \tag{4.4.3}$$

   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 possibiliy 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 assgnable 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 characteristizing 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 receival 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 wuold seem that thee 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.

4.5 Quantum model for hearing

It is very difficult to understand how neural processing could cope with the fast temporal gradients of the auditory input: the rate of nerve pulse transmission is simply too slow for this. The basic difficulty is that the time scale of nerve pulses is below millisecond whereas the highest audible sounds correspond to frequencies of about 200 kHz for some sea mammals [36]. Also bats hear very high frequencies. The frequencies below kHz seem to be coded to spike interval distributions [58] but for higher frequencies this is not possible. The mystery is how brain -or whatever is the ultimate perceiver-receives the information about higher frequencies. There is also the mystery of missing fundamenta [38], which suggestsa feedback from brain to ear, which is indeed known to exist and can sometimes be even heard directly as otoacoustic sounds.

4.5.1 Basic facts about hearing and their interpretation in TGD framework

It is good to start by a summary of the basic facts about hearing before applying the already summarized general model.

Inner and outer hair cells

Cochlea [47] is the basic structure responsible for the transformation of sound to nerve pulse patterns and conscious experience. It is located in the inner ear together with the vestibular system [43] responsible for equilibrioception- sense of balance requiring coding of information about the position and orientation of head. Both these systems utilize hair cells [32] to detect the motion of the fluid and the only basic difference is that in the case of hair cells related to hearing the motion is oscillatory inducing oscillation of membrane potential whereas for vestibular system the motion is non-periodic inducing a shift of the membrane potential.

The ear of mammals involves outer and inner hair cells [36, 32]. Outer hair cells have no axons to brain but there are efferents from cortex to them. The interpretation is that outer hair cells act as pre-amplifiers. They also make possible feedback from cortex allowing to build sensory percepts already at the level of ear. This makes reasonable the idea that sensory representations are indeed constructed at the level of sensory organs.

Hair cells act as filters selecting only one particular frequency. For cochlea piano keyboard is a good but not complete metaphor. The input at a given frequency presses various keys with a maximum activation at a key characterized by this frequency. Stereo cilia are nanotubes emerging from the surface of hair cell and participate the motion of the oscillation cochlear fluid. In inner cells this mechanism induces evoked potential varying in the rhythm of the filtered frequency. In outer cells the hair cell feeds actively energy to the sound wave and amplifies it. Outer hair cells as a dancer is a good metaphor.

The coupling of hair cells with neurons

The coupling of hair cells with neurons mediating neuronal signals to brain is poorly understood [36, 32].

1. The transmission of neurotransmitters to postsynaptic neuron from the hair cell should be uncannily fast. The existence of unidentified very fast neurotransmitter is postulated.

2. Hair cell contains near presynaptic cleft a mysterious structure with ring like shape known as presynaptic dense body. The function of this structure is not known but is believed to be crucial for the transfer of the neural transmitter.

3. There is chronical Ca^{2+} leakage to the hair cell. This is also believed to be crucial for the transmission of the mystery transmitter.

Hearing range

The hearing ranges [48] are the basic quantitative facts that the model of hearing should be able to explain.

1. For humans the hearing range is between 20 Hz and 20 kHz. For dogs the hearing range is from 40 Hz to 60 kHz. For bats the hearing range is between 20 Hz and 120 kHz. This suggests the existence of two different mechanisms of hearing. For mice the hearing range is from 1 kHz to 70 kHz, which suggests that the ranges $20-10^3$ Hz and the range above it are fundamentally different as far hearing is considered. One explanation is that rate coding is lacking.

   Sea mammals have also wide hearing ranges. Harbour porpoise emits sounds at two bands: one at 2 kHz and one above 110 kHz and the cochlear of these dolphins are specialized to accommodate extremely high frequencies. Bottlenose dolphin produces sound in a range varying from 250 Hz to 150 kHz. Marine mammals are also known to possess language and whales are known to sing.

2. Outer hair cells -possessed only by mammals- are known to be crucial for the expansion of the hearing range besides pre-amplification increasing the sensitivity and it might be that the two hearing ranges relate to the presence of two kinds of hair cells. Mechanoreception is based on vibrations of stereocialia in the cochlear fluid mediating the sound vibrations.

Hearing range involves several poorly understood aspects. Frequencies above kHz do not allow rate coding by nerve pulses and one mystery of neuroscience is how these sounds give rise to a conscious experience. One should also understand why 20 Hz defines the lower bound of audible frequencies and why the fundamental frequency of speech organs is 10 Hz, which by the way suggests that harmonics of 10 Hz could provide a fundamental representation of frequencies. One should identify the mechanism giving rise to the two audible ranges suggested by the hearing of bats and sea mammals.

Pitch

Pitch corresponds to the subjective sensation created by the sound and is determined by the fundamental frequency and its harmonics which are its integer multiples. If the distribution of frequencies is even (inharmonicy) there is no distinguishable pitch. The sounds produced by music instruments to represent melodies have well-defined pitch.

The phenomenon of missing fundamental means that fundamental is experienced although it is not present. This can be understood in terms of the feedback from brain artificially generating the missing harmonic in outer hair cells. The higher harmonics of the fundamental determine the character of the pitch and define the recognizable character of music instrument and human voice (timbre).

The relative resolution of pitch is $\Delta f/f = 4.3$ per cent so that octave could be divided to 86 notes distinguishable from each other to be compared with 12 notes in the well-tempered scale. If the two frequencies are heard simultaneously the resolution increases since beat frequences can be perceived. According to [37] even subjects with absolute pitch require a context in order to recognize the pitch of the sound. There are several acoustic illusions related to pitch. For instance, a continues or discrete sequence of specially formed tones can be made to sound as if the sequence would continue to ascend or descend indefinitely.

Other aspects of hearing

Hearing involves also many other aspects discussed in [37] and is clearly an exceptional sensory modality.

1. One key aspect of hearing relates to the determination of the direction of the sound source. This is known to involve the comparison of timing of the signals coming to ears and involves neuronal activity.

2. Hearing can be selective and auditory system is able to recognize the voice of a familiar person from the crowd. This suggests that the feedback generating artificial percept is especially important for hearing. I have a personal experience about conference held in Finland, where I listened english for a week. As I returned from the conference I heard to my surprise the finnish language as english for some time. Obviously, my brain manipulated the auditory input very actively.

3. Music experience involves several poorly understood phenomena serving as guidelines for anyone trying to understand sensory experience at deeper level. Mention only octave phenomenon and harmony and rhythm and pitch are dual aspects of the music.

4. Speech and language relate also to hearing. Why just hearing? Does this reflect that fact that pitch is a quale of magnetic body? And how internal speech relates to speech and hearing? The interpretation of internal speech as imagined speech would look natural but the challenge is to understand what imagination is. Could internal speech be based to a cortical projection to outer hair cells generating a weak auditory stimulus? Or could neurons generate internal speech in terms of neuronal quale distributions analogous to hearing quale but without the signalling to the magnetic body? Also sign languages are possible but sign language might express internal speech. Right brain sings-left brain talks metaphor has also something in it and the theory should provide insights about this specialization.

Cochlea and its magnetic body could give rise not only to auditory qualia but also define low level cognitive and emotional representations of auditory input realized already at the magnetic body of cochlea and realized in terms of cyclotron phase transitions. The right brain signs-left brain talks metaphor suggests an identification of cognitive *resp.* emotional representations as sequences of "phonemes" *resp.* "notes". The construction of the sensory representations involves in an essential manner back projection from brain to outer hair cells. Astrocytes regarded earlier as mere metabolic energy reservoirs are in this model carriers of higher level cognitive and emotional representations: this applies to all qualia. Microtubuli are responsible for mediating auditory input to brain as acoustic/electric signals (also propagating conformational patterns could be involved) and this resolves the mystery of how frequencies above kHz frequency are heard.

4.5.2 How pitch is represented?

The proposed vision about sensory perception would suggests that pitch is directly experienced at the magnetic body of the cochlea or some higher level magnetic body. This would solve the problem posed by high pitches for the model based on rate coding. The frequency modulated Josephson radiation generated by the hair cells would define the experienced pitch. Given hair cell would correspond to a specific position of the magnetic body and Josephson radiation from the hair cell could induce cyclotron transition at it.

The frequencies assignable to CDs seem to be involved

The frequency coding by cyclotron frequencies or by harmonics assignable to various kinds of CDs is highly suggestive.

1. This coding need not be same as the coding by cyclotron frequencies. Indeed, since the time scale of CD scales as $\hbar$, the CDs in question must correspond to the standard value of Planck constant. This would require that Josephson photons leak to these CDs and are transformed to bunches of ordinary photons. The proposed model for the generation of quale involves a leakage of two quark-antiquark pairs to a space-time sheet with ordinary value of $\hbar$ for a time interval defined by the corresponding CD scale. This CD could be interpreted as the imbedding space region in which attention is directed when mental image is created. For low frequencies electron CD would be involved also.

2. Quark sub-CD correspond to time span of 1 ms (d quark) or 6.5 ms (u quark) and electronic sub-CD to the time scale .1 s. The restriction to harmonics of the fundamental frequency would mean frequency cutoff $f_{low} = (2\times 10^3, 320, 20)$ Hz for (d, u, e) respectively. For frequencies below the 320 Hz electronic sub-CD should be used and this gives IR cutoff frequency of 20 Hz, which is ineed the cutoff for audible frequencies.

3. The Josephson radiation with frequencies above $f_{low} = (2 \times 10^3, 320, 20)$ Hz could be generated during the nerve pulse and induce (d, u, e) cyclotron transition at the flux tube assignable to the sensory pathway corresponding to a given frequency. Rate coding by nerve pulse patterns could apply below frequencies sufficiently below kHz. These frequencies would correspond most naturally to harmonics of the fundamental frequency (10,160,1280) Hz, which suggests that this coding relates to music experience.

4. The frequencies could be coded by the local value of the magnetic field at magnetic body and the pitch of the sound could be represented in this manner as a quale of the magnetic body. Similar coding is possible for other qualia. One can of course ask whether cyclotron frequencies are involved with this coding at all. The idea about resonance at the level of CD is suggestive but a proper formulation for this idea is lacking.

Codings based on cyclotron frequencies

The cyclotron frequencies of electron and quarks would define three different frequency ranges. For the standard vacuum (classical Z^0 field is very small) electron, u, and d quarks would define for $B_{end} = .2$ Gauss the basic cyclotron frequencies as $f_{up} = (564, 94, 19)$ kHz. The lower bound for the cyclotron frequency would be above $f_{low} = (2 \times 10^3, 320, 20)$ Hz for B_{end}. For electron this would give $B_{end,min} = 2$ nT, which represents an alarmingly weak magnetic field but could make sense if the value of Planck constant is large.

One can imagine several kinds of codings even if one assumes that the ultimate representation of the pitch is based a cyclotron transitions and that Josephson frequencies or their modulation codes for qualia. It is not completely clear what the correct option could be. Two basic classes of codings can be considered depending on whether the magnetic flux quanta correspond to the ordinary value of $\hbar$ or not.

1. If one assumes generalized flux quantization posing no conditions on the thickness of the flux quanta, the frequency can be coded by $B_{end} \propto 1/\hbar$, and one can assume that they correspond to flux tubes assignable to cell membranes. It seems that this option is the only reasonable one if flux tubes correspond to large $\hbar$. This in turn is supported by the dual interpretation of Josephson radiation in terms of biophotons and EEG.

2. If one assumes that flux tube correspond to the ordinary value of $\hbar$ and that the geometric data about percept -say the direction of the sound source- are coded by Josephson radiation, one must assume that the quanta of Josephson radiation are transformed to bundles of ordinary photons with cyclotron frequency in a phase transition changing the value of $\hbar$.

Two mechanisms for the coding of the pitch using cyclotron frequencies

One can imagine several mechanisms for the coding of the pitch.

1. The sound is directely converted to electromagnetic oscillations so that Josephson frequencies would not be involved at all. This requires piezoelectricity. Biomolecules are typically electrets and often also piezeoelectrics. The interaction of the electric field perhaps represented as MEs with the magnetic field body would induce cyclotron transitions. This option can be defended because Josephson frequencies as such cannot code for the pitch.

2. Second mechanism relies on the modulation of Josephson frequency by sound frequency codes for the sound frequency.

The latter option allows several alternatives but since Josephson frequencies are involved large $\hbar$ is unavoidable.

1. If the modulation frequency is much lower than Josephson frequency, the periodic variation of the Josephson frequency around cyclotron frequency induces a sequence of peaks as the Josephson frequency passes through the cyclotron frequence and this sequence would generate the quale. The same mechanism could generate for frequencies below kHz with sequence of nerve pulses generating sequence of pulse of Josephson radiation generating the cyclotron transition.

2. In principle the cyclotron frequency need not depend on the frequency detected by the hair cell of can be piecewise constant functions of it. However, if all frequencies in a given range excite the same same position of the magnetic body, one loses the outcome of the frequency analysis. Therefore Josephson radiation should be guided by magnetic flux tubes -most naturally flux tubes assignable to cell membranes or microtuli- to different positions of the magnetic body.

3. Josephson frequency need not correspond to the auditory frequency but cannot too large as compared to it. Certainly a rather large value of $\hbar$ is needed for Josephson radiation and also for the flux tubes unless Josephson radiation is transformed to a energy radiation radiation with ordinary value of Planck constant before the interaction with the cyclotron condensate. The amplitude of the modulation of the membrane potential would define the maximum deviation from the cyclotron resonance.

4. Cyclotron frequency could be proportional to the audible frequency so that the modulation frequency would be in a constant proportion to modulated frequency. In this case, place coding by position at magnetic body would result even when only massless extremals propagating in arbitrary directions are used (mass communication). This would require that the field strength at the magnetic body varies. The magnetic body of the entire cochlea would experience the sounds as spatial patterns of cyclotron transitions.

5. Each hair cell could represent its special frequency at the magnetic body of the group of hair cells coding for the same frequency. If Josephson frequency equals to the modulating frequency, one cannot speak about frequency modulation anymore. The resulting Josephson radiation would be at the harmonics of the audible frequency. If the cyclotron frequencies are identical to Josephson frequencies, one would have a coding of audible frequencies by magnetic field strength. $B_{end} = .2$ Gauss is a good guess for the order of magnitude. This option is attractive since the modulation can be said to be in resonance.

   This option is problematic if one assumes flux quantization in the form $\int BdA = n\hbar$. As explained, there are two manners to avoid the problems. The first one relies on currents at the boundaries flux tubes generating the magnetic flux. Second one assumes ordinary value of Planck constant and that Josephson photons are first transformed to bunches of ordinary cyclotron photons. For both options magnetic field strength is proportional to $1/\hbar$ which therefore codes for the frequency. For the first option the transversal scale of the flux tube can be independent of $\hbar$ constant and most naturally corresponds to that for the axonal membrane.

The cyclotron frequencies of electron and quarks define three different frequency ranges and all these might be involved with frequency coding.

1. For the standard vacuum (classical Z^0 field is very small) and for $B_{end} = .2$ Gauss the cyclotron frequencies would be $(f_e, f_u, f_d) = (564, 94, 19)$ kHz. For $f = 20$ Hz frequency the ratio $f/f_d \sim 10^{-3}$ would be obtained for d quark. These choices would allow to understand all hearing ranges. 150 kHz is the highest upper bound for the hearing range and should corresponds to electron's cyclotron frequency. The coding of 20 Hz frequency for d quark would require $B_{end,min}/B_{end,max} = 10^{-3}$ in the case of human auditory range containing 10 octaves. The same ratio would predict hearing range 94 Hz-94 kHz for u quark and hearing range 564 Hz-564 kHz for electron. For $B_{end,max} = .2$ Gauss one would have $B_{end,min} = .2\ \mu$T. Magnetic fields of strength of order .05 μT have effects on living matter [53] so that the proposal is consistent with experimental findings.

2. The flux tubes could also correspond to almost vacuum extremals. In this case the values of cyclotron frquencies would be considerable higher. This option does not seem to bring anything essentially new to the picture but cannot be excluded. It might even forced by the fact that cell membrane space-time sheet corresponds to almost vacuum extremal. In this case the frequencies corresponding to $B_{end} = .2$ Gauss are $(f_e, f_u, f_d) = (8.996, 2.275, .947)$ MHz. This option would give $B_{end,min}/B_{end,max} \simeq 10^{-5}$ and $B_{end,min} \sim .4$ nT if d quark is required to code for 20 Hz.

3. Fractality encourages to consider a fractal consisting of flux tubes inside flux tubes with flux tubes associated with the low frequencies containing those assigned to high frequencies. The quantization of magnetic flux is consistent with this mechanism. For B_{end} the flux tube thickness from the quantization of the magnetic flux would be about cell size, which looks natural. For larger values of $\hbar$ the natural quantization condition at the axonal level involves the currens at the boundaries of the flux tube generating the magnetic field. The flux tubes assignable to axons and other structures could fuse outside the body to larger flux tubes satisfying the standard quantization condition of magnetic flux and form flux tubes inside flux tubes.

4. If the magnetic field of Earth is used for place coding the distance to the flux tube would code for the frequency. This would however induce frequency dependent phase shift and distortion of spectrum. This suggests that endogoneus magnetic field -that is magnetic field assignable to personal magnetic body must be used. The most natural quanta are the flux tubes assignable to teh cell membranes.

4.5.3 The mystery of the fast transmitter

The extreme rapidity of the transfer of the postulated unidentified nerve transmitter from the hair cells to the nerve axons is a mystery.

1. The transmitter is not needed at all if Josephson radiation mediates the signal along the auditory pathways and possibly also re-generates the quale at neuronal level. This is certainly the most elegant solution of the mystery since Josephson radiation has also interpretation in terms of EEG and EEG correlates strongly with the contents of conscious experience. The chronic leakage of Ca^{++} wave would relate to the Josephson current and the related Josephson radiation would provides EEG representation of the quale.

2. Also microtubuli could mediate the information about evoked potentials at hair cell membrane to brain as microtubular conformal patterns and/or acoustic/electric waves. Acoustic and electric waves would be both present since microtubuli are electrets.

   (a) The transfer of auditory information from hair cells to postsynaptic neuron could occur also via acoustic transmission meaning that the time lag spent in this step would be of order $\sim .1$ ns only. The reported extreme sensitivity of of the axonal signal to the evoked potential (the resolution is about $\Delta V \sim .1$ mV) [36] conforms with the view that evoked potential provides a representation of the sensory input.

   (b) The representation and communication of acoustic signals at microtubular level could induce the coding of frequencies sufficiently below 1 kHz to spike interval distributions [58]. The obvious critical question is how badly nerve pulse disturbs microtubular communications. One might argue that these perturbations do not affect conformational waves. As proposed earlier, the microtubular conformational wave patterns could be responsible for long term memories for instance. Acoustic waves could fulfill the same function.

   (c) For this option the presynaptic dense body would be involved with the transformation of the temporal pattern represented by the time pattern of Ca^{2+} leakage to a signal propagating along the microtubule. Coupling to the microtubular conformational waves/acoustic signals could be also mechanical and the dense body could generate acoustic oscillations representing the temporal pattern of Ca^{2+} waves.

4.6 Music and consciousness

Music experience provides an interesting testing ground for several assumptions of quantum TGD and TGD inspired theory of consciousness. The notion of self is especially interesting in this respect.

4.6.1 Some aspects of music experience

It is good to list first some elementary characteristics of music experience that the model should be able to explain. Both rhytmic aspects and pitch of the sound are important. Rhytmic aspects correspond to time domain representation for the intentisity of sound carrying local information about sound wave whereas pitch carries global information. The relationship between these two elements of music is like that of function and its Fourier transform. Harmony enters the game when several frequencies are present.

Rhythm

There are two basic types of views about rhythm, additive and divisive, and they correspond to the multiplication and sum as basic arithmetic operations.

1. In western music rhythm corresponds to a division of longer periods of time divived into smaller rhytmic units. Rhythm is basically a clock and rhytm is essentially a decomposition of integer to a product of integers defining the rhythmic unit and their number. Classical western music is relatively simple rhythmically (consider only the music of Bach). In the music of Chopin tempo rubato makes the duration of the basic rhythmic unit and of its basic structural elements dnamical but rhythms are still relatively simple altough simultaneous 3/4 and 3/8+3/8 appears often. In jazz and various forms of popular music rhythms tend to be highly clocklike but are very complex.

2. In Indian music for instance, rhytms are additive and larger periods of time are constructed from smaller rhythmic unis added to the end of the previous unit. This division corresponds to addition rather than multiplication algebraically. Also intermediate forms can appear and do so often in folk music (say folk music of Greece, Balkan, and Spain). For instance, one can have the sum of 3/4+3/8+3/8 as a repeating rhytmic unit. In flamenco form known as Bulerias [50] the basic rhytmic unit consists of 12 beats and the collective performance creates a very complex and emotionally catching rhythm, which is almost impossible to analyze to pieces. It is easy to believe the claim that artists often fall in trance during the flamenco sessions.

Pitch

Pitch can be identified as the fundamental frequency of note. Pure sine wave is aesthetically unpleasing and harmonics are always present and characterize the music instrument. Not only frequencies but also phase relationships between them are important. For instance, they distinguish between the phonemes of spoken language and in the case of singing this brings in an important additional element not so important for non-electronic instrumental music. Furthermore, melody is never a mere sequence of precisely defined frequencies. For instance, slow modulations of the pitch reducing mathematically to a superposition of closely separated frequencies and glissandos have emotional affect.

The model of music experience should explain also the following aspects related to pitch understand as fundamental frequency.

1. Octaves of the fundamental are experienced as equivalent. The presence of higher harmonics is needed to make pure sinus wave a musical note. Higher harmonics determine the character of the pitch chracterizing the music instrument.

2. There exists a large number of different scales to which one assigns attributes like diatonic, minor, chromatic, whole tone, pentatonic, diminished... All these scales have quite specific emotional coloring and they characterize different music styles. The minimum frequency interval corresponds to a minimal scaling of the frequency and depends on music style. Western classical music uses semitone as the basic unit correwponding to the scaling $2^{1/12}$ in equally tempered scale but also microintervals are used and the only limitation comes the from ability to discriminate between different frequencies. The scales have special notes such as tonic, supertonic, mediant, subdominant, dominant, submediant, subtonic with special roles in harmony. For instance, listener is often able to remember the basic scales even if the tonic of the scale has suffered several modulations during the music piece. Deviations from basic scale have important emotional effects (say in the case of minor scale).

3. Ancient mathematicians believed that the presence of rational multiples of fundamental frequencies are essential for harmony. It is possible to construct the basic scales involving only rational multiples of the fundamental in terms of selected harmonics. For instance, Pythagorean construction uses only powers of 3/2 and octaves to construct the basic scale (C,G,D,A,E,H,...). Although the pitch is distinguished only within a finite resolution and equally tempered 12-note scale uses only powers of $2^{1/12}$ of the fundamental, rational multiples of the fundamental might relate deeply to the basic physics of cognition and to the frequencies generated in brain as opposed to those used to produce the music.

4. The expectation of an engineer is that the transposition of the scale should not effect on the music experience and one could think that it could be done in a continuous manner. Many composers, for instances Sibelius, experienced different modes differently and as synesthetes assigned to them different visual associations. Many people are able to recognize the ratios of

notes but there is also the much rare phenomenon of absolute ear meaning that subject person is able to tell the pitch of the note directly. A synesthesia like phenomen is probably in question.

5. An interesting question the notion of absolute scale could make sense to some degree? The fundamental frequency of sound producing organs is 10 Hz and the region of audible frequencies begins at 20 Hz and consists of approximately 10 octaves. kHz frequency is the resonance frequence of head sized object and at this frequency the mechanism allowing to deduce the direction of sound source changes. The biological basis for this would be that 10 Hz and 1 kHz define fundamental biorhythms. The quantum physical basis for this could relate to the p-adic length scale hypothesis predicting that 10 Hz and 1280 Hz could correspond CDs of electron and quarks. To get a contact with concretia note that soprano C corresponds to 1046.50 Hz. Also the cyclotron frequencies assignable to various biologically important ions in endogenic magnetic fields could defined preferred scales. The A above middle C corresponds by convention to 440 Hz, which is integer multiple of 10 Hz but by pure convention and fifth octave of 8.175 Hz which is not too far from the lowest Schumann resonance. An interesting question is whether the transposition to a scale for which the fundamental is simple rational multiple of 10 Hz or lowest Schumann resonance might have some specific emotional effect.

Harmony and other collective aspects of music

Harmony relates closely to the interaction of different frequencies and is therefore one particular collective aspect of music experience.

In the terminology of physicists, harmony is a phenomenon of many particle physics with particles replaced notes of the scale and many-particle states with chords. Depending on the ratios of the frequencies certain chords are aesthetically pleasing and emotionally significant and there are also principles goverining aesthetically pleasing chord progressions. Harmony might be seen as the vertical aspect of the music whereas melody would correspond to horizontal one. Dissonance is the opposite of harmony and tritonus was forbidden in the early western music but is nowadays used to create tension. Polyphony -say in Bach's music- and simple chords used to accompany singing represent two opposite views about harmony. Chopin's music has especially rich harmonies and emotional expressive power.

While listening music one typically selects some instrument as figure and the rest as a background. In romantic piano concertos the competition between the solist and orchestra about the attention of the listener creates the basic tension. In polyphonic music one must also select the tone progression to which attention is directed and it is difficult -perhaps even impossible- to simultaneously grasp the separte tone progressions. Same applies to other elements of music.

4.6.2 Zero energy ontology, hierarchy of Planck constants, and number theoretic physics

The number theoretic vision brings interesting new physics elements which might help to understand music experience.

1. The hierarchy of selves has as an imbedding space correlate the hierarchy of CD is basic prediction. p-Adic length scale hypothesis suggests that quantization of size scales of CDs as octaves and the question is whether this relates directly to the preferred role of octaves in music experience. The time scales of CDs define preferred fundamental frequencies coming as octaves and the hierarchy of Planck constants defines scaled variants of these as rational or integer multiples (depending on generalization of the imbedding space).

2. The question is whether these fundamental frequencies also define fundamental keys so that music experience would depend on absolute frequency scale. Even if CDs define fundamental keys, the frequency scale associated with sub-CD as experienced in the rest system of CD can be scaled continuously by performing a Lorentz boost for CD. Even glissando could be achieved for CD by performing to the sub-CD a Lorentz boost continuously and leaving the other tip of CD invariant. The boost would be the hyperbolic analog of an ordinary rotation and act like acceleration from rest to constant velocity inside sub-CD. If one takes this picture seriously also Lorentz boosts would be important part of the representation of music at the level of magnetic body (presumably using MEs). Quantum TGD proper suggests the quantization of these boosts.

3. Number theoretic vision predicts an infinite number of algebraic extensions of p-adic numbers -in particular those corresponding to roots of unity. In the p-adic context the proper representation of sine waves requires the introduction of these algebraic extensions and the prediction is that rational multiples of the fundamental frequencies assignable to p-adic length scales should have a special role from the point of view of cognition.

   This might justify the belief that the notes of the scale should be expressible in the optimal situation as rational multiples of the fundamental note. The cognitive representation of the music in the intersection of real and p-adic worlds should map the physical frequencies or rather the sine waves at a discrete set of time values to their p-adic counterparts. One has to deal with phase factors defined by plane waves $exp(ift_n)$ at discrete set of points t_n such that the exponent equals to $exp(i2\pi m/N)$ and belongs to the algebraic extension. The harmonics of f obviously satisfy the same condition. The representation of pitch in terms of algebraic extensions of rationals requires that the corresponding partonic 2-surfaces correspond to complex enough algebraic extensions of rationals containing high enough roots of unity. The modulation of the pitch as superposition of two nearby rational frequencies could is possible without leaving this framework.

4. One can consider also different but not exclusive explanation for why scales define preferred collections of frequencies. Pythagorean scale involves rational multiples of fundamental obtained as powers of 3/2 and 2 so that the frequencies involved correspond to rationals of form 3^m2^n for which only 3-adic and 2-adic norms differ from one. Small-p p-adicity associated with $p = 2$ and $p = 3$ could select the preferred frequencies.

4.6.3 Why octaves are experienced similarly?

The model should explain the basic features of music experience. There are many interesting questions related to this. One of the most important is why frequencies which are 2^k- multiples of the fundamental frequency, notes differing by octaves, are experienced as identical notes.

1. p-Adic length scale hypothesis, zero energy ontology, and octaves

Thus the phenomenon of octaves could relate to the p-adic length scale hypothesis, which implies that physically preferred p-adic primes correspond to primes near prime power powers of two. For instance, this implies that the massless extremals (MEs) associated with physically important p-adic primes have fundamental frequencies which are octaves of each other. Therefore a classical resonance via the formation of join along boundaries bonds becomes possible and real space-time sheets corresponding to preferred p-adic primes can form larger resonant structures. This universal resonance could explain why octaves are experienced similarly. The problem of this argument was that primary p-adic time scales would come as half octaves instead of octaves.

Octaves seem to have much deeper significance than I thought originally and seem to emerge at the level of fundamental formulation of quantum TGD rather than characterizing only a very special kind of sensory experience. In the recent formulation of quantum TGD using zero energy ontology [17, 16] one uses zero energy states which have their positive and negative energy parts at the light-like boundaries of causal diamonds consisting of future and past directed light-cones.

Physics as a generalized number theory vision, in particular the assumption that real physics and various p-adic physics result as algebraic completions of rational physics, motivates the hypothesis that the temporal distance T between the tips of the causal diamond is quantized and corresponds to powers of 2 using time scale defined by CP_2 size as a basic unit. This assumption allows to deduce p-adic length scale hypothesis ($p \simeq 2^k$, k integer), and to identify T as a secondary p-adic time scale. For electron this time scale is .1 seconds and corresponds to the fundamental 10 Hz biorhythm. For non-standard values of Planck constant T is scaled by a factor $\hbar/\hbar_0$. Thus octaves become a key element of fundamental physics. One can say that causal diamonds as space-time correlates of self appear naturally as octaves. Also rational multiples of fundamental frequency emerge via the hierarchy of Planck constants: in principle all rational scalings of the basic hierarchy are allowed.

2. Is sensory experience 2-adic in some sense?

A stronger hypothesis for the phenomenon of octaves is that cognitive music selves are 2-adic or that real music selves can transform easily to 2-adic selves. One might even consider the possibility that the phenomenon is much more general. Music metaphor has indeed turned out to be of crucial importance for the theory of qualia. Thus music metaphor could reflect the underlying 2-adicity of the sensory experience (at some level of self hierarchy). Perhaps at least some aspects of our experience result from a mimicry of the lowest level of the p-adic self-hierarchy. Taking 2-adicity seriously, one is forced to ask for the possible consequences of 2-adicity. For instance, could it be that at the level of primary qualia the intensity of sensation as function of stimulus depends on the 2-adic norm of the 2-adic counterpart of the stimulus and is thus a piecewise constant function if sensory input?

An observation supporting this speculation is following. When overlearning occurs in tasks involving temporal discrimination, the intensity of sensation as a function of stimulus deviates from smooth logarithmic form in small scales by becoming piecewise continuous function [49] such that the plateus, where response remains constant are octaves of each other.

This observation suggests a generalization inspired by 2-adic version of music metaphor. Primary quale has a multiple of cyclotron frequency as its correlate and, being integer valued, is essentially 2-based logarithm of the 2-adic norm for the 2-adic counterpart of the intensity of the sensory input. Hence the increase of intensity of the sensory input by octave correspond to a jumpwise replacement of the n:th harmonic by $n+1$:th one and should be seen in EEG. Our experience usually corresponds to the average over a large number of this kind of primary experiences so that underlying 2-adicity is smoothed out. In case of overlearning or neurons involved act unisono and the underlying 2-adicity is not masked anymore.

At the level of MEs this would mean generation of higher harmonic when the number of nerve pulses per unit of time achieves threshold value allowing the amplification of corresponding frequency by the mechanism discussed already earlier. This certainly would mean that cognition is an important part of music experience. The strongest assumption is that the real note selves are able to transform to 2-adic selves by a phase transition changing local topology from real to 2-adic. Note however that p-adic length scale hypothesis might be enough.

4.6.4 Does harmonic complexity reduce to 3-adicity?

An interesting question relates to the conditions guaranteing that a chord is experienced as harmonious in the Pythagorean sense [34]. Pythagorean tuning is based on the notion of perfect fifths identified as scalings by 3/2 producing the sequence C,G,D,A,E,.. In this tuning major-C scale corresponds to ratios $C=1/1, D=9/8, E=81/64, F=4/3$, $G=3/2, A=27/16, B=243/128, C=2/1$. E_b and $F_{\#}$ correspond to ratios $2^5/3^3$ and $3^6/2^9$. All notes are expressible as powers of two and three. Since the multiplication of any note by a power of two does not affect the harmony it should be to drop the powers of two from the integers characterizing the notes in the ratio of three notes. For instance, C-E-G reduces $3:3^4:1$, $C-E_b-G$ to $3^4:1:3^3$, and tritonus $C-E_b-F_{\#}$ to $3^9:1:3^3$. The problem of Pythagorean tuning is that one cannot represent 2 as an exact integer power of 3/2 and the scalings give infinite number of tones. If the construction starts from G_b then $F_{\#}$ and G_b correspond to frequencies, which are not quite identical in Pythagorean tuning. One could make compromize by introducing the geometric mean of $F_{\#}$ and G_b but this would bring in $\sqrt{3}$ and would force to leave the world of pure rationals. For string instruments and electronic instruments the Pythagorean tuning is practical but for instruments like piano the transposition of the scale is impossible.

One should be able to characterize a given chord harmonically by a function $F(a,b,c)$, which is symmetric under the permutations of the reduced pitches a,b and c obtained by dropping powers of two and is invariant under over all scaling of the reduce frequencies. The elementary symmetric functions $F(a,b,c)=[a^2(b+c)+b^2(a+c)+c^2(a+b)]/abc$ and $G(a,b,c)=[a^3+b^3+c^3]/abc$ are the simplest functions of this kind. Either of these functions or their product or ratio could be considered as a measure for the harmonic complexity. The value of the denominator abc equals to 3^n, $n=3,7,12$ in the cases considered. The numerator has in all cases 3-adic norm equal to one for both F and G. This suggests that the 3-based logarithm of the 3-adic norm $1/|abc|_3=|F|_3=|G|_3$ having the values 3,7, and 12 for C-major, C-minor, and tritonus could serve as the measure for the complexity. It is indeed smallest for major and largest for tritonus. 3-adic norm for the product $1/a_1a_2...a_n$ of n notes of the chord defines a measure of complexity in more general case. A good guess is that the 3-adic norms of the elementary symmetric functions give rise to the same measure.

For the chords C-E-G, F-A-C, and G-H-D appearing as basic chords in C- major scale the values of the harmonic measure are 3, 2, and 8. This means that the basic chords are not harmonically equivalent in Pythagorean system whereas in equally tempered system they would be. One might think that this explains why the tonic is remembered. The anomalously low value for F-A-C relates to the fact that it is only tone for which the power of 3 is negative. Situation changes of F is identified as a minimal power of 3 giving F equivalent with Pythagorean F within the resolution of ear to pitch which is about $|\Delta f/f| = 4.3$ per cent . $F = 3^5/2^8$ gives $|\Delta f/f| = 4.8$ per cent. This F would give for F-A-C the harmonic measure 8 which equals to that for G. This looks more reasonable than the purely Pythagorean value. This definition would also allow to find a unique choice of powers of three for 12-chord system. For instance, $F_{\#}$ is favored over G_b since it corresponds to a positive power of 3.

4.6.5 The notion of self and music

The music experience allows also to test the ideas related to the notion of self.

1. Summation hypothesis states that self is a sum of abstracted experiences of sub-selves and thus representing kind of averages about the experiences of sub-sub-selves.

   (a) The conscious experience induced by music decomposes in a clear manner to basic elements identifiable as subselves. For instance, melody and more generally various tone progressions could define such subselves and the experiences of these subselves would sum up to music experience. In the same manner rhytmic patterns define their own subselves. Therefore it might make sense to speak about "frequency subselves" and "rhythm subselves".

   (b) At space-time level the magnetic body and massless extremals (MEs) are the natural candidate for the representation of "frequency subselves". One can say that MEs provide a universal music instrument at the level of magnetic body since they allow arbitrary superposition of collinear waves proceeding in the same direction which is non-dispersive (shape of the pulse is preserved) so that arbitrary harmonics are possible for a ME with fixed length. Maybe the temporal duration of subselves assignable to MEs is what distinguishes between these representations.

   (c) A collection of subselves associated with ME at precisely defined periodically appearing positions could define rhythm whereas frequency selves would correspond to MEs with relatively long temporal duration. Interpreting MEs in terms of communications to the magnetic body, one expects that the rhythm automatically generates short-lasting MEs communication the pulses defining the rhythm to the magnetic body whereas pitch corresponds to long lasting MEs.

   (d) This picture challenges the assumption that the mental images created during music experience are localized to brain. Rather, MEs and magnetic body would be the carriers of the mental images. Maybe one could say that nerve pulse patterns induce these MEs. In left hemisphere nerve pulse patterns induced by the beats of rhythm and having a total duration considerably below .1 second would send single ME to the magnetic body. In right hemisphere the pulse patterns would integrate to single ME having duration of the note.

2. The hypothesis that entanglement creates wholes from parts and that there are three cognitive modes corresponding to reductionistic and holistic cognition and their hybrid based on negentropic entanglement is of special interest in the context of music experience.

   (a) Even admitting the dangers of naive right-left thinking it would seem natural to assign the rhythmic aspects of the music to the reductionistic regions of brain and various aspects related to pitch to the right brain hemisphere. At least in the latter case MEs are highly suggestive as a fundamental representation of music at the level of magnetic body. Perhaps music experience actually involves in a very essential manner also magnetic body. That "eastern" music favors additive instead of divisive rhythm could be understood as higher right brain dominance. The extremely mechanical rhytms characterizing the popular music today, the lack of melodic aspects, and the use of the volume of music as the basic means to induce emotional effect, could in turn interpreted in terms of extreme left brain dominance.

   (b) Music can have a strong emotional effects and this allows to test the hypothesis that the character of entanglement correlates with the emotional color. Maybe just the fact that these emotions are enjoyable irrespective of whether they are sad or joyful and have an undeniable healing effect can be interpreted in terms of the presence of the negentropic entanglement. For instance, the ability of good music to generate vibrations in spine could relate to this negentropic aspects. Music as purely intellectual experience could induce essentially an analysis of what was heard based on the use of holistic-reductionistic dichotomy. Chopin's music has especially strong healing effect. Tempo rubato might reflect the profound integration of rhytmic aspects, melodic, and harmonic to single organic whole both at the level of representation and music experience.

3. The model of subjective memory and the new view about time might be relevant for the understanding of how the basic key of the music piece can be remembered. If conscious experience for a given self is about the space-time region defined by corresponding CD, one could understand how Mozart was able to experience the entire composition as a single whole. If the music piece defines in the ideal case the fundamental CD inside which the sub-selves representing the elements of the music oiece reside, this CD could also define the fundamental "key " and would be more or less sensorily experienced and need not even to be remembered. This would explain why the return to the original key in classical is so important to relieve the tension created by modulations.

4.6.6 Harmony and self-organization

The phenomenon of harmony should be somehow related to quantum self-organization: perhaps the often used metaphor of harmonious co-existence could be turned around. Various notes correspond to sub-selves in the population of sub-selves and it might be that self-organization favours simultaneous conscious existence of sub-selves corresponding to subsets of frequencies defining basic chords. One could even consider some kind of co-operation between the frequency selves belonging to same basic chord.

The simplest model for the phenomenon of harmony relies on the identification of the chords as 'chord selves' formed by entangled 'note selves' consisting of negentropically entangled 'frequency selves'. The listener is self having as sub-selves (mental images) note selves and chord selves which correspond to the same level of the self hierarchy. The entanglement between note selves could occur even at the level of ear between the mindlike space-time sheets sensitive to various frequencies. Topologically it would correspond to the formation of magnetic flux tubes between corresponding partonic 2-surfaces. The ability of the 'note selves' of the chord to have stable flux tube bonds between themselves should depend crucially on the fact that the frequencies of the notes of the basic chords have simple rational ratios so that the oscillations involved are commensurate and match together. Hence a resonance phenomenon ins spirit of classical physics involving rational ratios of frequencies would be in question. During listening the chord self continually decomposes into sub-selves when listener consciously concentrates attention to some notes in the chord.

The ability of the music to occasionally create thrills in spine could correspond to whole-body consciousness in unusually large length scale. Note the this scale could correspond also to the secondary time length scale assignable to CD. It presumably involves a resonant fusion of also other than note sub-selves to larger negentropic sub-selves by the formation of stable join along boundaries bonds identifiable as magnetic flux tubes. The ability of certain sounds ('Om') to promote the emergence of whole-body consciousness could be due to the ability to very effectively generate negentropic entanglement direction. Perhaps the frequency spectrum of 'Om' contains resonant frequencies of several sub-selves and induces large sub-selves. Also the healing effect of music and sounds could rely on this mechanism.

Focusing attention to some instrument producing melody creates kind of figure-background relationship. This requires that entire instrument playing the melody is represented by 'instrument self'. An interesting possibility is that various instruments give rise to their own ensembles of frequency-selves. Note that the model makes it easy to understand why experienced performance is not simply the sum of invidividual performances. Music experience is a complicated self-organization process in which parts compose to wholes by quantum entanglement and vice versa according to how the listener directs his/her attention.

4.6.7 Absolute ear

Absolute ear means the existence of a preferred hardwired scale and ability to associate to the heard notes their names. Transposing an instrument is painful for an instrumentalist with perfect pitch since the notes she's playing are not the ones she's hearing.

Musicians with absolute ear can even decompose sounds that are usually regarded as a noise to a collection of notes with well-defined pitches. Obviously absolute ear means a well-developed ability of some part of brain to perform a Fourier analysis for the incoming sounds. It is known that the temporal planum part of the cortex is much more developed on the left side than on the right side for people with absolute ear [39]. The larger size of left temporal planum correlates also with right-handedness so that "absolutists" might be more strongly righthanded than usual. The increased size of the left temporal planum is also involved with reading: people with dyslexia tend to lack temporal planum asymmetry [35].

Perhaps the left temporal planum of the "absolutist" automatically assigns to the heard notes a symbolic representation as written notes. If only right brain hemisphere performs the Fourier analysis, this would require right-left communication which could be also carried out via the magnetic body inducing generalized motor action associating to the pitch pattern heard by right magnetic body their names in left temporal planum.

One can however imagine much simpler mechanism. During the recognition task the left temporal planum could simply send Josephson radiation from the points representing the names of notes to the right magnetic body at the frequency of the note in question. The recognition of the note would be based on resonance with the Josephson signal coming from the signal representing the music percept. This would also allow to detect dissonance. The inability to adapt to a new scale would be due to the fact that the Josephson frequencies in the left temporal planum are hard wired.

4.7 Logic, fermions, and language

The state basis for the fermionic Fock space has a natural interpretation as a Boolean algebra (fermion number =1/0$\leftrightarrow$ yes/no). In this manner ordinary Boolean algebra is extended to vector space spanned by fermionic states. When cognitive fermion pairs are used instead of fermions, fermion number conservation does not pose any constraints and full linear superposition of the Boolean algebra elements is possible. An interesting question is whether one could consider ordinary Boolean logic as some kind of limit for the complex quantum logic.

The simplest TGD based model for thinking systems leads to the result that thoughts correspond to quantum states in discrete spaces. The reason is that slightly non-deterministic classical time evolution means a finite number of multi-furcations. These additional dynamical degrees of freedom correspond to N-element set labeling the different time evolutions associated with given initial values. This suggests that a suitably defined *binary* Hilbert space having Z_2 rather than complex numbers as a coefficient field could provide a simple quantum model for a thinking system. This raises the following question.

What would a quantum field theory in discrete space and with the field of complex numbers replaced with binary numbers Z_2 (0,1/Yes,No) look like?

The answer is following.

1. The state basis of the quantum field theory defined in N-element set is nothing but a Boolean algebra consisting of 2^N elements: all possible statements about the N elements interpreted as propositions! Bosons and fermions are one and the same thing and behave like fermions since occupation number can have only the values 0 and 1.

2. The requirement that triangle equality for the inner product is satisfied, does not allow linear superposition and one must choose some orthogonal basis for the space. The absence of quantum superposition means that theory is completely classical. Thus it seems that Boolean QFT is completely classical and the transition from classical mechanics to quantum theory could be regarded as a transition from binary QFT to complex QFT or from a binary logic to complex logic.

3. Quantization means construction of statements about statements: the simplest model for an abstraction process one can imagine! One can of course continue this quantization: second, third, etc., quantization is possible and this corresponds to a construction of statements about statements about..... Hence a direct connection with the ideas about genetic code emerges.

4. Also the state basis in the Fock space of the ordinary fermions has interpretation as a Boolean algebra, all possible statements about some propositions (particle with a definite spin component is at point x).

4.7.1 The state basis of fermionic Fock space as Boolean algebra

The state basis of a fermionic Fock space can be interpreted as a basis of a Boolean algebra. In quantum TGD all elementary particles are constructed using fermionic oscillators operators. This suggests that entire quantum field theory is actually a representation of Boolean algebra and N-fermion states have interpretation as statements about basic propositions labeled by the indices labeling fermionic oscillator operators. In particular, configuration space spinor structure is constructed in terms of the fermionic oscillator operators for the second quantized spinor fields on space-time and this suggests a deep connection between spinor geometry and logic. Perhaps one could say that quantum logic is C-valued in the sense that all complex superpositions of a statement and its negation are possible.

In Boolean algebra one can select the maximum number of 2^{N-1} mutually consistent statements as axioms. An interesting possibility is that only these mutually consistent statements are physically realized so that the number of states is reduced by a factor of one half. Amusingly, in the ordinary fermionic field theory the states created by a finite number of oscillator operators are the counterparts of the mutually consistent statements, their negations would correspond to a vacuum state obtained as an infinite product of all creation operators annihilated by creation operators. The states created by annihilation operators from this states are not allowed in QFT since they would have infinite energy.

One can identify the complex valued linear space of fermions as a generalization of Boolean algebra to complex Hilbert space. Cognitive fermion pairs could provide realization for this space as pairs of fermion and antifermion belonging to different space-time sheets and representing logical statement and its negation: the automatic presence of negation is rather natural from the point of view of consciousness theory. The splitting of the wormhole contacts connecting the space-time sheets gives rise to annihilation process generating fermion and antifermion pair (fermionic quantum numbers reside on the boundary components of the split wormhole contact). In this manner one avoids problems related to fermion number conservation encountered otherwise in physical realization of the fermionic logic. Alternative possibility is to assume fixed number of fermions and associate truth values with the direction of spin.

4.7.2 Boolean algebra as Boolean QFT

Boolean algebra $B(N)$ is generated by all possible yes/no statements about N propositions. It consists of sequences of N binary digits of form $(...,1,0,0,..,1)$ having value of 0 or 1. Addition is with respect to Z_2 so that $1+1=0$. Boolean algebra is Z_2 linear space and the elementwise multiplication of the binary digits in the string makes it algebra. $(0,0,0,..)$ and $(1,1,....,)$ are zero and unit elements of the algebra.

Geometrically Boolean algebra $B(N)$ corresponds to all possible subsets of an N-element set. Sum corresponds to a symmetric difference (take the union of sets and throw away the common elements). Multiplication corresponds to the intersection of the sets. Entire set represents unit element and empty set zero. Empty set is not physically realizable, or equivalently, the zero element of the Boolean algebra does not correspond to a physical state in the Z_2 Hilbert space defined by the Boolean algebra.

Quantum field theory in N-element set formed by the basic propositions (analogous to 3-space in QFT) means associating to each element of the N-element set creation and annihilation operators and postulating standard commutation relations with them:

$$[a^\dagger(i), a(j)] = 1 \quad .$$

One can also consider fermions that is anticommutation relations but since -1=1 in Boolean algebra, they are equivalent with the bosonic commutation relations so that Boolean bosons and fermions are one and the same thing in the Boolean QFT.

The states of this QFT are constructed in the usual manner. The only difference is the occupation numbers are Z_2 valued and are either one or zero just as in the case of fermions. Thus Boolean particles are fermions always. Since N creation operators are involved one obtains a space generated by 2^N states. The proposition and its negation correspond to the states created by, say I oscillator operators and the dual of this state created by the remaining $N-I$ oscillators operators. Statement corresponds to I particles and its negation to I holes in the dual ground state containing all N oscillator operators.

Thus the state basis is nothing but the Boolean algebra associated with the N element set! Thus the state basis of Z_2 valued quantum field theory in the set of N propositions is nothing but the formation of all possible statements about these statements: a model for abstraction process. One can apply this process to the 2^N-1 element set and by continuing this process get a sequence of second quantizations as a sequence of abstractions.

The assumption of unrestricted linear superposition in Z_2 Hilbert space leads to difficulties with Schwartz and triangle inequalities. The physical interpretation of the theory requires that inner product satisfies Schwartz inequality

$$|(x,y)| \leq |x||y| \ .$$

Linear superposition allows states, say y, with zero norm since any superposition of even number of orthonormal states has zero norm in Z_2. The norm of the inner product of one of the basis states appearing in zero norm state, call it x, with the zero norm state y equals to one and is not smaller than the product of the norm of the basis state and state with vanishing norm: one obtains $1<0$, which does not make sense if inner product is interpreted as real number (as a Z_2 valued number one could perhaps say $1=-1<0$). One ends up to difficulties also with the triangle inequality: $|x+y| \leq |x|+|y|$ if x and y are zero norm states with single common element of orthonormal basis so that one has $|x+y|=1$.

The only possible manner to save Schwartz and triangle inequalities is to assume that linear superposition is not allowed for Z_2 Hilbert space. This in turn means that situation is completely classical! If the set generating Boolean algebra consists of entire 3-space, this means that every state is gauge equivalent with an N-particle state of completely localized particles. This in turn implies that Boolean QFT should be more or less equivalent with classical mechanics and one could understand the transition from classical physics to quantum physics as the replacement of Z_2 with complex numbers C as the coefficient field of the state space.

One can change state basis by unitary transformations. Unitary matrices are obtained from orthogonal Z_2 valued unit vectors possessing entries equal to 1 or 0. Any unitary matrix corresponds to a matrix representing the permutation of 2^N elements of the basis of the Boolean algebra. Time development operator in this quantum field theory is always defined for a *finite* time interval only (the length of the 'chronon' is fixed naturally in p-adic QFT) and represents a permutation of this basis. In particular, a nonlinear transformation of the oscillator operators in general occurs. All unitary transformations are permutations, which do *not* lead to state basis involving superpositions of the basic states. This is in accordance with the observation that Boolean QFT is completely classical.

4.7.3 Fermions, zero energy ontology, and Boolean cognition

Fermionic Fock state basis defines naturally a quantum version of Boolean algebra. In zero energy ontology predicting that physical states have vanishing net quantum numbers, positive and negative energy components of zero energy states with opposite fermion numbers define realizations of Boolean functions via time-like quantum entanglement. One can also consider an interpretation of zero energy states in terms of rules of form $A \rightarrow B$ with the instances of A and B represented as elements Fock state basis fixed by the diagonalization of the density matrix defined by $M-$-matrix. Hence Boolean conciousness would be basic aspect of zero energy states. Physical states would be more like memes than matter. Note also that the fundamental super-symmetric duality between bosonic degrees of freedom (size and shape of the 3-surface) and fermionic degrees of freedom would correspond to the sensory-cognitive duality.

This would explain why Boolean and temporal causalities are so closely related. Note that zero energy ontology is certainly consistent with the usual positive energy ontology if unitary process U associated with the quantum jump is more or less trivial in the degrees of freedom usually assigned with the material world. There are arguments suggesting that U is tensor product of of factoring S-matrices associated with 2-D integrable QFT theories [16]: these are indeed almost trivial in momentum degrees of freedom. This would also imply that our geometric past is rather stable so that quantum jump of geometric past does not suddenly change your profession from that of musician to that of physicist. The maximal diagonality of U-matrix for p-adic-to-real transitions would in turn favor precise realization of intentions as actions. One must however take this kind of arguments with extreme caution.

4.7.4 Negentropic entanglement, fuzzy logic, quantum groups, and Jones inclusions

Matrix logic [27] emerges naturally when one calculates expectation values of logical functions defined by the zero energy states with positive energy fermionic Fock states interpreted as inputs and corresponding negative energy states interpreted as outputs. Also the non-commutative version of the quantum logic, with spinor components representing amplitudes for truth values replaced with non-commutative operators, emerges naturally. The finite resolution of quantum measurement generalizes to a finite resolution of Boolean cognition and allows description in terms of Jones inclusions $\mathcal{N} \subset \mathcal{M}$ of infinite-dimensional Clifford algebras of the world of classical worlds (WCW) identifiable in terms of fermionic oscillator algebras. $\mathcal{N}$ defines the resolution in the sense that quantum measurement and conscious experience does not distinguish between states differing from each other by the action of $\mathcal{N}$.

The finite-dimensional quantum Clifford algebra $\mathcal{M}/\mathcal{N}$ creates the physical states modulo the resolution. This algebra is non-commutative which means that corresponding quantum spinors have non-commutative components. The non-commutativity codes for the that the spinor components are correlated: the quantized fractal dimension for quantum counterparts of 2-spinors satisfying $d = 2cos(\pi/n) \leq 2$ expresses this correlation as a reduction of effective dimension.

The moduli of spinor components however commute and have interpretation as eigenvalues of truth and false operators or probabilities that the statement is true/false. They have quantized spectrum having also interpretation as probabilities for truth values and this spectrum differs from the spectrum $\{1, 0\}$ for the ordinary logic so that fuzzy logic results from the finite resolution of Boolean cognition [22].

4.7.5 Cognitive codes and fermions

p-Adic length scale hypothesis leads to the idea that each $p \simeq 2^k$, k integer, defines a hierarchy of cognitive codes with code word having duration given by the n-ary p-adic time scale $T(n, k)$ and number of bits given by any factor of k. Especially interesting codes are those for which the number of bits is prime factor or power of prime factor of k. $n = 2$ seems to be in special position in zero energy ontology. This is a strong quantitative prediction since the duration of both the code word and bit correspond to definite frequencies serving as signatures for the occurrence of commutations utilizing these codes.

If k is prime, the amount of information carried by the codon is maximal but there is no obvious manner to detect errors. If k is not prime there are several codes with various numbers of bits: information content is not maximal but it is possible to detect errors. For instance, $k = 252$ gives rise to code words for which the number of bits is $k_1 = 252, 126, 63, 84, 42, 21_2, 9, 7, 6_2, 4, 3_2, 2$: the subscript $_2$ tells that there are two non-equivalent manners to get this number of bits. For instance, $126 = 42 \times 3$-bit codon can have 42 -bit parity codon: the bits of this codon would be products of three subsequent bits of 126-bit codon. This allows error detection by comparing the error codon for communicated codon and communicated error codon.

Mersenne primes are especially interesting as far as cognitive codes are considered the Mersenne prime M_{127} assignable to electron is of special interest since the corresponding time scale for CD is .1 seconds whereas the duration of bit corresponds to the time scale of 1 ms assignable to quark CDs.

Combinatorial Hierarchy as a hierarchy of 'genetic codes'

The simplest model for abstraction process is based on the process in which one forms first all possible Boolean statements about N basic statements, 2^N alltogether. If one drops one of the statements one has $M_N = 2^N - 1$ statements: M_N is Mersenne number. The motivation for the dropping of one statement might be that in set theoretical realization one of the statements corresponds to empty set and is not realizable. Alternatively, in the realization based on many-fermion states, vacuum state could correspond to this kind of state. One can form also statements about statements: the first level of abstraction. This leads to $M_{M_N} = 2^{M_N} - 1$ many-fermion states. Construction is especially intersting if the numbers $M(M_N)$ are primes, so called Mersenne primes. Indeed, in some cases one obtains hierarchies of Mersenne primes by repeating the construction as long as it works.

The so called Combinatorial Hierarchy, shown already earlier to provide an explanation for the numbers of the Genetic Code, emerges as the most notable hierarchy. The Combinatorial Hierarchy [26] consists of the Mersenne numbers $2, M(1) = 3, 7$,$127, 2^{127} - 1, ..$ constructed using the rule $M(n+1) = M_{M(n)} = 2^{M(n)} - 1$. The explicitely listed ones are known to be primes. Combinatorial Hierarchy emerges from a model of abstraction process as subsequent transitions from level to metalevel by forming Boolean statements about Boolean statements of level n and dropping one statement away and starting from $n = 2$ basic statements. Combinatorial Hierarchy results also by constructing the sets of all subsets with empty set excluded starting from two element set.

The set of statements at level n can be given a structure of Finite Field $G(M(n), 1)$ if $M(n)$ is prime. The multiplicative groups $Z_{M(n)-1}$ form a nested hierarchy and the coset spaces $Z_{k_n} \equiv Z_{M(n+1)-1}/Z_{M(n)-1}$ are cyclic groups. Combinatorial Hierarchy based model of Genetic Code explains the number of DNA:s and aminoacids and the representation of words of the GC as triplets of 4 different codons. Aminoacids correspond to $k_{n=3} = 21$ axioms of a formal system defined by $n = 3$ level of Combinatorial Hierarchy having a unique imbedding as the group $Z_{k_n} \subset Z_{M(n)-1} = Z_{126}$ and DNA:s correspond to the set $X_{N(DNA)} \subset Z_{M(n)-1}$ of $N(DNA) = (M(n) + 1)/2 = 64$ mutually consistent statements at level n regarded as special cases of general theorems. GC corresponds to the mapping $x \to x^{k_{n-1}} = x^6$ in $Z_{M(n)-1}$ mapping DNA type statements to aminoacid type statements. The numbers of DNA:s coding single aminoacid are reproduced in a symmetry breaking mechanism involving the finite groups $Z_{p_{n-1}}$ and Z_{k_n} and symmetry breaking is in a well defined sense minimal. The infinite hierarchy of possible genetic codes suggests the possibility of an infinite hierarchy of increasingly complicated lifeforms or forms of intelligence.

Boolean mind 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 $a \to b$ 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-CDs of electronic CD give to a realization of memetic code word as a sequence of 126 quark like sub-CDs. 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 o 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 [24, 17, 44].

How nerve pulse patterns and membrane oscillations could be coded to Boolean statements?

The original proposal for the realization of the memetic code was based on the notion of cognitive neutrino pair. Zero energy ontology however disfavors this identification since the time scale assignable to CD of neutrino is of order 10^4 years. Therefore neutrinos would most naturally correspond to a time scale of consciousness much longer than the time scale of .1 seconds predicted to be present. If the proposed view about cell membrane is correct, classical weak fields should be important within the Compton length of any particle and therefore the interactions of neutrinos with Z^0 fields should be important as also the large chiral asymmetry in living matter suggests.

The realization of memetic codewords in terms of sub-CDs assignable to u and d quarks look much more attractive option since they have time scale of 1/1.28 millisecond.

1. The bit would correspond to quark existing in this kind of sub-CD. Memetic codon would correspond to electron's sub-CD containing a row of 127 quark sub-CDs. Standard physics interpretation could be as quantum fluctuation generating virtual pair of quark and negative energy antiquark. For non-standard values of $\hbar$ the durations of codewords and bits would be scaled up.

2. The time-like row of quark sub-CDs resides in em (and possibly also Z^0) field associated with the cell membrane and having the direction of the axon. There is a time-like row of quark sub-CD at some points of axon with one sub-CD per millisecond time interval between sub-CDs. DNA as topological quantum computer hypothesis suggests that each lipid could correspond to quark sub-CD so that many-quark system would be in question. The minimization of the magnetic

energy for a given sub-CD fixes the direction of spin and one has spontaneous magnetization in the case that the direction of magnetic field inside quark sub-CD does not change during the pulse.

3. The time that it takes for a nerve pulse to traverse the point is slightly longer than millisecond. If the time which magnetic field has reversed direction is of order millisecond then the magnetic field experienced by quark can preserve its direction during the time interval that quark exists from the point of view of outsider. This is achieved if the temporal center of mass positions of the quark sub-CDs are given by $t_n = nz_0/v$, where z_0 is the distance between lipids containing quark sub-CD and the position of nerve pulse is given by $z = vt$, where v is the conduction velocity of nerve pulse. Unless this condition is satisfied, the direction of magnetic field changes during the time interval associated with sub-CD. In this case a superposition of bits identifiable as a qubit results.

4. This means that nerve pulse sequence defines a (qu-)bit sequence with the direction of spin telling whether there was nerve pulse present in particular sub-CD. The presence/absence of nerve pulse corresponds to true/false statement in accordance with neuro science intuition.

Memetic code, and genetic code as a representation of phonemes?

The average duration of phonemes is about 140 ms, which is by a factor $\sqrt{2}$ longer than the duration .1 seconds of the memetic codon. Durations vary in the range 60-300 ms. Note that the 250-300 Hz rhythm associated with speech organs defines the pitch of speech but phonemes can be recognized even in the absence of the fundamental. The basic pitch of about 250 Hz implies that the number of memetic codons associated single single period is at most 2.

Phonemes can be classified by the vocal tract mechanism generating them and phonemes can be also recognized by their spectral decomposition.

1. Formants [44, 33] correspond to vowels, approximants (say (r,l) and (j,w)) , and nasals (m and n). Only few resonant frequencies are needed to characterize the formant. Lowest formant is below 1 kHz but higher formants above kHz and frequencies up to 3 kHz are possible. It is easy to understsand that for vowels the frequency distribution does not depend on time for approximants and nasals it does.

2. Fricatives (hiss, buzz). Fricatives lack the formant structure. Both correspond to a repeated time amplitude peak and frequency distribution involves wide range of frequencies with same intensity.

3. Plosives (such as p,b and t,d) correspond to a single peak in the time domain and constant frequency distribution.

All sensory input might be transformed by a feedback circuit to sequences or notes/memetic codons represented as a modulation of the membrane voltage providing a universal cognitive/emotional representations. Also ordinary phonemes and notes would be represented in this manner.

Also other p-adic codes are possible. Phonemes, the number of which is 41 in American english, could correspond to a sub-code reducing to a genetic code with 64 codons. It is important to notice that the temporal distance between memetic codons does not matter. Other memetic codons could code for recognizable sound patterns not representing phonemes and could have meaning at some other levels of self hierarchy.

One can argue that the representations as "notes" and "phonemes" should carry roughly the same amount of information. For frequency representation as a sequence of "notes" 10 octaves represents upper limit for the modulation frequencies. For high modulating frequencies the representation tends however to fail since slow modulation is not anymore in question. This would mean that the number of distinguishable "notes" is below $10 \times N$, where N is the maximum number of distinguishable frequencies inside octave. $N = 12$, the number of half notes in octave, would give 120 different "notes", which is not far from 127 and corresponds to M_7 allowing $2^7 - 1$ different codons making almost 7 bits with bit duration of 67 ms. Since the first codon in pulse-no pulse representation must be always pulse to tell that the codeword starts, this leaves 6 bits and genetic code. Codons can have varying but long enough pauses between them and the average duration .14 s of phonemes allows this. The association of genetic or memetic codons to characteristic spectrograms of phonemes as a function of time and frequency would result by cortical feedback.

Bibliography

Books about TGD

[1] M. Pitkänen (2006), *Topological Geometrodynamics: Overview.*
http://tgd.wippiespace.com/public_html/tgdview/tgdview.html.

[2] M. Pitkänen (2006), *Quantum Physics as Infinite-Dimensional Geometry.*
http://tgd.wippiespace.com/public_html/tgdgeom/tgdgeom.html.

[3] M. Pitkänen (2006), *Physics in Many-Sheeted Space-Time.*
http://tgd.wippiespace.com/public_html/tgdclass/tgdclass.html.

[4] M. Pitkänen (2006), *p-Adic length Scale Hypothesis and Dark Matter Hierarchy.*
http://tgd.wippiespace.com/public_html/paddark/paddark.html.

[5] M. Pitkänen (2006), *Quantum TGD.*
http://tgd.wippiespace.com/public_html/tgdquant/tgdquant.html.

[6] M. Pitkänen (2006), *TGD as a Generalized Number Theory.*
http://tgd.wippiespace.com/public_html/tgdnumber/tgdnumber.html.

[7] M. Pitkänen (2006), *TGD and Fringe Physics.*
http://tgd.wippiespace.com/public_html/freenergy/freenergy.html.

Books about TGD Inspired Theory of Consciousness and Quantum Biology

[8] M. Pitkänen (2006), *TGD Inspired Theory of Consciousness.*
http://tgd.wippiespace.com/public_html/tgdconsc/tgdconsc.html.

[9] M. Pitkänen (2006), *Bio-Systems as Self-Organizing Quantum Systems.*
http://tgd.wippiespace.com/public_html/bioselforg/bioselforg.html.

[10] M. Pitkänen (2006), *Quantum Hardware of Living Matter.*
http://tgd.wippiespace.com/public_html/bioware/bioware.html.

[11] M. Pitkänen (2006), *Bio-Systems as Conscious Holograms.*
http://tgd.wippiespace.com/public_html/hologram/hologram.html.

[12] M. Pitkänen (2006), *Genes and Memes.*
http://tgd.wippiespace.com/public_html/genememe/genememe.html.

[13] M. Pitkänen (2006), *Magnetospheric Consciousness.*
http://tgd.wippiespace.com/public_html/magnconsc/magnconsc.html.

[14] M. Pitkänen (2006), *Mathematical Aspects of Consciousness Theory.*
http://tgd.wippiespace.com/public_html/mathconsc/mathconsc.html.

[15] M. Pitkänen (2006), *TGD and EEG.*
http://tgd.wippiespace.com/public_html/tgdeeg/tgdeeg.html.

References to the chapters of the books about TGD

[16] The chapter *Construction of Quantum Theory: S-matrix* of [3].
http://tgd.wippiespace.com/public_html/tgdquant/tgdquant.html#towards.

[17] The chapter *Construction of Quantum Theory: Symmetries* of [3].
http://tgd.wippiespace.com/public_html/tgdquant/tgdquant.html#quthe.

[18] The chapter *Was von Neumann Right After All* of [3].
http://tgd.wippiespace.com/public_html/tgdquant/tgdquant.html#vNeumann.

References to the chapters of the books about TGD Inspired Theory of Consciousness and Quantum Biology

[19] The chapter *Quantum Model of EEG* of [13].

http://tgd.wippiespace.com/public_html/tgdeeg/tgdeeg.html#eegII.

[20] The chapter *Quantum Model for Nerve Pulse* of [13].
http://tgd.wippiespace.com/public_html//tgdeeg/tgdeeg/tgdeeg.html#pulse.

[21] The chapter *Self and Binding* of [8].
http://tgd.wippiespace.com/public_html/tgdconsc/tgdconsc.html#selfbindc.

[22] The chapter *Negentropy Maximization Principle* of [8].
http://tgd.wippiespace.com/public_html/tgdconsc/tgdconsc.html#nmpc.

[23] The chapter *DNA as Topological Quantum Computer* of [12].
http://tgd.wippiespace.com/public_html/genememe/genememe.html#dnatqc.

[24] The chapter *Genes and Memes* of [12].
http://tgd.wippiespace.com/public_html/genememe/genememe.html#genememec.

Appendices and references to some older books

[25] M. Pitkänen (2006) *Basic Properties of CP_2 and Elementary Facts about p-Adic Numbers*
http://tgd.wippiespace.com/public_html/pdfpool/append.pdf.

Mathematics

[26] T. Bastin, H.P. Noyes, J. Amson and C. W. Kilminster (1979), Int. J. of Th. Phys. Vol 18, No 7, p. 445.

[27] A. Stern (1988), *Matrix Logic*. North-Holland.

Particle and nuclear physics

[28] D. T. H. Davies *et al* (2010), *Precise Charm to Strange Mass Ratio and Light Quark Masses from Full Lattice QCD*. Phys. Rev. Lett. 104, 132003. http://prl.aps.org/abstract/PRL/v104/i13/e132003.
A. Cho (2010), *Mass of the common quark finally nailed down*. http://news.sciencemag.org/sciencenow/2010/04/mass-of-the-common-quark-finally.html.

Biology related references

[29] F. A. Popp, B.Ruth, W.Bahr, J. Boehm, P.Grass (1981), G.Grolig, M.Rattemeyer, H.G.Schmidt and P.Wulle: *Emission of Visible and Ultraviolet Radiation by Active Biological Systems*. Collective Phenomena(Gordon and Breach), 3, 187-214.
F. A. Popp, K. H. Li, and Q. Gu (eds.) (1992): *Recent Advances in Bio-photon Research and its Applications*. World Scientific, Singapore-New Jersey.
F.- A. Popp: *Photon-storage in biological systems, in: Electromagnetic Bio-Information*. pp.123-149. Eds. F.A.Popp, G.Becker, W.L.König, and W.Peschka. Urban & Schwarzenberg, Muenchen-Baltimore.
F.-A. Popp (2001), *About the Coherence of Bio-photons*. http://www.datadiwan.de/iib/ib0201e1.htm.
F.-A. Popp and J.-J. Chang (2001), *Photon Sucking and the Basis of Biological Organization*. http://www.datadiwan.de/iib/ib0201e3.htm.
F.-A. Popp and Y. Yan (2001), *Delayed Luminescence of Biological Systems in Terms of States*. http://www.datadiwan.de/iib/pub2001-07.htm.

[30] Fröhlich, H. (1975) *The extraordinary dielectric properties of biological materials and the action of enzymes*. Proc. Natl. Acad. Sci. 72:4211-4215.
Ibid (1968), Int. J. Quantum Chem. 641-649.
Ibid (1970), Nature 316, 349-351.
H. Fröhlich and F. Kremer (1983), *Coherent Excitations in Biological Systems*. Springer Verlag, New York.

Neuroscience

[31] *Retinal Transduction: Hyperpolarization of Primary Photoreceptors by Ligh*. http://www.acbrown.com/neuro/Lectures/NrVisn/NrVisnRtnlHprp.htm.

[32] *Hair cell*. http://en.wikipedia.org/wiki/Hair_cell.

[33] *Formant*. http://en.wikipedia.org/wiki/Formant.

[34] *Pythagorean tuning*. http://en.wikipedia.org/wiki/Pythagorean_tuning.

[35] M. P. Bryden (1989), *The biology of reading*. http://www.chass.utoronto.ca/epc/srb/srb/reading.html.

[36] *Auditory system*. http://en.wikipedia.org/wiki/Auditory_system.

[37] O. B. Burchhardt (2003), *Spirals to Unravel a Mystery* essay by Olivier Burckhardt Quadrant No. 393, Vol. 47, pp. 71-78 & No. 394, Vol. 47, pp. 58-64. http://www.obfuchai.com/pages/spirals.html.

[38] *Missing fundamental*. http://en.wikipedia.org/wiki/Missing_fundamental.

[39] F. Ernould (2003), *The perfect pitch*. http://www.macmusic.org/articles/view.php/lang/EN/id/10/.

[40] *Color vision*. http://en.wikipedia.org/wiki/Color_vision.

[41] *Action potential*. http://en.wikipedia.org/wiki/Action_potential.

[42] P. Cariani (1995), *As if time really mattered: Temporal strategies for neural coding of sensory information*. Communican and Cognition-Artificial Intelligence (CC-AI), March, Vol 12, nos. 1-2, pp. 157-219.

[43] *Vestibular system*. http://en.wikipedia.org/wiki/Vestibular_system.

[44] T. Carmell, *Spectral Cues for the Broad Categories of Speech Sounds*. http://cslu.cse.ogi.edu/tutordemos/SpectrogramReading/ipa/ipahome.html.

[45] G. Cheron *et al* (2004), *Inactivation of Calcium-Binding Protein Genes Induces 160 Hz Oscillations in the Cerebellar Cortex of Alert Mice*. The Journal of Neuroscience, January 14, 2004, 24(2): 434-441.http://www.jneurosci.org/cgi/content/full/24/2/434.

[46] *Photoreceptor cell*. http://en.wikipedia.org/wiki/Photoreceptor_cell.

[47] *Cochlea*. http://en.wikipedia.org/wiki/Cochlea.

[48] *Hearing range*. http://en.wikipedia.org/wiki/Hearing_range.

[49] Geissler H.-G. (1997) , *Is there a way from behavior to non-linear brain dynamics? On quantal periods in cognition and the place of alpha in brain resonances*. International Journal of Psychophysiology 26, 381-393.

[50] *Bulerias*. http://en.wikipedia.org/wiki/Bulerias.

[51] J. P. Miller (1996), *Brain Waves Deciphered*. article about the work of Wehr and Laurent in Nature, vol 384 (14 November).

Consciousness related references

[52] A. K. Engel *et al*(2000) *Temporal Binding, Binocular Rivalry, and Consciousness*. http://www.phil.vt.edu/ASSC/engel/engel.html.

[53] A. R. Liboff (2009), *Electric Polarization and the Viability of Living Systems: Ion Cyclotron Resonance-Like Interactions*. Electromagnetic Biology and Medicine 1536-8386, Vol. 28, Issue 2, pp. 124-134.

Chapter 5

TGD Inspired Model for Nerve Pulse

5.1 Introduction

The model of nerve pulse has developed through several tortuous twists reflecting the development of the basic ideas of TGD inspired theory of consciousness and of bio-systems as macroscopic quantum systems. The chapters about EEG and ZEG provide a necessary background for the model of nerve pulse. The chapters [44] written before dark matter revolution provide a detailed discussion of basic aspects of EEG. The newest chapter [20] related to EEG provides a very general vision about the hierarchy of EEGs based on dark matter hierarchy and about its generalization to ZEG and even WEG (Z and W denote for dark Z^0 and W boson fields with interaction range which can be arbitrary long at higher levels of dark matter hierarchy). This model derives from the model of bio-superconductivity as quantum critical high T_c super-conductivity [29, 23]. The consistency with the model of DNA as topological quantum computer [28] poses additional strong constraints on the model.

The basic hypothesis has been that quantum jump takes the resting potential below the threshold for the generation of nerve pulse. One can imagine several manners for how this could happen.

1. The first idea was that axonal membrane acts as a Josephson junction and that a soliton propagating along it induces the nerve pulse. The model for the high T_c electronic superconductivity allowed to construct a detailed model for this Josephson junction and "timelike" and possibly also space-like soliton sequences are indeed present. Time-like soliton sequences however represent oscillations at a frequency of order 10^{13} Hz. For the scaled up dark matter variants of cell membrane Josephson junction at $k = 4$ level of dark matter hierarchy standing EEG waves at 5 Hz frequency can be identified as Josephson oscillations. It is however clear that moving solitons cannot correspond to nerve pulses.

2. The next working hypothesis was that massless extremals (MEs, topological light rays) carrying classical Z^0 fields drifting along axon induce the nerve pulse. It became clear that this model [46] cannot be the whole truth although a pulse propagating along MEs parallel to axon combined with drifting of ME cannot be excluded as initiator of the nerve pulse. In the recent model this idea is given up.

3. Dark matter revolution led to a much more elegant looking idea. Nerve pulse could be generated as the charged entanglement induced by W MEs connecting magnetic body and cell interior is reduced in a quantum jump leading to a state in which cell interior receives a positive exotic charge due to exotic ionization of a Bose Einstein condensate of the bosonic ions so that the value of the resting potential is reduced below the critical level. This process would occur only at the axonal hillock and one might hope that the rest would be more or less ordinary biochemistry. This need not be the case as the strange findings about ionic membrane currents discussed in [23] demonstrate. It turns out that exchange of W bosons could indeed be the primary cause of nerve pulse generation but that also other options are possible.

4. Quite recently I learned [67, 71, 60, 61, 58] (thanks to Ulla Mattfolk) that nerve pulse propagation seems to be an adiabatic process and thus does not dissipate: the authors propose that 2-D acoustic soliton is in question. Adiabaticity is what one expects if the ionic currents are dark currents (large $\hbar$ and low dissipation) or even supra currents. Furthermore, Josephson currents are oscillatory so that no pumping is needed. Combining this input with the model of DNA as topological quantum computer (tqc) [28] leads to a rather precise model for the generation of nerve pulse.

5.1.1 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 [71, 123] discussed in the article "Time, Space-time and Consciousness" in [49] and chapter [43].

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 fermonic 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.

5.1.2 A general view about quantum control, coordination and communication inspired by dark matter hierarchy

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 [20].

1. 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.

2. 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 serving as templates for axons and possibly other similar structures and define the communication lines connecting cell membranes to the magnetic body.

3. 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. 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.

4. 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 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 and exotic ion. The same can happen at the higher levels of dark matter hierarchy.

5. Massless extremals (MEs, topological light rays) serve as correlates for coherent states and Bose-Einstein condensates of dark bosons. Besides neutral massless extremals (MEs) TGD predicts also charged massless extremals obtained from their neutral counterparts by a mere color rotation (color and weak quantum numbers are not totally independent in TGD framework). The second nonlocal quantum control mechanism is based on em charge entanglement involving a superposition of 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. 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 [26].

6. These nonlocal quantal mechanisms can induce or change electromagnetic polarization in turn inducing ordinary charge flows and thus making 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. Also remote mental interactions, in particular telekinesis, might rely on this mechanism.

5.1.3 The role of electronic super-conductivity

General mechanisms of bio-superconductivity

The many-sheeted space-time concept provides a very general mechanism of superconductivity based on the 'dropping' of charged particles from atomic space-time sheets to larger space-time sheets. The first guess was that larger space-time sheets are very dry, cool and silent so that the necessary conditions for the formation of high T_c macroscopic quantum phases are met.

The possibility of large $\hbar$ quantum coherent phases makes however the assumption about thermal isolation between space-time sheets un-necessary. This isolation might of course be present and make possible ionic super-conductivity. At larger space-time sheet the interactions of the charged particles with classical em fields generated by various wormhole contacts feeding gauge fluxes to and from the space-time sheet in question give rise to the necessary gap energy. The simplest model for Cooper pair is space-time sheet containing charged particles having attractive Coulombic interaction with the quarks and antiquarks associated with the throats of the wormhole contacts.

A crucial element is quantum criticality predicting that new kind of superconductivity, "boundary superconductivity", appears at the fluctuating boundaries of competing ordinary and large $\hbar$ phases for nuclei besides large $\hbar$ variant of ordinary superconductivity in the interior. The Cooper pairs of interior and boundary supra currents are different with interior Cooper pairs being BCS type. These two superconducting phases compete in certain narrow interval around critical temperature for which body temperature of endotherms is a good candidate in the case of living matter. Also high T_c superfluidity of bosonic atoms dropped to space-time sheets of electronic Cooper pairs becomes possible besides ionic super conductivity. Even dark neutrino superconductivity can be considered below the weak length scale of scaled down weak bosons.

Magnetic c flux tubes and sheets are especially interesting candidates for dark supra current carriers and might define Josephson junctions. In this case the Cooper pairs must have spin one and this is indeed possible for wormholy Cooper pairs. The fact that the critical magnetic fields can be very weak or large values of $\hbar$ is in accordance with the idea that various almost topological quantum numbers characterizing induced magnetic fields provide a storage mechanism of bio-information.

This mechanism is extremely general and works for electrons, protons, ions, charged molecules and even exotic neutrinos and an entire zoo of high T_c bio-superconductors, super-fluids and Bose-Einstein condensates is predicted. Of course, there are restrictions due to the thermal stability it room temperature and it seems that only electron, neutrino, and possibly proton Cooper pairs are possible at room temperature. The effects of ELF em fields on vertebrates suggest that Bose-Einstein condensates of all bosonic ions and their exotic counterparts resulting when some nuclear color bonds become charged [36] are there but the model of high T_c super-conductivity does not favor them. It is of course possible that the temperature at dark magnetic space-time sheets is lower than at the visible space-time sheets.

Bose-Einstein condensates at magnetic flux quanta in astrophysical length scales

The new model for the topological condensation at magnetic flux quanta of endogenous magnetic field $B = .2$ Gauss is based on the dark matter hierarchy with levels characterized by the values of $\hbar r \hbar_0$ of Planck constant.

1. 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.

   The hypothesis that Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1 + i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241..\}$ (the number theoretical miracle is that all the four p-adic length scales sith $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm) define scaled up copies of electro-weak and QCD type physics with ordinary value of $\hbar$ and that these physics are induced by dark variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$, and the resulting picture finds support from the ensuing models for biological evolution and for EEG [20]. This hypothesis - to be referred to as Mersenne hypothesis - replaces the earlier rather ad hoc proposal $r = \hbar/\hbar_0 = 2^{11k}$ for the preferred values of Planck constant.

2. There are several levels of dynamics. In topological condensation the internal dynamics of ions is unaffected and $\hbar$ has the ordinary value. The formation of Cooper pairs involves dynamics at loweset levels of dark matter hierarchy. Also the dynamics of ionic Cooper pairs remains unaffected in the topological condensation to magnetic flux quanta obeying dark dynamics with large value of Planck constant.

3. Cyclotron energies scale as as $r = 2^{k_d}$ so that for a sufficiently high value of k_d thermal stability of cyclotron states at room temperature is achieved. Spin interaction energy $\mu \cdot B \propto S \cdot B$ scales

as $1/\hbar$ since four-momentum and angular momentum are by Poincare symmetry invariant under the scaling of $\hbar$ (the highly non-trivial implications of the invariance of angular momentum are discussed in [22]). Hence spin interaction energy has the ordinary value. Unless thermal isolation is assumed, spin degrees of freedom are thermalized, and only cyclotron degrees of freedom can be quantum coherent. This is a testable prediction distinguishing between the new and old model.

4. If the flux quanta of $B = .2$ Gauss correspond to $k_d = 44$ level of dark matter hierarchy, cyclotron energies $E = (\hbar/2\pi) \times ZeB/Am_p$ are scaled up by a factor $2^{k_d} \simeq 2^{44}$ from their ordinary values and are above thermal energy at room temperature for $A \leq 233Z$, where Z is the charge of the ion. Even for $Z = 1$ this includes all stable nuclei. Bose-Einstein condensates of bosonic ions are thus possible at room temperatures at Earth's surface.

Experimental evidence for bio-superconductivity

From the beginning it has been obvious that super-conductivity serves some important function in nerve pulse conduction. For instance, Josephson currents are optimal for quantal alarm clocks [44]. Already before the ideas inspired by the dark matter hierarchy the contact by Hafedh Abdelmelek and his group [107] led to a crucial step of progress in the understanding of this function. It became clear that genuine or effective electronic super-conductivity (in the sense that Cooper pairs are dropped temporarily to larger space-time sheets implying dissipation) is most probably involved with the propagation of the nerve signal through the myelin sheathed portions of the axon.

The resulting simple model explained the experimental findings at quantitative level correctly and makes several predictions. In particular, one can understand why physiological temperature can have only a rather restricted range. The breaking of the electronic super-conductivity is an essential aspect of the ordinary nerve pulse conduction in this model. Also the distinction between poikilotherms (such as frog) and endotherms (such as rabbit) can be understood. As it often happens, the most recent model is not consistent with this model but is preferred by its simplicity.

Strange findings about cell membrane

There are very strange findings challenging the notions of ionic pumps and channels [86, 93, 100, 91], and suggesting a mechanism dramatically reducing the metabolic costs involved with the ionic pumping. Second finding is that ionic currents seem to be quantal and are same for polymer membrane than for cell membrane! A further strange finding [67] is that the propagation of nerve pulse does not cause heating of the cell membrane implied by the model of nerve pulse based on chemistry. This suggests that dissipation is absent also during nerve pulse propagation and that the process might not be chemical as assumed hitherto.

One can imagine two explanations.

1. The first explanation would be that ionic currents are actually dark supra currents flowing along larger space-time sheet connecting cell interior and exterior. The model of high T_c super conductivity favors only electronic and protonic super conductivity at room temperature [29] whereas the model for EEG favors the presence of Bose-Einstein condensates of ions. Bosonic ions are required: the new nuclear physics predicted by TGD [36] allows to assign to fermionic ions their bosonic chemical equivalents. Even permanent connections with the cell exterior (by magnetic flux tubes, say) are possible since Josephson currents oscillate. One can of course consider the possibility that dissipation rate is small due to the large value of Planck constant even in the absence of super conductivity. Also the temperature could be lower at the magnetic flux tubes containing dark ions but this assumption will not be made.

2. Second model that one can imagine relies on the exotic nuclear physics predicted by nuclear string model [36] and the predicted hierarchy of fractally scaled up variants of weak interaction physics. If weak interactions can be present in cell length scales, the exchange of virtual or real $W^\pm$ bosons between nuclei could induce purely quantal and non-dissipative charge transfer between cell interior and exterior. Also charge entanglement becomes possible. The emission of $W^\pm$ would modify the nucleus to an exotic charged state in which one of the neutral color bonds connecting nucleons is charged. Since W exchange does not depend on cell membrane at

all, the prediction would indeed be that ionic currents do not depend at all on the membrane in question. The model of nerve pulse however suggests that W exchange can have only a role of a control signal.

One can argue that pumps in case of ordinary matter are needed only when the cell interior and exterior are connected by join along boundaries bonds and that this connection is built only for diagnostic purposes in order to measure the concentrations of ions by measuring the ionic currents by their dissipation. The remote metabolism made possible by many-sheeted lasers reduces further the energy costs when pumping actually occurs.

5.1.4 The role of MEs and magnetic flux tube circuitry

The developments in the understanding of the role of MEs and magnetic flux tube circuitry have repeatedly forced to rethink the model of nerve pulse and EEG.

Universe as a conscious hologram

1. The notion of conscious hologram means that Universe is an extremely complex fractal Feynmann diagram with lines replaced by 4-dimensional space-time sheets and MEs are particular kinds of lines analogous to photon lines. These lines are like laser beams, which interfere in the vertices of the Feynmann diagram: vertices correspond to material space-time sheets, atoms, molecules, ..., cells, ... Super-conducting magnetic flux tubes are also important and act effectively as wave guides along which MEs propagate.

2. Topological field quantization allows to assign to any material system a field (magnetic) body. The view that "me" corresponds to the personal magnetic body of an astrophysical size receiving information from the material body by both classical communications and by sharing of the mental images realized in terms of bound state entanglement having negative energy MEs as a space-time correlate, has become a key hypothesis in the attempts to understand the functions of nerve pulse and EEG. The idea about brain as the sole seat of consciousness is deeply rooted in scientific thinking, and it took some time before I was able to take really seriously the idea about magnetic body as an intentional agent controlling the material body serving as its sensory and motor organ. In this respect the latest developments occurred while writing this article.

3. MEs, in particular, the topological field quanta of ELF fields are in a crucial role as far as the understanding of EEG (and the predicted ZEG and WEG) is involved. After dark matter revolution it became clear that MEs are the natural correlates for coherent states and Bose-Einstein condensates of dark matter bosons. It is still an open question whether ordinary laser light might be regarded as a special case of dark photons. Certainly the transformation of dark bosons to ordinary ones would occur through a de-coherence phase transition just like the transformation of laser light to ordinary photons.

Various kinds of MEs

One can imagine many kinds of MEs.

1. Interior MEs correspond to what might be called ELF MEs but they form only a small portion of the spectrum of MEs characterized by the fundamental frequencies defined by their lengths $f = c/L$ extended to ULF frequencies which correspond to length scales of order light lifetime. Also MEs in time scales at least down to 10^{14} Hz corresponding to visible photons are predicted be important.

2. Also boundary MEs identified as MEs attached to the boundaries of matter carrying space-time sheet and drifting along it quantum jump by quantum jump by a velocity $v < c$ can be considered and MEs of this kind were in a key role in the previous model for nerve pulse generation. In the case of boundary MEs, which are assumed to be positive energy MEs, the effective phase velocity satisfies $v << c$, and from $f = v/L$ the sizes of the structures associated with a given frequency are smaller by a factor v/c.

3. Negative energy MEs, which correspond to phase conjugate laser light, make possible intentional action at the micro-tubular level, they are crucial for the understanding of the macro-temporal quantum coherence, and have also inspired the notions of remote metabolism and quantum credit card. The newest discovery along this line is what might be called seesaw mechanism of energy metabolism (see the article "Time, Space-time and Consciousness" in [49]). Phase conjugate laser beams [70, 62] seem to be the standard physics counterpart of negative energy em MEs and negative energy photons accompanying them.

4. Fractality implies that MEs contain MEs within MEs: this conforms with the general ideas about dark matter hierarchy and p-adic length scale hierarchy. MEs within MEs is the topological correlate for de-coherence of Fourier components of classical field. In the simplest situation MEs appear as pairs of high frequency and low frequency MEs. The scaling law of homeopathy [40] states that low frequencies are accompanied by high frequencies such that the frequency ratio has preferred predictable values identifiable as characteristic velocities in the system (such as EEG phase velocity): $f_{low}/f_{high} = v/c$. The most general assumption about the spectrum of high frequency MEs inside low energy MEs is that it is scale invariant in the sense that the intensity satisfies $I(f_{high}, f_{low}) = I(f_{high}/f_{low})$.

   Low frequency negative energy MEs could serve as correlates for remote quantum entanglement in cyclotron degrees of freedom. W MEs would make possible charged entanglement. High frequency MEs travel effectively like massless particles along the bridges defined by the low frequency MEs and can transform to boundary MEs serving as bridges between different space-time sheets at the receiving end, in which case their effective phase velocity is reduced to $v << c$. These MEs could induce a leakage of ions between different space-time sheets, breaking of super-conductivity and dissipative self-organization. This process which is analogous to the formation of hologram, is responsible for homeostasis and metabolism and gives rise to many-sheeted ionic flow equilibrium. Also many-sheeted lasers acting in a very wide range of frequencies become possible. The frequencies correspond to differences for the energies of ions at the space-time sheets involved. MEs parallel to axons can also act as Josephson junctions connecting space-time sheets which can correspond to different p-adic primes.

The strange effects of ELF em fields on vertebrates as a key to the model for hierarchy of EEGs

The experimental findings of the pioneers of bio-electromagnetism [84] demonstrate that electromagnetic radiation at the harmonics of cyclotron frequencies of various ions in magnetic field $B = .2$ Gauss, in particular Ca^{+2} ion, are somehow involved with the bio-control. The dropping of ions from smaller space-time sheets to the super-conducting magnetic flux tubes of B indeed generates cyclotron radiation. The generalization of this mechanism [48, 42] explains the findings of Gariaev [98] about radio waves induced by laser irradiation of DNA. The detailed model explaining various aspects of these findings on basis of TGD inspired model of high T_c superconductivity led to a detailed model for the hierarchy of EEGs (or EWEGS, with EW for electro-weak) generated by Josephson junctions as Josephson and by cyclotron transitions of Bose-Einstein condensates of bosonic ions.

5.1.5 The most recent model for the generation of nerve pulse

Quite recently I learned [67, 71, 60, 61, 58] (thanks to Ulla Mattfolk) that nerve pulse propagation seems to be an adiabatic process and thus does not dissipate: the authors propose that 2-D acoustic soliton is in question. Adiabaticity is what one expects if the ionic currents are dark currents (large $\hbar$ and low dissipation) or even supra currents. Furthermore, Josephson currents are oscillatory so that no pumping is needed. Combining this input with the model of DNA as topological quantum computer (tqc) [28] leads to a rather precise model for the generation of nerve pulse.

1. The system would consist of two superconductors- microtubule space-time sheet and the space-time sheet in cell exterior- connected by Josephson junctions represented by magnetic flux tubes defining also braiding in the model of tqc. The phase difference between two super-conductors would obey Sine-Gordon equation allowing both standing and propagating solitonic solutions. A sequence of rotating gravitational penduli coupled to each other would be the mechanical

analog for the system. Soliton sequences having as a mechanical analog penduli rotating with constant velocity but with a constant phase difference between them would generate moving kHz synchronous oscillation. Periodic boundary conditions at the ends of the axon rather than chemistry determine the propagation velocities of kHz waves and kHz synchrony is an automatic consequence since the times taken by the pulses to travel along the axon are multiples of same time unit. Also moving oscillations in EEG range can be considered and would require larger value of Planck constant in accordance with vision about evolution as gradual increase of Planck constant.

2. During nerve pulse one pendulum would be kicked so that it would start to oscillate instead of rotating and this oscillation pattern would move with the velocity of kHz soliton sequence. The velocity of kHz wave and nerve pulse is fixed by periodic boundary conditions at the ends of the axon implying that the time spent by the nerve pulse in traveling along axon is always a multiple of the same unit: this implies kHz synchrony. The model predicts the value of Planck constant for the magnetic flux tubes associated with Josephson junctions and the predicted force caused by the ionic Josephson currents is of correct order of magnitude for reasonable values of the densities of ions. The model predicts kHz em radiation as Josephson radiation generated by moving soliton sequences. EEG would also correspond to Josephson radiation: it could be generated either by moving or standing soliton sequences (latter are naturally assignable to neuronal cell bodies for which $\hbar$ should be correspondingly larger): synchrony is predicted also now.

3. The previous view about microtubules in nerve pulse conduction can be sharpened. Microtubular electric field (always in the same direction) could explain why kHz and EEG waves and nerve pulse propagate always in same direction and might also feed energy to system so that solitonic velocity could be interpreted as drift velocity. This also inspires a generalization of the model of DNA as tqc sine also microtubule-cell membrane systems are good candidates for performers of tqc. Cell replication during which DNA is out of game seems to require this and microtubule-cell membrane tqc would represent higher level tqc distinguishing between multi-cellulars and mono-cellulars.

4. New physics would enter in several manners. Ions should form Bose-Einstein cyclotron condensates. The new nuclear physics predicted by TGD [36] predicts that ordinary fermionic ions (such as K^+, Na^+, Cl^-) have bosonic chemical equivalents with slightly differing mass number. Anomalies of nuclear physics and cold fusion provide experimental support for the predicted new nuclear physics. Electronic supra current pulse from microtubules could induce the kick of pendulum inducing nerve pulse and induce a small heating and expansion of the axon. The return flux of ionic Josephson currents would induce convective cooling of the axonal membrane. Clearly, the temperature at dark magnetic flux tubes could be lower than the physiological temperature. The model for the role of DC currents and potentials in healing discussed in [28] suggests that metabolic energy quanta of order 1 meV are involved in bio-control so that the temperature at magnetic flux tubes containing ions could be by a factor of order 10^{-2} lower than the physiological temperature. A small transfer of small positive charge into the inner lipid layer could induce electronic supra current by attractive Coulomb interaction. The exchange of exotic W bosons which are scaled up variants of ordinary $W^{\pm}$ bosons is a natural manner to achieve this if new nuclear physics is indeed present.

5.1.6 What happens at the micro-tubular level during nerve pulse?

What happens at the micro-tubular level during the nerve pulse? How gel phase differs from sol phase? What occurs in sol-gel transition? These questions represent some of the principal challenges faced by quantum theories of consciousness.

There are two candidates for Bose-Einstein (BE) condensates associated with the ordered phases (say gel) of water. This derives from the fact that the zero point kinetic energy of hydrogen atom at space-time sheet k is in a good approximation same as the zero point kinetic energy of an electronic Cooper pair at space-time sheet $k+10$ (see the article "Time, Space-time, and Consciousness" in [49]). Thus both the BE condensates of hydrogen atoms at tubular $k = 139$ space-time sheets forming bundles behaving like liquid crystals and BE condensates of electronic Cooper pairs at $k = 149$ space-time sheets forming linear structures could accompany gel phase and ordered water phases. Positive and negative energy IR photons at energy of $\sim .125$ eV belong to the predicted fractal hierarchy of metabolic currencies, and allow to control the stability of this BE condensate so that a precisely targeted control of the cellular state by local sol-gel transitions becomes possible. Albrecht-Buehler [79] has demonstrated that photons with energy $E \sim .1$ eV have a maximal effect on cells.

The seesaw mechanism discussed in the article "Quantum model of sensory receptor" of [49] minimizes dissipative losses and allows to understand how micro-tubular surfaces could provide dynamical records for the cellular sol-gel transitions, and thus define a fundamental micro-tubular representation of declarative long term memories.

As far as nerve pulse is considered, one ends up with the proposal that the soliton propagating along axon might be a shadow of a more fundamental soliton propagating along microtubular surface and inducing gel-sol-gel transition meaning disassembly and reassembly of tubulins which induces a braiding of magnetic flux tubes coding the details of the sensory signal below millisecond time scale to the braiding pattern.

5.2 Exotic charge transfer between cell interior and exterior as fundamental control mechanism

The notions of ionic channels and pumps associated with the cell membrane are central for the standard cell biology [92]. There are however puzzling observations challenging this dogma and suggesting that the currents between cell interior and exterior have quantum nature and are universal in the sense that they not depend on the cell membrane at all [91, 94, 102, 93, 100]. One of the pioneers in the field has been Gilbert Ling [91], who has devoted for more than three decades to the problem, developed ingenious experiments, and written several books about the topic. The introduction of the book [86]) gives an excellent layman summary about the paradoxical experimental results.

It was a pleasant surprise to find that these experimental findings give direct support for the existence of an exotic charge transfer between cell interior and exterior.

Ionic supra currents and Josephson currents or the exchange of exotic W bosons could be in question. For the first option, the experimental data led to a model for cell homeostasis as a flow equilibrium in which very small densities of super-conducting ions (also molecular ions) and ionic supercurrents at cellular and other super-conducting space-time sheets dictate the corresponding densities at the atomic space-time sheets. Z^0 super-conductivity possible for almost vacuum extremals in principle allows to generalize the model also to the control of the densities of neural atoms and molecules at atomic space-time sheets.

This control mechanism need not be the only one. Magnetic flux tubes serving as colored braid strands connecting different bio-molecules in highly selective manner and phase transitions reducing or increasing $\hbar$ could explain the mysterious precision of bio-catalysis as how the prebiotic evolution has led to the known biology [28]. Magnetic flux tubes could also act as Josephson junctions between widely separated structures.

5.2.1 Strange behavior of the intracellular water

The basic strange feature of cellular interior is related to its gelatinous nature and is in fact familiar for everyone. Although 80 percent of hamburger is water, it is extremely difficult to extract this water out. Ling [94] has demonstrated this at cellular level by using a centrifuge and cells for which cell membrane is cut open: centrifugal accelerations as high as 1000 g fail to induce the separation of the intracellular water.

The assumption that cytoplasm behaves like gel explains these findings. Egg is very familiar example of gel phase so that this proposal could have been made already by the pioneers. The dipolar nature of bio-molecules and induced polarization are basis prerequisites for the formation of gels. Ling raises the cohesion between water and protein molecules caused by electric dipole forces as a fundamental principle and calls this principle association-induction hypothesis [91]. This cohesion gives rise to liquid crystal [71] like structure of water implying among other things layered structures and internal electric fields orthogonal to the plane of the layers [91, 90, 104]. For instance, cell membranes can be understood as resulting from the self-organization of liquid crystals [34]. The fundamental importance of electret nature of biomatter was also realized by Fröhlich [96] and led him to suggest that macroscopic quantum phases of electric dipoles might be possible. This concept, which is in central role in many theories of quantum consciousness, has not been established empirically.

5.2.2 Are channels and pumps really there?

Standard neurophysiology relies strongly on the concepts of what might be called hydro-electro-chemistry. The development of the theory has occurred through gradual improvements saving the existing theory.

The development began from the basic observation that cells are stable gelatinous entities not mixing with the surrounding water. This led to the hypothesis that cell membrane takes care that the contents of the cell do not mix with the cell exterior. It was however soon found that cell membrane allows some ions to flow through. The interaction between theory and experiment led gradually to the notions of ion channel and ion pump, which are still central for the standard paradigm of the cell [92]. Note that also 'electric pump' taking care that membrane potential is preserved, is needed.

These notions developed gradually during the period when cell was seen as a bag containing water and a mixture of various biochemicals. If cell biology would have started to develop during the latter half of this century and after the discovery of DNA, cell as a computer metaphor might have led to a quite different conceptualization for what happens in the vicinity of the cell membrane. Also the notion of liquid crystals [71] would have probably led to different ideas about how homeostasis between cell interior and exterior is realized [91, 90, 104].

For me it was quite a surprise to find that pump-channel paradigm is not at all so well-established as I had believed as an innocent and ignorant outsider. The first chapter of the book "Cells, Gels and the Engines of Life" of Gerald Pollack [86] provides a summary about the experimental paradoxes (the interested reader can find the first chapter of this book from web).

The standard theoretical picture about cell is based on the observation that cell exterior and interior are in a relative non-equilibrium. The measured concentrations of various atomic ions and organic molecules are in general different in the interior and exterior and cell membrane seems to behave like a semi-permeable membrane. There is also a very strong electric field over the cell membrane. In standard approach, which emerged around 1940, one can understand the situation by assuming that there are cell membrane pumps pumping ions from cell interior to exterior or vice versa and channels through which the ions can leak back. Quite a many candidates for proteins which seem to function like pump and channel proteins have been identified: even a pump protein for water [86]! This does not however prove that pumping and channeling is the main function of these proteins or that they have anything to do with how ionic and molecular concentrations in the interior and exterior of the cell are determined. It could quite well be that pump and channel proteins are receptors involved with the transfer of information rather than charges and only effectively act as pumps and channels.

There are several serious objections of principle against the vision of cell as a bag of water containing a mixture of chemicals. Even worse, the hypothesis seems to be in conflict with experimental data.

Selectivity problem

Cell membrane is extremely selective and this leads to an inflation in the complexity of channels and pumps. The problem might be christened as a dog-door problem: the door for dog allows also cat go through it. Channels cannot be simple sieves: it is known that channels which let some ions through do not let much smaller ions through. There must be more complicated criteria than geometric size for whether the channel lets the ion go through. Quite generally, channels must be highly selective and this seems to require complicated information processing to decide which ion goes through and which not. As a consequence, the models for channels inflate in their complexity.

Inflation in the number of pumps and channels

Channels and pumps for atomic ions and channels and pumps for an astronomical number of organic molecules are needed. The first question is where to put all those channels and pumps? Of course, one could think that pumps and channels are constructed by the cell only when they are needed. But how does the cell know when a new pump is needed if the cell as never met the molecule in question: for instance, antibiotic or curare molecule?

To realize how weird the picture based on channels and pumps is, it is useful to imagine a hotel in which there is a door for every possible client letting only that client through but no one else. This strange hotel would have separate door for every five point five milliard humans. Alternatively, the building would be in a continual state of renovation, new doors being built and old being blocked.

There is however an TGD based objection against this slightly arrogant argument. In TGD framework cell is a self-organizing structure and it might be that there is some mechanism which forces the cell to produce these pumps and channels by self-organization. Perhaps the basic characteristic of quantum control in many-sheeted space-time is that it somehow forces this kind of miracles to occur.

Why pumping does not stop when metabolism stops?

One can also wonder how metabolism is able to provide the needed energy to this continual construction of pumps and channels and also do the pumping. For instance, sodium pump alone is estimated to take 45-50 per cent of the cell's metabolic energy supply. Ling has studied the viability of the notion of the ionic pump experimentally [91] by exposing cell to a cocktail of metabolic poisons and depriving it from oxygen: this should stop the metabolic activities of the cell and stop also the pumping. Rather remarkably, nothing happened to the concentration gradients! Presumably this is the case also for the membrane potential so that also the notion of metabolically driven electrostatic pumps seems to fail. Of course, some metabolism is needed to keep the equilibrium but the mechanism does not seem to be a molecular mechanism and somehow manages to use extremely small amount of metabolic energy.

How it is possible that ionic currents through silicon rubber membrane are similar to those through cell membrane?

A crucial verification of the channel concept was thought to come in the experiment of Neher and Sakmann [89] (which led to a Nobel prize). The ingenious experimental arrangement was following. A patch of membrane is sucked from the cell and remains stuck on the micropipet orifice. A steady voltage is applied over the patch of the membrane and the resulting current is measured. It was found that the current consists of discrete pulses in consistency with the assumption that a genuine quantum level current is in question. The observation was taken as a direct evidence for the postulate that the ionic currents through the cell membrane flow through ionic channels.

The later experiments of Fred Sachs [93] however yielded a complete surprise. Sachs found that when the patch of the cell membrane was replaced by a patch of silicon rubber, the discrete currents did not disappear: they remained essentially indistinguishable from cell membrane currents! Even more surprisingly, the silicon rubber membrane showed ion-selectivity features, which were essentially same as those of the cell membrane! Also the currents through synthetic polymer filters [100] were found to have essentially similar properties: as if ion selectivity, reversal potential, and ionic gating would not depend at all on the structure of the membrane and were more or less universal properties. Also experiments with pure lipid-layer membranes [102] containing no channel proteins demonstrated that the basic features – including step conductance changes, flickering, ion selectivity, and in-activation– characterized also cell membranes containing no ionic channels.

The in-escapable conclusion forced by these results seems to be that the existing 60-year old paradigm is somehow wrong. Ionic currents and the their properties seem to be universal and depend only on very weakly on the properties of the membrane.

5.2.3 Cytoplasm as gel

The solution to the above described anomalies proposed by Pollack is that cytoplasm is gel phase [86]. Pollack describes in detail various aspects of cytoplasm as a gel phase and here only short summary can be given.

1. Cytoplasm can be regarded as a network consisting of cross-linked negatively charged proteins. Water is condensed around the proteins to form structured water. If protein is hydrophilic, water self-organizes around it as a multilayered structure: the number of molecular layers can as high as 600 and the thickness of the layered structure is a considerable fraction of micrometer. If the protein is hydrophobic, water forms another structured phase known as clathrate water: in this case the number of hydrogen bonds between water atoms is large. These phases can be regarded as intermediate between ice and water. Also ordinary ions have this kind of layered structure

around them. Chemical cross-links tend to be stable with heat, pH, and solvent composition whereas physical cross-links formed by intermolecular interactions are sensitive to environmental interactions and are of special interest from the point of view of phase transitions.

2. Pollack proposes that the formation of polymers takes place in an environment containing layered water for the simple reason that monomers cannot diffuse to the layered water so that the probability of association with the end of the growing polymer increases.

3. Cell interior is populated by micro-tubules, various filamentary structures, and the so called micro-trabecular matrix. Micro-trabecular network divides cell into a compartments in such a manner that the typical distance between two proteins in water is about 5 nm: this corresponds to the p-adic length scale $L(149)$, the thickness of the lipid layer of cell membrane. This is probably not an accident and the micro-trabecular network might be closely involved with the highly folded network of intracellular membranes. There would be a layer of thickness of about 6 water molecules per given protein surface so that a dominating portion of intracellular water could be structured.

4. The layered water has several tell-tale signatures that have been observed in gels. It freezes at much lower temperature than ordinary water; various relaxation times are shorter since the energy transfer to the water lattice occurs faster than to non-structure water; the diffusion rates of particles into the structured water are much slower than to ordinary water by entropy argument; a simple geometric argument tells that the larger the size of the hydrated ion the lower the diffusion rate; strong gradients of ionic concentrations can form in gel phase as has been observed.

The identification of the cytoplasm as a gel has profound implications for the standard views about cell.

1. The original motivation for postulating semipermeable cell membrane, channels, and pumps was the need to hinder the diffusion of various ions between cell interior and exterior taking place if cytoplasm is ordinary water into which molecules are dissolved. If cytoplasm is in gel phase, cell membrane need not perform pumping and channeling anymore except perhaps in situations involving the formation of a local sol phase. This raises the question about the proper functions of the cell membrane.

2. It is possible to drill to cell membrane holes with size of order 1 μm without an appreciable effect on the functioning of the cell and also show that these holes remain as such for long periods of time [86]. It is also possible to splice cells into pieces continuing to function for days. That K^+ flux through cell membrane does not change when lipids are partially removed. These findings force to ask whether the assumption about the continuity of the cell membrane might be too strong [86]. Electron micrographs however demonstrate the presence of the bi-layered structure. What is intriguing that this structure is seen even in the absence of lipid layers. In TGD framework this paradoxical finding might be understood in terms of a presence of space-time sheets corresponding to p-adic length scales $L(k)$, $k = 149, 151$ as vacuum structures predicted also by TGD inspired model of high T_c super-conductivity [29].

3. There is also the strange finding that water flux through cell membrane is much higher than the flux through isolate lipid bi-layer as if some unidentified channels were present. In TGD framework this might be seen as an evidence for the presence of (wormhole) magnetic flux tubes as carriers of water molecules.

4. The fundamental assumptions about ionic equilibrium must be reconsidered, and the Hodkin-Huxley model for the generation of nerve pulse becomes more or less obsolete. Indeed, it has been found that action potentials can be generated even in absence of Na^+ and K^+ ions playing a key role in Hodkin-Huxley model. Rather remarkably, the high concentration of K^+ ions and low concentration of Na_+ ions in cytoplasm could be understood on basis of gel property only. Also new view about cell (note membrane-!) potential emerges. The standard paradigm states that the resting potential is over the cell membrane. Potentials of same order of magnitude have been however seen in de-membraned cells (50 mV in slight excess of action potential and critical

potential), colloidal suspensions, and gels which suggest that larger part of cell than mere cell membrane is involved with the generation of the action potential and one should thus speak of cell potential instead of membrane potential.

5. Pollack suggests that the phase transitions of the gel phase make possible to realize various functions at molecular and cellular level and represents empirical evidence for the phase transition like aspects assigned to these functions including sensitivity to various factors such as pH, temperature, chemical environment, electromagnetic fields, mechanical forces, etc... and the threshold behavior [86]. Also the responses are typical for phase transitions in that they involve dramatic changes in volume, shape, di-electric constant, etc.. With these motivations Pollack discusses phase transition based models for contraction, motility, secretion, transport or molecules, organized flow of particles during cell division, cell locomotion, contraction of muscle, generation of action potentials, etc.. For instance, the transport of bio-molecules along micro-tubule could involve propagating gel-sol-gel phase transition meaning also propagating melting of the layered water around micro-tubule.

6. Divalent ions, such as Mg^{+2} and Ca^{+2} can act as cross links between negatively charged proteins binding them to form networks. Monovalent ions cannot do this. Peripheral cytoskeleton is this kind of network consisting of micro-tubules and actin molecules cross-linked - according to Pollack- by Ca^{+2} ions. On the other hand, it is known that Mg^{+2} (Ca^{+2}) ions dominate in the cell interior (exterior) and that the presence of Ca^{+2} ions in the cell exterior is crucial the for generation of nerve pulse. The influx of Na^{+} ions having higher affinity to proteins can induce a phase transition to sol-like phase. Pollack suggests a model of nerve pulse based on this mechanism of gel-sol phase transition for peripheral cytoskeleton: this model does not actually explain why Ca^{+2} ions in the exterior of axon are necessary.

5.2.4 TGD based vision inspired by the findings

The vision about dark matter and the model of nerve pulse formulated in terms of Josephson currents brings an additional perspective to the role of pumps and channels and allows to avoid harmony with the standard views about their role.

1. In long length scales visible matter forms roughly 5 per cent of the total amount of matter. In TGD Universe the dark matter would correspond to matter with large Planck constant including dark variants of ordinary elementary particles. In living matter situation could be the same and visible matter could form only a small part of the living matter. Dark matter would be however visible in the sense that it would interact with visible matter via classical electromagnetic fields and photon exchanges with photons suffering Planck constant changing phase transition. Hence one can consider the possibility that most of the biologically important ions and perhaps even molecules reside at the magnetic flux quanta in large $\hbar$ phase.

2. Bosonic ions could form Bose-Einstein condensates at the flux tubes in which case supra currents flowing without any dissipation would be possible. The model for high T_c super-conductivity suggests that only electronic and protonic super-conductivity are possible at room temperature. If so, Cooper pairs of fermionic ions are excluded. New nuclear physics predicted by TGD could however come in rescue here. The TGD based model for atomic nucleus assumes that nuclei are strings of nucleons connected by color bonds having quark and antiquark at their ends. Also charged color bonds are possible and this means the existence of nuclei with anomalous charge. This makes possible bosonic variants of fermionic ions with different mass number and it would be interesting to check whether biological important ions like Na^{+}, Cl^{-}, and K^{+} might actually correspond to this kind of exotic ions.

This leads to the following TGD inspired vision about cell as a gel.

1. DNA as tqc hypothesis and cell membrane as sensory receptor provide possible candidates for the actual functions of the cell membrane and ionic channels and pumps could act as kind of receptors. That standard physics is able to to describe gel phase is of course a mere belief and (wormhole) magnetic flux tubes connecting various molecules (DNA, RNA, aminoacids, biologically important ions) would be "new physics" cross-links could explain the strong correlations between distant molecules of the gel phase.

2. Dark ionic currents are quantal currents. If the dark ions flow along magnetic or wormhole magnetic flux tubes connecting cell interior and exterior, their currents through cell membrane would be same as through an artificial membrane.

3. Pumps and channels could serve the role of sensory receptors by allowing to take samples about chemical environment. One cannot exclude the possibility that proteins act as pumps and channels in sol phase if magnetic flux tubes are absent in this phase since also in TGD Universe homeostasis and its control at the level of visible matter in sol phase might requires them. The metabolic energy needed for this purpose would be however dramatically smaller and a reliable estimate for this would allow an estimate of the portion of dark matter in living systems.

4. 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 rachet 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.

5. 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 [86]. If wormhole magnetic flux are taken are taken as a basic prerequisite of life, one must ask whether these "artificial proteins" represent artificial life.

6. The fact that cytoskeleton rather than only cell membrane is involved with the generation of action potential conforms with the idea that nerve pulse propagating along axon involves also axonal micro-tubules and that Josephson currents between axon and micro-tubules are involved in the process.

7. Di-valent ions (Ca^{+2} ions according to Pollack) serve as cross links in the peripheral cytoskeleton. The influx of monovalent ions from the exterior of axon induces gel-sol phase transition replacing di-valent ions with monovalent ions. One can consider two models.

   i) The minimal assumption is that this phase transition is induced $\hbar$ increasing phase transition the flow of the monovalent ions like Na^+ from the cell exterior along the magnetic flux tubes connecting axonal interior and interior. Suppose that in the original situation the flux tubes end to axonal membrane (this is not the only possibility, they could also end to Ca^{+2} ions). The flux tubes extending to the axonal exterior could result by $\hbar$ increasing phase transition increasing the length of the flux tubes connecting peripheral cytoskeleton to the axonal membrane so that they extend to the exterior of axon. This option is rather elegant since gel-sol phase transition itself can be understood in terms of "standard chemistry". In this model the very slow diffusion rate of the ions to gel phase would have explanation in terms of new physics involving dark matter and (wormhole) magnetic flux tubes.

   ii) One can consider also an option in which divalent ions such as Ca^{+2} or Mg^{+2} are connected by two flux tubes to amino-acids of two negatively charged proteins whereas monovalent biological ions like Na^+ would have single flux tube of this kind and could not act as cross links. In the phase transitions removing the cross links the replacement of divalent ion with two monovalent positively charged ions would take place. If one believes in standard chemistry, Na^+ ions would flow in automatically. First the increase of Planck constant would induce the lengthening of the magnetic flux tubes and thus the expansion of the gel phase making possible the influx of monovalent ions. If Na^+ ions are dark, flux tubes connecting peripheral cytoskeleton to the axonal exterior are required and the mechanism of option i) is also needed.

8. The mechanisms i) and ii) could be fused to a single one. The hint comes from the presence of Ca^{+2} ions in the exterior of axon is necessary for the generation of action potential. The simplest possibility is that the flux tubes connecting proteins to intracellular Ca^{+2} cross links in gel phase connects them after the length increasing phase transition to extracellular Ca^{+2} ions and Na^+ ions flow along these flux tubes.

9. The increase of the Planck constant would induce the expansion of the peripheral cytoskeleton making possible the inflow of Na^+ ions, and divalent ions binding negatively charged actin molecules to a network would be replaced with inflowing Na^+ ions. After this a reverse phase transition would occur. Both phase transitions could be induced by a quantal control signal (Josephson current) inducing quantum criticality and a change of Planck constant.

10. A propagating Ca^{+2} wave inducing the gel-sol-gel phase transition of peripheral cytoskeleton would accompany nerve pulse. Quite generally, Ca^{+2} waves are known to play a fundamental role in living matter as kind of biological rhythms. Irrespective of whether one believes option i) or ii), this might relate to the cross-linking by flux tubes and gel-sol-gel phase transitions induce by phase transitions increasing Planck constant temporarily. The velocities and oscillation periods of Ca^{+2} waves vary in an extremely wide range: this can be understood if the flux tubes involved correspond to a very wide spectrum of Planck constant.

To sum up, the strange discoveries about the behavior of cell membrane provide direct experimental evidence for the presence of dark matter in living systems, for the prediction that it interacts with ordinary matter via classical electromagnetic fields, and for the assumption that it does not dissipate appreciably and could therefore have large value of $\hbar$ and form macroscopic quantum phases.

5.3 Further experimental findings

In this section I discuss further experimental findings giving support for the TGD based vision about living cell.

5.3.1 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, Stphane Ferris, Jean-Luc Montagnier, and Claude Lavalle published in the journal Interdiscip. Sci. Comput. Life Sci. (2009) [78].

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 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 [44]. 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 his. 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 specials, 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 [97] 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 [28]. 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 [36] 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.

5.3.2 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" [61] and "Making Fuel from Water" [56]. The articles summarize an experimental discovery which could be called Pollack-Zheng effect [73, 55]. 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 [28, 19]. 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 $E(k,n) = (1-2 < sup > -n < /sup >)E(k)$ 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 [88]: 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 [61].

Exclusion zones

The article summarizes the sequence of events initiated by the discovery of Gerald Pollack and his student Jian-ming Zheng [73, 55]. 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. Whats 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 [55]. 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 bio-catalysis [32].

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 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 served as one motivation for the original $\hbar/\hbar_0 = 2^{11k}$ hypothesis for the preferred values of Planck constant. 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.

3. 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.

4. 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 [28]. 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.

1. 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.

2. 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 [28]. 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.

3. 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 [29]. Cell membrane acts as a Josephson junction in TGD based model of cell membrane, nerve pulse, and EEG.

5.3.3 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 $L(178) \simeq 100\ \mu$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 [101]. This suggests a connection with Pollack-Zheng effect [73]. 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 orto 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 [73] does not change sign under the reflection of the molecule so

that spin polarization independent of chirality could result form 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 aminocids 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.

5.3.4 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 [61, 56, 65, 66] 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" [61] told about the formation of exclusion zones around hydrophilic surfaces, typically gels in the experiments considered [73]. 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 suggests only few molecular layers instead of millions. Sunlight induced the effect. This finding allow 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?" [65] 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 [57]. The mystery is of course how so low frequency can induce burning. The article "The body does burn water" [66] 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 [72]. 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 [56]. 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 [19].

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 [67, 64, 68, 69]. 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 [57]: 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?" [65] provides new information about burning salt water [57], 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) [98], and that even a realization of genetic code in terms of the time variation of polarization direction could be involved. TGD based model [33, 24] 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 [74]. 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 [58] - 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 [82]. 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 [36].

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 energy around .4 eV [44, 16]. 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 $f = 2\times 10^{14} >$ 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 [72] 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 [61].

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.

5.4 TGD based model for the generation of nerve pulse and EEG

The general vision about living system as a conscious hologram and the view about how "topological light rays" (massless extremals, MEs) serve as remote entanglers and induce self-organization via the leakage of ionic currents between various space-time sheets implies that several space-time sheet pairs are involved with the bio-control. Perhaps the most radical deviation from the standard neuroscience thinking came with the realization that in TGD Universe every physical system has also magnetic/field body of size much larger than the material body and that material bodies can be seen as motor and sensor organs of the personal magnetic body. This counter intuitive conclusion is unavoidable if one accepts many-sheeted macroscopic quantum coherence, Uncertainty Principle and topological field quantization. p-Adic physics as physics of intention and cognition provides an additional support for this view: the smaller the space-time sheet is p-adically, the larger it is in the real sense so that cognition and intentionality are predicted to be astrophysical phenomena and evolve from long to short length and time scales just as it indeed occurs when motor activity is learned.

The TGD based view about dark matter hierarchy involving a hierarchy of values of Planck constant provides a justification for this picture. Dark matter hierarchy corresponds to the hierarchy of moments of consciousness with increasingly long duration with respect to geometric time and defines a hierarchy of conscious entities and reflective levels of consciousness.

Dark matter hierarchy provides a mechanism for the formation of macroscopic and macro-temporal quantum phases in all length scales. The earlier assumption about thermal isolation of space-time sheets corresponding to different p-adic length scales can be given up and thermal stability condition becomes an additional strong constraint allowing to eliminate various options very effectively. Since cyclotron energies scale like $\hbar$, thermal stability is possible to achieve for them.

In this section TGD based model of nerve pulse and EEG inspired by the soliton model of Danish researchers and the model of Pollack is discussed. Also a model for the action of anesthetics is proposed.

5.4.1 Soliton model of nerve pulse

Let us first briefly summarize soliton model of nerve pulse proposed by Danish researchers [71, 60, 61, 58].

1. The temperature of the axon is slightly above the critical temperature T_c for the phase transition leading from crystal like state of the lipid layers to a liquid crystal state. Near criticality the

elastic constants and heat capacity of the membrane vary strongly and have maxima at criticality so that also sound velocity varies strongly near criticality. Also the relaxation times are long. There is also dispersion present meaning that the frequency of sound wave depends nonlinearly on wave vector. Non-linearity and dispersion are prerequisites for the presence of solitons which by definition do not dissipate energy.

2. Variations of temperature, volume, area, and thickness and also other mechanical effects are known to accompany nerve pulse propagation. It is also known that the heat density and temperature of the cell membrane increases slightly first and is then reduced. This suggests adiabaticity in average sense. These findings motivate the assumption that nerve pulse actually corresponds to acoustic soliton [60, 61].

3. Soliton model reproduces correctly the velocity of nerve pulse inside myelin sheaths but it is not clear to me how well the much lower conduction velocity in non-myelin sheathed regions is reproduced. It is not clear how the lower values of the conduction velocity and its proportionality to the axonal radius in non-myelinated regions can be understood. Intuitively it however seems clear that the lower velocity is due to the feedback from the interaction of ions with the region exterior to cell membrane. In the case of myelin sheaths the conduction of nerve pulse is usually believed to take place via saltation [117]: the depolarization induced at Ranvier node is believed to be enough to take the membrane potential below critical value in the next node so that nerve pulse hops between the nodes. Insulation would improve the insulation and make this process possible. The reversible heat transfer process is however known to be present also in the myelinated portions of axon so that there must be a pulse propagating also in these regions [61]. It is not clear how the myelin sheet can increase the velocity in the soliton model but the reduction of the feedback inducing friction suggests itself.

4. Soliton property predicts adiabaticity. Ordinary ionic currents however dissipate so that adiabaticity assumption is questionable in standard physics context. The model does not predict the growth of entropy followed by its reduction. This behavior is consistent with adiabaticity in a time resolution of order millisecond.

5. The estimate for the capacitor energy density during the nerve pulse is considerably smaller than the energy density is many times magnitude smaller than that of the acoustic wave. This might allow to demonstrate that Hodgkin-Huxley model is not a complete description of the situation.

6. Authors notice [60, 61] that the shapes curves representing solitonic energy density and the capacitor energy density as a function of time are essentially identical. Same applies to the experimentally deduced heat change release curve and capacitor energy density for garfish axon. Also heat release and the deviation of the membrane potential from its resting value are in exact phase. These similarities could reflect a control signal responsible for the nerve pulse originating somewhere else, perhaps at micro-tubules. This could explain why secondary nerve pulse is not generated immediately after the first one although the temperature is slightly lower after the pulse than before it. This could of course be also due to the exhaustion of the metabolic resources.

5.4.2 TGD based model of nerve pulse assuming far from vacuum extremals

The model of nerve pulse described below can be motivated by the observed adiabaticity of the nerve pulse and by the strange findings about ionic currents associated with the cell membrane and by the model of Danish researchers for the nerve pulse [67, 71, 60, 61]. The model involves also a fusion of various ideas of earlier models. In particular, Josephson currents and solitons are in a key role in the model but with the necessary flexibility brought in by the hierarchy of Planck constants. The model of nerve pulse by Pollack [86] discussed at the end of previous section allows to understand the behavior of ionic currents quantitatively. In this subsection a model of nerve pulse based on the assumption that cell membrane represents far from vacuum extremals so that classical Z^0 field is very small will be discussed. In subsequent subsections the model for which cell membrane is almost vacuum extremal will be developed with main motivation coming from the observation that the model predicts correctly the frequencies of peak sensitivity for the four photoreceptors.

Consistency with the absence of dissipative currents through the axonal membrane

The basic inputs of the TGD based model are following.

1. The presence of acoustic soliton or density pulse proposed by Danish researchers [61] looks plausible but a a more fundamental quantum control mechanism inducing the acoustic soliton cannot be excluded. Among other things this should explain why acoustic solitons propagate always in the same direction. In particular, one can consider a soliton like excitation (say breather for Sine-Gordon equation) associated with the electronic or ionic Josephson currents running along magnetic flux tubes. The strange effects associated with the ionic currents through the cell membrane suggest quite generally that at least weak ionic currents through normal cell membrane are non-dissipative quantal currents. The adiabaticity of the nerve pulse suggests that also strong ionic currents are quantal.

2. Strong ionic currents generating nerve pulse through axonal membrane are absent in the resting state. The naive explanation is simple: the life time of the magnetic flux tubes connecting the axonal interior to the exterior is short or the flux tubes are altogether absent. The observation that Josephson currents in constant voltage are automatically periodic suggests a less naive explanation allowing the flux tubes to be present all the time. The presence of ionic Josephson currents predicts a small amplitude oscillation of membrane potential for which 1 kHz synchronous oscillation is a natural identification. Josephson oscillation correspond naturally to propagating soliton sequences for Sine-Gordon equation. The dynamics of the simplest modes is equivalent to the rotational motion of gravitational pendulum: the oscillation of membrane potential corresponds to the variation of $d\Phi/dt \propto V$. Note that if axon is above the melting temperature, the lipid layer is in gel phase and fluid motion is impossible. The surface density of lipids is dramatically reduced at criticality so that lipid layers behave like fluids [61]. This means that tqc is not possible by the braiding of lipids.

3. Nerve pulse is generated when the magnitude of the negative membrane potential is reduced below the critical value. Generation of the nerve pulse is like a kick to a rotating gravitational pendulum changing the sign of $\Omega = d\Phi/dt$ so that rotational motion is transformed to oscillatory motion lasting for about the period of rotation. An opposite but slightly stronger kick must reduce the situation to the original one but with a slightly higher value of Ω. These kicks could correspond to voltage pulse between micro-tubules and inner lipid layer of cell membrane induced by the addition of small positive (negative) charge on lipid layer. This pulse would induce electronic DC Josephson current inducing the kick and thus reducing V. The exchange of scaled variants of W bosons (assignable to W MEs) could mediate the transfer of charge through the cell membrane and reduce the membrane potential below the critical value but one can consider also other mechanisms.

4. The conservative option would be that ordinary ionic currents take care of the rest and Hogkin-Huxley model applies. This was assumed in the earliest model in which soliton sequence for Josephson current was assumed to induce nerve pulse sequence: in the recent model this assumption does not make sense. The findings of Danish researchers do not however support the conservative option [61]. Nerve pulse could be due to dark ionic (possibly supra -) currents with large $\hbar$ with a low dissipation rate. Their flow would be made possible by the presence of magnetic flux tubes connecting cell interior and exterior.

The relationship with the model of Pollack

In the model of Pollack [86] for the action potential gel-sol-gel phase transition for the peripheral cytoskeleton accompanies the generation of the action potential. The model allows to understand reasonably well the behavior and the physical role of the ionic currents and explains various anomalies. Using pendulum analogy, the kick to the rotating pendulum representing Josephson junction would force it to an oscillatory motion inducing a gel-sol-gel phase transition propagating along the peripheral cytoskeleton.

The challenge is to understand how quantum criticality making possible the phase transition is induced.

1. The primary Josephson currents from the micro-tubuli to the axonal membrane would reduce the magnitude of the cell potential below the critical value (slowing down of the pendulum rotation). This should somehow take the peripheral cytoskeleton near to quantum criticality and induce the increase of Planck constant for the flux tubes connecting peripheral cytoskeleton to the axonal membrane and increasing their length so that they would extend to axonal exterior. This would make possible the flow of monovalent dark ions (say Na^+) from the axonal exterior replacing Ca^{+2} acting as cross links between negatively charged proteins and in this manner induce gel-sol phase transition. The reverse phase transition would reduce Planck constant. If ionic currents are non-dissipative they flow back automatically much like oscillating Josephson currents.

2. Gel-sol phase transition can be compared to melting since in the gel phase the hydrogen bonds induce effective freezing of various globular proteins to their folded configuration and naturally unfolded proteins to their unfolded configurations. This melting quite generally induces protein aggregtion. Melting requires energy to destroy the hydrogen bonds and during action potential the system receives this energy somehow. One could even imagine that action potential generates both positive energy Josephson radiation inducing melting and phase conjugate Josephson radiation inducing freezing again and that these two steps correspond to an increase of Planck constant and its reduction back to the original value. Josephson radiation could quite generally control biological functions by inducing protein aggregation.

3. There are two forms of quantum criticality corresponding to critical sub-manifolds $M^2 \times CP_2$ and $M^4 \times S^2$, where $M^2 \subset M^4$ has interpretation as plane of non-physical polarizations and $S^2 \subset CP_2$ is a homologically trivial geodesic sphere of CP_2 with vanishing induced Kähler form (see the Appendix of [28]). The latter kind of quantum criticality corresponds to very weak induced Kähler fields and thus to almost vacuum extremals. Given electromagnetic field can be imbedded as a 4-surface in many manners: as a vacuum extremal, as a surface maximizing Kähler electric energy, or something between them.

4. Quantum criticality suggests that em fields in the cell interior correspond to non-vanishing but not too large induced Kähler fields in the resting state. The magnitude of the cell potential in the absence of the membrane is about -50 mV and slightly below the magnitude of the critical potential of -55 mV [86]. Hence the reduction of the magnitude of the em (-or more precisely- Kähler-) voltage between the inner boundary of the peripheral cytoskeleton and cell exterior to a small enough value could induce almost vacuum extremal property and quantum criticality making $\hbar$ increasing phase transition for the magnetic flux tubes connecting peripheral cytoskeleton to the axonal membrane possible. This framework would also allow to understand the paradoxical fact that a reduction of the magnitude of the cell potential induces the action potential rather than its increase as the naive idea about di-electric breakdown would suggest.

5. Action potential should induce gel-to-sol phase transition somehow and Josephson radiation generated during the action potential should be responsible for this. During action potential the energy of Josephson covers a wide range so that it could couple to metabolic energy quanta. If the frequency of Josephson radiation is considerably higher than the rate of variation of the action potential the situation is adiabatic in the sense that the energy of Josephson radiation is effectively constant. The situation is optimal during the maximum +40 mV of the action potential. Josephson radiation could couple resonantly to the gel defined by the peripheral cytoskeleton and induce fast transfer of protons from large to small space-time sheets and generate metabolic energy quanta helping to destroying the hydrogen bonds. This should somehow induce the increase of Planck constant for the magnetic flux tubes responsible for the gel-to-sol phase transition. This admittedly speculative and somewhat misty idea has been discussed already earlier and will reconsidered in the section where the relationship of the model with microtubular level is discussed.

6. The value of the membrane potential is -55 meV at criticality for the generation of the action potential and +40 meV at the maximum [106]. All the values between them could correspond

to energies of Josephson radiation, which for certain values of membrane potential correspond to metabolic energy quanta. The range of variation for membrane voltage allows all Josephson energies down to cutoff energy for which the frequency of Josephson radiation is of same order than the rate of relative variation of the membrane potential. Explicitly this condition reads as

$$\frac{\frac{dV}{dt}}{V} \ll \frac{f_0}{r}\frac{V}{V_0} \quad , \quad r = \frac{\hbar}{\hbar_0} \quad .$$

Here f_0 is the the Josephson frequency for $r = 1$ and for the resting potential V_0 and is of order 10^{14} Hz for almost vacuum extremals and 10^{13} Hz for far from vacuum extremals. Josephson frequency must be considerably above kHz frequency defined by the duration of the action potential. Therefore Josephson radiations below *resp.* above kHz frequency must relate to resting state *resp.* action potential and must correspond to different biological functions. For $r = 2^{k_d}$ the kHz frequency correspond roughly to $k_d = 36$ for almost vacuum extremals and to $k_d = 33$ for far from vacua. Note that the p-adic length scale determined by the wave length of Josephson radiation for $k_d = 36$ is 16 cm - the size scale scale of brain.

7. There are two options depending on whether the cell membrane is assumed to correspond to almost vacuum extremal or not.

   (a) For far from vacuum extremal option the energies of Josephson photons in case of proton are 55 meV and 40 meV for the mentioned values of membrane potential and corresponds to IR radiation. The Josephson energies in case of proton and electron are by an order of magnitude smaller than the nominal energy .5 eV for standard metabolic energy quantum. The metabolic energy quantum liberated in the dropping of proton Cooper pair from $k = 139$ atomic space-time sheet or of electron Cooper pair from $k = 151$ cell membrane space-time sheet to a much larger space-time sheet is $\simeq$ .62 eV for the nominal value of .5 eV for the dropping of proton from $k = 137$ space-time sheet to much larger space-time sheet. Note however that $E = E_0(1 - 2^{-k})$ specrum for metabolic energy quanta gives energy $E = 47$ meV for $k = 2$. One can criticize this option because one must assume non-standard metabolic energy quanta and there must be a separate control mechanism inducing their generation.

   (b) The cutoff frequency is certainly considerably higher than kHz. For almost vacuum extremal the Josephson energy is

   $$E = Q_{eff}(p)e \times V \quad , \quad Q_{eff}(p) = 3 - \frac{1}{2p} \quad , \quad p = sin^2(\theta_W) = .029 \quad .$$

   One has $E = .7$ eV for V=-55 mV and $E = .56$ eV for V=+40 meV. The latter value is not too far from the nominal value .5 eV for the basic metabolic energy quantum. Note that during nerve pulse Josephson radiation in a wide range of energies is emitted. Besides this there is energy spectrum associated with ions. The energies for $(Na^+.Cl^-, K^+, Ca^{+2})$ are (2.2,2.74,3.07,2.31) eV for -55 mV and (1.60,2.00,2.23,1.68) eV for +40 mV (Table 3). Note that at maximum of V 2.00 eV metabolic energy quantum is associated with Cl^-.

What the replacement of Ohmic ionic currents with quantal currents means?

Before the replacement of Hodgkin-Huxley model with a genuinely quantal model can be taken seriously, one must answer many difficult questions which also Hodgkin and Huxley must have faced as they developed their own model.

1. *Questions and answers*

Q: In the resting state membrane potential is negative and cell has a negative net charge. What stabilizes the cell against the leakage of the negative charge if pumps and channels are not responsible for this?

A: The findings about the strange behavior of cell membrane inspire TGD based answer. Cell membrane space-time sheet is its own quantum world and the flow of ions occurs only in the presence of magnetic flux tubes connecting it to the external world. These currents a however oscillatory

Josephson currents if dissipation is absent. Hence there is no need to cut completely the connections to the external world.

Q: How the resting state can result spontaneously if pumps are absent?

A: If ionic currents are Josephson currents, they are automatically oscillating and the return to the original state is guaranteed. The flux tubes carrying the ionic currents will be assumed to connect axonal micro-tubules to the space-time sheet of the cell interior. Consider first the most obvious objections.

1. Dark ions cannot transform to ordinary ones in the exterior of the cell membrane. This might indeed kill the model.

2. The second objection is that all biologically important ions are not bosons and the model for high T_c super-conductor in its recent form allows only electronic and protonic Cooper pairs at room temperature [29]. TGD based nuclear physics however predicts the possibility of exotic nuclei for which one or more color bonds connecting nucleons to the nuclear string are charged. These exotic nuclei with electronic states identical to those of genuine ions could save the situation.

The table below describes how cyclotron frequencies for $B = .2$ Gauss of the most important ions are modified in the simplest replacements with exotic ions. For instance, the notation Mg_{-}^{+2} tells that there is double electronic ionization and electron shell of Argon as usual but that one color bond is negatively charged.

$$\begin{array}{llll} Ion & f_c/Hz & Pseudo-ion & f_c/Hz \\ ^{23}Na^{+} & 13.1 & ^{19}Ne_{+} & 15.7 \\ ^{23}Na^{+} & 13.1 & ^{24}Mg_{-}^{+2} & 12.5 \\ ^{39}K^{+} & 7.7 & ^{40}A_{+} & 7.5 \\ ^{39}K^{+} & 7.7 & ^{40}Ca_{-}^{+2} & 7.5 \\ ^{35}Cl^{-} & 8.6 & ^{40}A_{-} & 7.5 \end{array} \quad (5.4.1)$$

$f_c(K+)$ and $f_c(Cl^-)$ are replaced with the frequency 7.5 Hz and one can do only using the cyclotron frequencies $f(Ca^{+2})/2 = 7.5$ Hz, $f_c(Mg^{+2}) = 12.5$ Hz, and $f(Ca^{+2}) = 15$ Hz. The nominal values of the lowest Schumann frequencies are 7.8 Hz and 14.3 Hz. All ions with relevance for nerve pulse and EEG could be bosonic ions or bosonic pseudo-ions. I do not know how well the needed ionization mechanisms are understood in the standard framework.

For small oscillations the maximal charge transfer ΔQ generated by an oscillating ionic Josephson current during the cycle is proportional to $\hbar/f_J \propto \hbar^2$ and $\hbar/\Omega \propto \hbar$ for solitonic situation. ΔQ is very small for the ordinary value of $\hbar$: also the oscillation period is very small. For large values of $\hbar$ situation changes and large maximal ion transfers are possible. An $\hbar$ increasing phase transition could be involved with the generation of the nerve pulse. Quantum criticality during nerve pulse generation indeed suggest the presence of flux tubes with varying values of $\hbar$. The lifetimes of the connected flux tubes could be proportional to $\hbar$ at criticality. A fractal hierarchy of pulses and EEG like oscillations of the membrane potential corresponding to various values of $\hbar$ is suggestive.

Q: Can one make this more quantitative?

A: One can construct a model based on Sine-Gordon wave equation for the phase difference Φ between the superconductors connected by Josephson junction sequences defined by magnetic flux tubes and idealizable as a continuous Josephson junction.

1. For a Josephson junction idealizable as a hollow cylinder with radius R and thickness d the expression of the Josephson current reads as

$$J = J_0 sin(Ze \int V dt/\hbar) \ .$$

J_0 is in case of cell membrane given by

$$J_0 = \frac{Ze2\pi dR}{\Lambda^2}\frac{\hbar}{m} \ ,$$

where R and d would be now the radius and thickness of the axon, Λ is the magnetic peneration length, and m is the mass of the charge carrier. Although this expression does not hold true as such when Josephson junctions are replaced by magnetic flux tubes connecting micro-tubules and axon, one can can safely make some qualitative conclusions. The amplitude of the Josephson current increases with $\hbar$. For electron the value of the amplitude is by a factor $x \simeq Am_p/m_e \simeq 2^{11}A$ larger than for ion with a mass number A. This gives for electron Cooper pairs a unique role as an initiator of the nerve pulse. Note that the amplitudes of the Josephson currents of electron and ions are quite near to each other if one has $\hbar(ion) = 2^{11}A\hbar e$.

2. Electronic Josephson current dominates and makes it ideal for the generation of nerve pulse (kick to gravitational pendulum). This is possible if the net amount of electronic charge is so small that it flows out during the generation of flux tubes. For ions this need not occur even if ion densities are of same order of magnitude. Constant voltage V creates an oscillating current and no catastrophic leakage takes place and the resting state results automatically. The ionic Josephson currents assignable to the magnetic flux tubes connecting micro-tubules through the cell membrane to the external world could be responsible for the nerve pulse.

3. The mechanical analog for Sine-Gordon system [54] assignable to Josephson junction is rotating pendulum but one must be cautious in applying this analogy. There are two options concerning the modeling of the situation.

   i) Membrane potential represents an external voltage $V(t)$ and one has $\Phi_i = Z_i e \int V dt/\hbar$, where Φ is the phase difference between Bose-Einstein condensates.

   ii) System is autonomous and membrane potential $V(t) = \hbar(d\Phi_i/dt)/Z_i e$ is completely determined by the dynamics of any phase Φ_i. This option is highly predictive and discussed in the sequel.

4. The analogy with gravitational pendulum allows to identify the phase angle Φ as the counterpart of angle Θ characterizing angular position of mathematical pendulum (note that this analogy can be misleading since it implicitly brings in 3-D thinking).

   i) In this picture rotating pendulum corresponds to a soliton sequence containing infinite number of solitons: both stationary and moving soliton sequences are obtained. The sign of $\Omega = d\Phi/dt$ is fixed and approximately constant for large values of Ω. Resting potential could correspond to this kind of situation and $\Omega \simeq 2\pi$ kHz is suggested by kHz synchrony. A mechanism of this synchrony will be discussed below. For large values of $\hbar$ even values of Ω in EEG range could correspond to membrane potential. For large values of Ω one as $V \simeq \hbar\Omega_i/Z_i e$. If also EEG rhythms correspond to Ω they must correspond to different values of $\hbar$ and $f \propto 1/\hbar$ would hold true. Changes in the dominating EEG rhythm (40 Hz, 10 Hz, 5 Hz,..) could correspond to phase transitions changing $\hbar$ to given value for a large number of axons. The maximal charge transfer during single period is proportional to $\Delta Q \propto 1/\Omega$.

   ii) Hyperpolarization/polarization would mean fastening/slowing down of the pendulum rotation and slowing down would make the system unstable. Near criticality against the generation of nerve pulse would mean that pendulum is rotating rather slowly ($\Omega \ll f_J$) so that a small kick can transform rotation to oscillation. The sign of $V \propto d\Phi/dt$ would change and large amplitude oscillatory motion would result for single period only after which a kick in opposite direction would lead back to the resting state. Membrane potential varies between the resting potential $V_0 = -75$ mV and $V_1 = +40$ mV during nerve pulse: $V_1 > |V_0|$ would have killed the model. Note that $V_1 = 40$ mV is rather near to the critical potential about $V_1 = 50$ mV: ideally these potentials should be identical.

   iii) The so called breathers -both stationary and moving- correspond to soliton-antisoliton bound state (see the visualization in [54]). Breathers could be identified as large amplitude oscillations around $\Phi = 0$ ground state. Physical intuition suggests that breathers are possible also for a ground state corresponding to a rotating pendulum (representing moving or stationary waves). They would correspond to kicking of one pendulum in a sequence of pendulums along z-axis rotating in phase at the initial moment. The kick could correspond to a genuine external perturbation generated by a pair electronic supra current pulses of opposite sign giving constant velocity increments $\Delta\Omega$ initiating and halting the nerve pulse just like they would do in the case of tqc but in opposite time order. If the background corresponds to a propagating EEG wave, also nerve pulse is expected to propagate with same velocity. The propagation direction of EEG wave would also explain why nerve pulses propagate only in single direction.

5. For the ordinary value of $\hbar$, the frequency Ω of the Josephson current corresponds to that assignable to energy .07 eV being around $f = 1.6 \times 10^{13}$ Hz and quite high. One can look at the situation in light of $r \equiv \hbar/\hbar_0 = 2^{11k}$ hypothesis, which has however turned out to be quite too restrictive. For $r \equiv \hbar/\hbar_0 = 2^{44}$ the frequency would be near to cyclotron frequency of about 1 Hz assignable to DNA strands. For $x = 3 \times 2^{3\times 13}$ f would be near to the fundamental 10 Hz frequency which is secondary p-adic time scale associated with electron and correspond to the temporal duration of negative energy space-time sheet assignable to electron. For $r = 3 \times 2^{3\times 11}$ one would obtain a 640 Hz frequency which corresponds to the time scale of nerve pulse. It seems clear that the original hypothesis that only powers of 2^{11} define the spectrum of Planck constant is too restrictive and Mersenne hypothesis introduced in the introduction seems more plausible hypothesis although even this hypothesis is too too restrictive [20]. The requirement that cyclotron frequencies and Josephson frequencies are proportional to each other for small oscillations would guarantee resonant behavior for common strength of the magnetic field would give $\hbar \propto A$. This would require that each ion species lives at its own flux tubes.

6. The realization that cell membrane could correspond to almost vacuum extremal [20] changed the situation completely. For vacuum extremals Z^0 and em fields are proportional and if one assumes that almost vacuum extremals define a phase in which the Z^0 charges of quarks are fed to almost vacuum extremal unlike electrons, one must replace ionic charges with effective charges proportional to the nuclear charge. This raises the energy scale defined by the resting potential to visible and UV range.Note that also neutral atoms are Z^0 ions in this phase. Otherwise the model for cell membrane as Josephson junction remains the same. This hypothesis can be defended by its success: it predicts correctly the values of frequencies of maximum sensitivity for photoreceptors in terms of Josephson energies of various ions and almost vacuum extremal property conforms also with the quantum criticality of living matter. This model will be be discussed in detail in the sequel.

Q: What instabilizes the axon? Why the reduction rather than increase of the magnitude of the membrane potential induces the instability? Why the reduction of the resting potential below the critical value induces nerve pulse?

A: Large enough voltage pulse between micro-tubules and membrane could generate electronic DC supra current. The introduction of a small amount of positive charge to the inner lipid layer and staying there for some time would generate the voltage pulse between micro-tubules and lipid layer so that DC electronic supra current would be induced, and induce the reduction $\Delta V \simeq .02$ eV of the magnitude of the membrane potential. A similar introduction of negative charge would induce hyperpolarization and the direction of the current would be opposite if it is generated at all. The mechanism generating the small positive charge to the inner lipid layer could be based on the exchange of exotic W bosons between pairs of exotic nuclei at opposite sides of the cell membrane so that the negative charge of the inner lipid layer would be reduced.

Q: Can one understand the observed radial force, the increase of the radius of axons and the reduction of its thickness, and heating followed by cooling?

A: The observed outward force acting on a test system might be due to the ionic Josephson currents to which the test system responds. During the second half of the pulse the sign of the ionic force is predicted to change. The pressure caused by the electronic Josephson current pulse might relate to the increase of the radius of the axonal membrane and with the reduction of its thickness as well as the slight increase of its temperature as being due to the electrons which heat the lipid layer as they collide with it. The ions return at the second half of the pulse and could transfer the heat away by convection.

1. This hypothesis gives the estimate for the force f per unit area as

$$\begin{aligned}
f_{2e}(t) &= \frac{dn(lipid)}{da} \times \frac{J(t)}{2e} \times \hbar k \\
&= \frac{dn}{da} \times U \times \frac{\hbar^2 k}{2m_e c} \times sin(\omega_J(2e)t) \ , \\
U &= \frac{2\pi A}{\Lambda^2} \ .
\end{aligned} \tag{5.4.2}$$

The parameter A corresponds to the parameter dR in the case that Josephson junctions have the thickness of axonal membrane, and is not relevant for order of magnitude estimate. R corresponds to the distance between micro-tubules and cell exterior space-time sheet to which flux tubes end. $dn(lipid)/da$ is the 2-D density Josephson junctions equal to the density of lipids.

$k \simeq 2\pi/R$ is the wave vector of electron Cooper pair at the magnetic flux tube. The 3-momentum of electron is enormous for the proposed value of $\hbar$, and the only possible interpretation is that the four-momentum of electron is virtual and space-like and corresponds to exchange of space-like virtual photon describing Coulomb interaction with lipid layer.

Λ^2 satisfies in the first approximation the formula

$$\Lambda^{-2} = \frac{4\pi e^2 n_e}{m_e} + \sum_I \frac{4\pi e^2 n_I}{A m_I} = \alpha_{em} 16\pi^2 \times [\frac{\hbar_0 n_e}{m_e} + \sum_I \frac{\hbar_0 n_I}{A_I m_I}] \ . \tag{5.4.3}$$

Note that there is no real dependence on $\hbar$. Above critical voltage electrons could dominate in the expression but during nerve pulse ions should give the dominating contributions. U cannot be too far from unity.

2. From this one can integrate the total momentum of Cooper pairs transferred to the lipid layer before the flux tubes fuse together if one knows the value of time t when this happens. $F \propto \hbar^2/m_e^2$ proportionality implies that for the required large value of $\hbar/\hbar_0 \simeq 3 \times 2^{33}$ the force is by a factor 6×10^{20} stronger than for $\hbar_0$.

3. The force caused by ionic Josephson currents on piston is given by

$$f(t) = \sum_I \frac{2me}{m_I} \frac{2}{Z_I} \times f_{2e}(\frac{Z_I}{2} \frac{\Omega}{\omega_J} t) \ . \tag{5.4.4}$$

The comparison with the observed force gives estimate for the value of magnetic penetration length and thus density of electrons at the flux tube.

4. According to [61] in one particular experiment the force on piston of area $S = .01$ cm^2 at the maximum of voltage ($t = 2\pi/\Omega$) is $F = 2$ nN. This gives a killer test for the model. One obtains an estimate for the parameter $U = \frac{\Lambda^2}{2\pi A}$ as

$$U \equiv \frac{\Lambda^2}{2\pi A} = \frac{dn}{da} S \times \frac{\hbar^2 k}{m_p c F} \times \sum_I \frac{2}{A_I Z_I} \ . \tag{5.4.5}$$

The value of U should not deviate too much from unity. One can use the estimates

$$\frac{\hbar}{\hbar_0} = 3 \times 2^{33} \ , \quad k = \frac{2\pi}{R} \ .$$

Note that the experimental arrangement forces to use this value of k. The actual value in normal situation could be smaller and depends on the distance of the boundary of cell exterior space-time sheet on micro-tubules. Using the values $d = 10$ nm and $R = 5$ μm this gives

$$\begin{aligned} U &\simeq \sum_I \frac{2}{A_I Z_I} \times X \ , \\ X &= 9 \times 2^{66} \times \frac{\hbar_0^2 2\pi}{m_p c F R} \times \frac{S}{S(lipid)} \ . \end{aligned} \tag{5.4.6}$$

The factor $X = .9267$ is of order unity! Taking into account that $\hbar/\hbar_0$ is enormously large number it is difficult to believe that the result could be mere accident. Hence U does not deviate too much from unity and there are good hopes that the model works.

For $n_I = x_I/a^3$, $a = 10^{-10}$ m, and $A = dR$ one obtains a direct estimate which combined with above estimate gives two conditions which should be consistent with each other:

$$\begin{aligned} &U = 76.1 \times \textstyle\sum_I \frac{x_I}{A_I} \ , \\ &U = .93 \times \textstyle\sum_I \frac{2}{A_I Z_I} \ . \end{aligned} \tag{5.4.7}$$

These estimates are consistent for $x_I \sim 10^{-2}$, which makes sense.

Q: Where the primary wave propagates: along axon or along micro-tubules?

A: This question need not make sense if micro-tubules and axon are connected by magnetic flux tubes to form single quantum coherent system. That axonal micro-tubules have constant electric field which is always in same direction could explain why the background soliton sequences and nerve pulses propagate always in the same direction and suggests that the primary wave propagates along micro-tubules. On the other hand, if W exchange between cell exterior and exterior reduces the negative charge of the inner lipid layer then axon could be seen as initiator. This could induce conformational or gel-sol phase transition propagating along micro-tubule and inducing the pair of voltage pulses in turn inducing the fusion of flux tubes at cell membrane which in turn would induce criticality of the axonal membrane. For this option axonal soliton would be a shadow of the micro-tubular soliton rather than completely independent dynamical process.

Q: How nerve pulse velocities are determined?

A: At first glance it seems nerve pulse velocity v could be determined by boundary conditions guaranteing synchronization of neuronal activity rather than by dissipation as in Hodgkin-Huxley model. As a matter fact, dissipation turns out to affect also v just because it is determined by boundary conditions!

1. Hodgkin-Huxley model would suggest that nerve pulse velocity is dictated by frictional effects as an analog of a drift velocity. The rough order of magnitude estimates for the velocities of conformational waves along micro-tubuli are consistent with the velocities of nerve pulses. The proportionality $v \propto d$ of nerve pulse velocity to nerve axonal radius might be understood as resulting on the dependence on the length of flux tubes connecting axon and micro-tubules and mediating a frictional feedback interaction from axon. Feedback would be naturally reduced as d increases. Feedback interaction could explain also the sensitivity of the thermal parameters of the axonal membrane to the proteins in its vicinity. If the frictional feedback is due to the environmental noise at the axon amplified at quantum criticality this is what one expects. Quite generally, quantum criticality would explain the high sensitivity of the thermal parameters on noise. Saltation cannot be responsible for the higher conduction velocity in myelin sheathed portions of axon. The insulation would reduce the environmental noise at the level of axons and thus reduce the frictional feedback from axon to the micro-tubules.

2. The introduction of friction is however problematic in the recent situation. In absence of boundary conditions Sine-Gordon equation predicts for the propagating soliton sequences a continuous velocity spectrum and friction should affect Ω and V rather than phase velocity v but it is not clear whether it can affect v.

   (a) In this framework the boundary boundary conditions at the ends of the axon or some subunit of axon would dictate the values of v: $\gamma\Omega L/v = n2\pi$ corresponds to periodic boundary conditions (note that $\gamma = \sqrt{1-(v/c)^2} \simeq 1$ holds true). $v = \Omega L/n2\pi$ implies that friction indeed affects also v.

   (b) The relationship states that the time taken by the nerve pulse propagate through the axon is always $T = L/v = n2\pi/\Omega$: this would synchronize neurons and $\Omega \simeq 2\pi$ kHz is suggested by the well-known 1 kHz synchrony difficult to understand in the standard framework where v would be determined by chemistry rather than geometry. Myelin shielding could in this picture guarantee that coherent wave propagation is possible over the entire axon so that boundary conditions can be applied.

   (c) This would give $v \simeq \Omega L/n2\pi < \Omega L/2\pi$. $\Omega = 2\pi$ kHz and $n = 1$ would give for $L \in$ [1 cm -10 cm] $v \in$ 10 m/s-100 m/s corresponding roughly to the observed range of values. For short axons velocity would be lower: for $L = 10$ μm one would have $v = .01$ m/s. For longer axons the value of n could be higher or the axon would decompose into structural units for which periodic boundary conditions are satisfied. The sections between Ranvier nodes have length measured in millimeters as are also the lengths of axonal micro-tubules and 1 mm would correspond to a velocity of 1 m/s. The actual velocity for the myelinated sections varies between 18-100 m/s so that basic structural units should be longer. The proportionality of v to the radius of axon would follow from the proportionality of the length of the axon or its basic sub-unit (not longer than $\sim$ 10 cm) to its radius: the simplest geometric explanation for this would be in terms of scaling invariance of the axonal geometry consistent with fractality of TGD Universe. In the standard framework this proportionality would be explained by the minimization of dissipative losses in the case of long axons: one cannot exclude some variant of this explanation also now since friction indeed reduces v.

   (d) There is an electric field associated with micro-tubules (always in same direction). Could this electric field play the role of external force feeding energy and momentum to the moving soliton sequence to compensate dissipation so that v would have interpretation as a drift velocity?

Q: Can one understand EEG in this framework?

A: Just like kHz waves also EEG generating waves could correspond to propagating soliton sequences. Since V is not affected, the value of $\hbar$ must be much larger and one must have $\hbar \propto f$, where f defines the EEG rhythm. It is known that EEG amplitudes associated with EEG rhythms behave roughly like $1/f$. This can be understood. By Maxwell's equation the divergence of electromagnetic field tensor is proportional to 4-current implying the amplitude of EEG identified as Josephson radiation is proportional J_0/Ω and therefore to $\hbar$. The propagation velocity $v = \Omega L/2\pi n$ of EEG generating waves is rather slow as compared to kHz waves: for $f = 10$ Hz one would have 10 cm long axon $v = 1$m /s. Synchronization results automatically from periodic boundary conditions at the ends of the axons.

Nerve pulses during EEG rhythms would have much slower velocity of propagation and the duration of nerve pulse would be much longer. The maximal charge transfer would be proportional to $1/\hbar$. It would thus seem that EEG and nerve pulse activity should exclude each other for a given axon. Ω is however smaller so that the generation of nerve pulse is easier unless also ion densities are lower so that J_0 (analogous to gravitational acceleration g in pendulum analogy) is reduced. Perhaps this takes place. The consistency with the propagation velocity of micro-tubular conformational (or even gel-sol-gel) waves might pose additional constraints on v and thus on frequencies Ω for which nerve pulses are possible. That ordinary EEG is not associated with ordinary cells might be due to the fact that $\hbar$ is much smaller: the fractal analog of EEG generating waves could be present but these EEG waves would correspond to faster oscillations in accordance with the view about evolution as an increase of $\hbar$.

Could Hodgkin-Huxley model provide a phenomenological description?

It is now clear that the physics behind Hodgkin-Huxley model is not consistent with the physics behind the TGD based model of nerve pulse. The cell as gel hypothesis excludes Hodkin-Huxley model even without any TGD based physics. If ionic currents were ordinary Ohmic currents as in the case of soliton model and Pollack's model, Hodgkin-Huxley model might be interpreted as a phenomenological description. In TGD framework the dark currents do not dissipate and the model can serve only a recipe to mimic the time evolution of the ionic currents by a judicious tailoring of the time dependence of ionic conductances.

The current associated with a given ion would be proportional to the sum of the electric forces experienced by the particle:

$$I_X = g_X\left[Q_X e(V_{em} - V_X)\right] \quad .$$

In the catastrophe theoretic variant of the Hodgkin-Huxley model [51], which assumes a wave (Ca^{+2} now) triggering the nerve pulse, the values of the ionic conductivities g_{Na}, g_{Cl} and g_K at resting state are $g_{Na} = 0$, $g_{Cl} = .15\ mmho/cm^2$ and $g_K = .24\ mmho/cm^2$ The values of V_X are $V_K = -77$, $v_{Na} = +50$, $v_{Cl} = -46$, when millivolt is used as unit. The value of the resting potential is $v_R = -65$ mV. The vanishing of g_{Na} at the resting value and down to the point, when nerve pulse is triggered, is assumed in Hodgkin-Huxley model and in the catastrophe theoretic model of the nerve pulse [51]. The vanishing of g_{Na} codes for the absence of magnetic flux tubes in TGD framework.

5.4.3 Could scaled variants of weak bosons be key players in the model nerve pulse?

One of the basic predictions of classical TGD is the presence of long range weak and color forces. It took quite a long time to accept this and realize that TGD predicts fractal hierarchy of copies of weak and color physics and that these scaled variants might be crucial for the understanding of living matter and even nuclear and condensed matter physics.

I have done a considerable amount of work in trying to clarify whether this new physics might allow to understand the generation of nerve pulse. Nerve pulse is generated when the voltage over cell membrane is reduced from $\simeq -70$ mV to a critical voltage $\simeq -55$ mV. This means that Josephson frequency is also reduced. Josephson current generates EEG and ZEG patterns as coherent states or Bose-Einstein condensates of photons and Z^0 quanta. The criticality with respect to nerve pulse generation means that the rotating pendulum representing the soliton sequence in the resting state has rotation velocity just above the critical velocity below which rotating motion transforms to oscillatory motion. The step reducing the voltage below the critical one is the flow of ions through the cell membrane.

The basic problem is to understand how resting potential is reduced below the critical value -55 mV. One can divide the mechanisms to three types depending on whether ordinary charge flow, reduction of charge entanglement, or exchange of virtual or real W bosons is involved.

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 exists a stronger correlation betweeen 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 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 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.

Mersenne primes and their Gaussian counterparts define a hierarchy of copies of standard weak physics with reduced mass scales and also their dark counterparts. Therefore weak interactions should be central for the understanding of living matter. For instance, chiral selection could be understood in terms of relatively strong parity breaking interactions assignable to weak bosons.

The narrow range of physiological temperatures suggest that almost vacuum extremal property is possible only above some temperature whereas superconductivity would be possible below some critical temperature. Therefore cell membrane can also correspond to far from vacuum extremal and if Josephson currents still flow, the scale of Josephson energies would be reduced to infrared and be just above the thermal threshold which encourages to consider this possibility seriously.

The two phases would differ in that for almost vacuum extremals classical em and Z^0 fields are possible and for far from vacuum extremals em and W boson fields are possible if one assumes a CP_2 projection of space-time surface to belong to a geodesic sphere, which can be homologically trivial or non-trivial. The challenge is to understand the implications from the point of view of bio-control and -communication.

Generation of charge by a state function reduction of a charge entangled state

MEs are ideal for control purposes since the field propagates with light velocity so that dispersion is absent and the field pattern is arbitrary as a function of time at a given point. Charged W MEs make possible charge entanglement between Bose-Einstein condensate of ions at various levels of p-adic and dark matter hierarchies. Denote the charges of ions in their usual state by Q_n and Q_m: the subscript refers to neuronal interior or magnetic body.

Charge entanglement means that cyclotron B-E condensates of ions with charges Q_n and Q_m develop exotic nuclear charges due to the transformation of $q\overline{q}$ color bonds to $u\overline{d}$ or $d\overline{u}$ type color bonds in the external W field.

If only single charged color bond can be created, the entangled state is of form

$$|Q\rangle = a|Q_n\rangle|Q_m\rangle + b|Q_n+1\rangle|Q_m-1\rangle + c|Q_n-1\rangle|Q_m+1\rangle \tag{5.4.8}$$

Since the classical W field inducing the entanglement is real, one must have $|b|^2 = |c|^2$. One has $|b|^2 \propto |W|^2$ in the approximation that the transversal W field associated with ME is constant inside neuron. $Ca^{++,+}$ and $Ca^{++,-}$ exotic ions are the most plausible option but their are also other options as Table 1 below shows. The reason for the preferred role of Ca ions is that Ca waves play a key role in bio-control in a wide range of time scales [108]. That they do not appear in the standard version of Hodgkin-Huxley model conforms with the assumption that they are in dark matter matter phase.

The quantum phase transition reducing the charged entanglement of the Bose-Einstein condensate leads with a probability $|b|^2$ to the state $|Q_n+1\rangle|Q_m-1\rangle$ so that the negative charge of the neuron interior is reduced. The rate for the state function reduction process is proportional to the intensity $|W|^2$ of W boson field and N^2, N the number of bosons in the condensate. The quantum randomness of the process is consistent with the randomness of nerve pulse emission.

If the resulting positive charge is large enough, membrane potential reduces below the value 50 mV at which nerve pulse is generated. Only this option is consistent with the model allowing to understand how big leaps in evolution (molecular life, prokaryotes, eukaryotes, animal cells, neurons, EEG) correspond to the emergence of new levels in dark matter hierarchy.

Exchange of exotic W bosons between cell interior and exterior

Exchange of exotic $W^{\pm}$ allows charge exchange between charged particles at different sides of cell membrane. This charge transfer mechanism would be nonlocal and essentially quantal. Quite generally, the exchange of $W^{\pm}$ boson could provide a very general non-local mechanism of bio-control by inducing currents of em and weak currents through Josephson junctions. Em and Z^0 fields would in turn be associated with communication and coordination.

If Bose-Einstein condensates are in question the rate of this process is large due to its quantum coherence. There are several candidates for the Bose-Einstein condensates.

The role of Ca^{+2} ions

Ca^{+2} ions are perhaps the most important bosonic ions and their dark Bose-Einstein condensates are expected to be key actors in bio-control although also other bosonic ions are very probably involved (see Table 1 below). Ca^{+2} waves are indeed central tool of bio-control and their velocities span a very wide range.

The model for nerve pulse led to a proposal that phase transitions increasing $\hbar$ and thus generating flux tubes between gel phase and its sol-like environment make possible the flow of mono-valent dark ions from the environment to the gel phase and induce gel-sol phase transition. The propagating gel-sol-gel phase transition would generate nerve pulse, and its fractally scaled variants corresponding to various values of $\hbar$ could generate Ca^{+2} waves accompanied by a periodic variation of em potentials. Also the miniature- and micro-potentials associated with the postsynaptic neuronal membrane could correspond to standing Ca^{+2} waves with an appropriate value of Planck constant.

A more speculative idea is that charge entanglement involving a periodically varying W boson field could induce Ca^{+2} waves by inducing the $\hbar$ increasing phase transition. The cautious prediction is that the most important time scales in question should come as $r = 2^{k_d}$ multiples of p-adic time scales defined by Mersenne primes and Gaussian Mersennes, where the values of k_d are fixed by Mersenne hypothesis introduced in the introduction. The propagation with a finite velocity could correspond to the motion of the second end of W boson ME along tissue or to a phase of W field varying in a direction transversal to the light-like wave vector assignable with W ME.

Ion	f_1/Hz	E_1/eV
$^6Li^+$	50.1	3.3
$^{24}Mg^{2+}$	25.0	1.65
$^{16}O^{2-}$	37.6	2.48
$^{32}S^{2-}$	18.8	1.24
$^{40}Ca^{2+}$	15.0	.99
$^{55}Mn^{2+}$	11.4	.75
$^{56}Fe^{2+}$	10.8	.71
$^{59}Co^{2+}$	10.0	.66
$^{64}Zn^{2+}$	9.4	.62
$^{80}Se^{2-}$	7.6	.5

Table 1. The first columns give the cyclotron frequencies and cyclotron energies for biologically relevant bosonic ions in endogenous magnetic field assumed to have strength $.2 \times 10^{-4}$ Tesla. The third column gives cyclotron energy.

1. Is nerve pulse conduction accompanied by the propagation of Ca^{+2} wave?

Hodgkin-Huxley model introduces the velocity of conduction of nerve pulse in a rather ad hoc manner. To my limited knowledge the mechanism behind the finite velocity of conduction of nerve pulse remains poorly understood. In the catastrophe theoretic model of the nerve pulse [51] an unidentified wave triggering nerve pulse is assumed for purely mathematical reasons. Ca^{+2} waves as waves guiding the propagation of nerve pulse are a natural guess in this respect. W MEs associated with nerve pulse transversal to axon could extend along its entire length and the variation of the phase of W ME in transversal direction could induce Ca^{+2} wave in turn inducing the conduction of nerve pulse with a finite velocity.

One can of course wonder whether the observed Ca^{+2} waves can really relate to entanglement oscillations of dark matter Bose-Einstein condensate. This depends on how direct the detection of the waves is: certainly the indirect detection of dark ions based on Faraday effect is possible. Note that Ca^{+2} BE condensate behaves like dark matter is consistent with the fact that Ca^{+2} conductance need not be taken account in the simplest variant of Hodgkin-Huxley model.

2. Ca^{+2} waves and synaptic contact

The action potential is known to trigger the transfer of Ca^{+2} ions into the presynaptic terminal and the presence of Ca^{+2} ions is essential for the emission of the neurotransmitters. The synaptic vesicles containing neuro-transmitters fuse with the presynaptic membrane and neurotransmitters are released. Neuro-transmitters bind to the postsynaptic proteins in the postsynaptic membrane changing their conformation, which in turns leads to ion flows and the generation of micro–potentials generated by transmitter molecules summing up to miniature synaptic potentials. It is known that the emission of the synaptic vesicles is a quantum process and that the emission of a single synaptic vesicle gives rise to a miniature synaptic potential of amplitude of about 1 mV [95].

The most natural interpretation for what happens in synaptic contact is that nerve pulse patterns are transformed to chemical qualia analogous to tastes and odors and that every synapse is specialized to generate particular kind of chemical qualia. These qualia need not be our chemical qualia which in TGD framework are assignable to the primary sensory organs. Neuronal sensory qualia could at our level of hierarchy give rise to emotions. These qualia could shared by the magnetic body at appropriate level of dark matter hierarchy. Charge entanglement for subsystems is the TGD based manner to achieve the sharing of mental images and this bring in Ca^{+2} B-E condensates.

3. Other functions of Ca^{+2} waves

Ca^{+2} currents are also related to the conformational changes of proteins, in particular microtubules, and are believed to be somehow involved with the delocalization of electrons. Ca^{+2} ions are also involved with GTP-GDP hydrolysis. Probably rather low level of dark matter hierarchy is in question in both cases.

Besides this Ca^{+2} ions are involved with local sol-gel transitions associated with the actin microfilaments driving cell motility, which involves generation of long range order and can be regarded as a self-organization process. Sol-gel transitions occur cyclically and the natural unit for rate is 10 cycles per second. This suggests that multiples of Ca^{+2} cyclotron frequency determine the rates and that the process is quantum controlled by EEG and WEG and corresponds to $k_d = 46$ level of dark matter hierarchy.

5.4.4 Could cell correspond to 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 [96] 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 prequisite 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 visiona 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 [45] 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 correponding 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 [45]

$$\gamma = 3J - \frac{p}{2}Z^0 \quad , \quad Q_Z = I_L^3 - pQ_{em} \quad , \quad p = sin^2(\theta_W) \tag{5.4.9}$$

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 large 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.

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 s 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

$$f_\nu = \frac{m_e}{m_\nu}\frac{1}{2sin^2(\theta_W)}f_e \quad .$$

From $f_e \simeq .57\times$ MHz and $p = sin^2(\theta_W) = .23$ one obtains $E_\nu = 1.7 \times 10^{-2}$ eV which is rouhgly 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 conlude that the value of Weinberg angle in the phase near vacuum extremal must be $p = .0295$ if one wants to reproduces 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

$$E = \sqrt{g_Z Q_Z B_Z 2\pi} \simeq .48\ \ eV$$

giving the metabolic energy quantum. Does this mean that Z^0 cyclotron frequency for neutrino is related to the transfer of metabolic energy using 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

$$E = \sqrt{n} r^{1/2} \sqrt{g_Z Q_Z B_Z 2\pi} \simeq r^{1/2} \times .48\ \ eV \ \ ,\ \ r = \sqrt{\hbar/\hbar_0}\ \ .$$

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 expecation vanishes so that this interpretation might make sense.

It is easy to test whether Hodgkin-Huxley model tolerates the inclusion of Z^0 field and the assumption that nuclei and neutrinos or antineutrinos serve as its sources. In the cell scale neutrinos would indeed serve as a natural source of classical Z^0 fields. The simplest assumption is that neutrino current guarantees that the almomst acuum extremal property prevails during the nerve pulse.

Goldman equation in Hodgkin-Huxley model

Consider first Hodgkin-Huxley model in order to understand how to generalize it to take into account the couplings of nuclei and neutrinos to the classical Z^0 field. In Hodkin-Huxley model the basic equations state flow equilibrium. The basic equation is so called Goldman equation [122].

1. Ion current j_A is a sum of two terms:

$$j_A = D_A(\frac{dn_A}{dz} - b_A n_A)\ \ ,\ \ b_A = \frac{q_A e E}{k_B T}\ \ ,\ \ E = \frac{V}{d}\ \ . \tag{5.4.10}$$

The first term is a diffusion term proportional to concentration gradient of ion and second term a drift term proportional to ion concentration n_A and the electric field E assignable to cell membrane and defined as membrane potential V divivided by the thickness of cell membrane d. Stokes-Einstein equation implies that the coefficient of electric force in drift velocity is expressible in terms of the diffusion constant D_A defining ionic permeability as $P_A = D_A/d$.

2. The equations for the ion currents can be integrated with respect to the coordinate z orthogonal to the cell membrane and give the currents in terms of differences of concentrations outside and inside membrane. The outcome is

$$j_A = D_A b_A \frac{n_A(in)exp(b_A d) + n_A(out)}{1 - exp(b_A d)} \ . \qquad (5.4.11)$$

The change of the sign of the charge changes the sign of b and implies only the replacement in$\leftrightarrow$out and changes of the sign in the above formula. The explicit expression reads as

$$j_A = \mu q_A P_A \frac{n_A)(out) - n_A(in)exp(q_A \mu)}{1 - exp(q_A \mu)} \ , \ \mu = \frac{eV}{kT} \ . \qquad (5.4.12)$$

Note that the multiplication by q_A compensates the change of sign in j_A.

3. The condition that total electric current vanishes reads as

$$j_{tot} = \sum q_A j_A = 0 \qquad (5.4.13)$$

It gives Goldman equation [122]. If the charges have same magnitude ($q_A = \pm 1$) the equation can be solved as

$$\begin{aligned} \mu &= log(\frac{w}{v}) \ , \\ w &= \sum_C P_C n_C(out) + \sum_A P_A n_A(int) \ , \\ v &= \sum_C P_C n_C(in) + \sum_A P_A n_A(out) \ . \end{aligned} \qquad (5.4.14)$$

Here C refers to positively charged ions (cations) and A to negatively charged ones (anions). In the physical situation only K_+,Na_+, and Cl_- are the interesting ions and only K_+ conductivity differs considerably from zero due to the continual pumping of K_+ ions against the concentration gradient. This gives a more explicit formula

$$eV = k_B T \times log(\frac{P_{K^+} n_{K^+}(out) + P_{Na^+} n_{Na^+}(out) + P_{Cl^-} n_{Cl^-}(in)}{P_{K^+} n_{K^+}(in) + P_{Na^+} n_{Na^+}(in) + P_{Cl^-} n_{Cl^-}(out)}) \ . \qquad (5.4.15)$$

relating the resting potential to the ratios of ionic concentrations outside and inside membrane and ionic conductivities which are parameters, which cell is able to modify and does it during the generation of nerve pulse. During nerve pulse in practice only the flows of K_+ and Na_+ ions matter. In the beginning of nerve pulse Na_+ conductance increases and K_+ conductance is reduced. This changes the sign of potential and after that the situation returns to the original one.

Hodgkin-Huxley model for the resting potential for nearly vacuum extremals

One can formulate Hodgkin-Huxley model for the resting potential for exact vacuum extremals by replacing the membrane potential with its Z^0 counterpart since the couplings to em charge vanish assuming that Weinberg angle vanishes for vacuum extremals. The surprising outcome is that one could understand the preferred frequencies for photo-receptors [109] 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. Also neutrino conductance could be added as a parameter to the model.

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 neuron (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 [106]. 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 vecotor coupling is following

$$\begin{aligned} (\frac{Z-N}{4}-pZ)Z^0+q_{em}\gamma &= Q_{eff}\gamma \ , \\ Q_{eff} &= -\frac{Z-N}{2p}+2Z+q_{em} \ . \end{aligned} \tag{5.4.16}$$

Here γ denotes em gauge potential. For K^+, Cl^-, Na^+, Ca^{+2} 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.

$E(Ion)/eV$	$V=-40\ mV$	$V=-60\ mV$	$V=-70\ mV$
Na^+	1.01	1.51	1.76
Cl^-	1.40	2.11	2.46
K^+	1.64	2.47	2.88
Ca^{+2}	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 $V=-40$ mV corresponds to the resting state for photoreceptors and $V=-70$ mV to the resting state of a typical neuron.

Consider now Hodgkin-Huxley model with the resting potential replaced with an effective resting potential due to the classical Z^0 field and the couplings of nuclei to it.

1. The flow equilibrium condition for the Hodgkin-Huxley model changes since the charges (1,-1,1) for K^+, Cl^- and Na^+ are replaced with the ratios $Q_{eff}(I)/Q_{eff}(K^+) = E(I)/E(K^+)$ giving ratios $(1, E(Cl^-/E(K^+), E(Na^+)/E(K^+)$, which are of same sign.

$$j_{em,tot} = \sum q_{em,A}j_A = 0 \ . \tag{5.4.17}$$

   The resulting equation for the resting potential is more complex and can be solved only numerically. The facts that the charges are of same sign and the conductivity of Cl^- is small, means however that the situation need not change too much qualitatively. Of course, all cell membranes need not be near to vacuum extremal. It could be that only neuronal membranes or only sensory receptor membranes ready to respond rapidly could satisfy this condition.

2. Also neutrino current would contribute to the ionic currents in the modification of the Hodgkin-Huxley model. If the near vacuum extremal property is preserved during the nerve pulse, neutrino current is fixed from the condition that it compensates the ionic contributions to Z^0 current in flow equilbrium. Since nuclei tend to have more neutrons than neutrinos, antineutrino background should more or less compensate the nuclear Z^0 charge so that the antineutrino current should be equal to the total ionic current. The condition that totalZ^0 current vanishes reads as

$$j_{Z^0,tot} = \sum q_{Z^0,A}j_A = 0 \ . \tag{5.4.18}$$

   Here also neutrino current is included and the condition allows to solve it in terms of other currents.

5.4.5 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 [109, 118]. 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^{+2} currents are known to present during the activation of the photoreceptors. Na^+ current defines the so called dark current [109] 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^{+2} 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 [105]. 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^{+2} 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^{+2}, and K^+ a correspond to the peak energies for cones sensitive to red, green, and blue respectively. Also Cl^- is in the blue region. Ca^{+2} 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 [105], which the normal value of resting potential. For this voltage Josephson energies are predicted to be in UV region except in case of Ca^{+2}. This would suggests 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^{+2}
$E_J(.04\ mV, p = .23)/eV$	1.01	1.40	1.51	1.76
$E_J(.065\ V, p = .23)/eV$	1.64	2.29	2.69	2.73
$E_J(40\ mV, p = .0295)/eV$	1.60	2.00	2.23	1.68
$E_J(50\ mV, p = .0295)/eV$	2.00	2.49	2.79	2.10
$E_J(55\ mV, p = .0295)/eV$	2.20	2.74	3.07	2.31
$E_J(65\ mV, p = .0295)/eV$	2.60	3.25	3.64	2.73
$E_J(70\ mV, p = .0295)/eV$	2.80	3.50	3.92	2.94
$E_J(75\ mV, p = .0295)/eV$	3.00	3.75	4.20	3.15
$E_J(80\ mV, p = .0295)/eV$	3.20	4.00	4.48	3.36
$E_J(90\ mV, p = .0295)/eV$	3.60	4.50	5.04	3.78
$E_J(95\ mV, p = .0295)/eV$	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^{+2} 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^{+2} 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^{+2} 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.

5.4.6 Model for anesthetic action

The molecular mechanism of the anesthetic action is a fascinating unsolved problem of neurophysiology. Noble gases have very weak chemical interactions. Despite this many noble gas such as Xe, Kr, Ar but to my best knowledge not Ne and He, act as anaesthetics. Also chemically non-inert molecules have quite similar narcotic effect so that chemistry does not seem to matter as Hodgkin-Huxley model would predict.

Simplest model for the anesthetic action

It is known that the narcotic efficiency of anesthetics correlates with their solubility in lipids [115]. Anesthetics also reduce the melting temperature of the lipid layer. Strong pressure increases the melting temperature and it is known that high pressure brings consciousness back. Thus anesthetic molecules dissolved into the lipid membrane should hinder the generation of the nerve pulse somehow and liquid state of the axonal membrane could be the reason for this. The explanation of the soliton model for the anesthetic action [58, 61] is that the metabolic energy needed to generate an acoustic soliton becomes too high when axon is too high above the critical temperature.

To get a useful perspective note that also the problem why ordinary cell and neuronal soma outside axonal hillock do not allow action potentials is poorly understood. The fact that anesthetes interact so weakly is the basic problem which could be solved by the almost vacuum extremal property predicting that also noble gas atoms are highly charged Z^0 ions so that they are expected to behave very much like ordinary ions in the cell membrane.

1. Pollack's model [86] suggests that anesthetics could hinder the occurrence of the gel-sol phase transition for the peripheral cytoskeleton. Suppose that $\hbar$ increasing phase transition for the magnetic flux tubes connecting peripheral cytoskeleton to the axon extends them to the axonal exterior and makes possible the influx of monovalent ions inducing gel-sol phase transition. Perhaps anestthetics prevent this phase transition somehow.

2. The obvious idea is that anesthetized axonal membrane (or at least axonal hillock) is just like the ordinary cell membrane. The model for DNA-cell membrane system as a topological quantum computer requires the liquid-crystal property of the lipid layers of the ordinary cell membrane and neuronal membrane outside axonal hillock. If this is the case, then liquid phase for axonal membrane implied by the anesthetic action would indeed make it more or less equivalent with the ordinary cell membrane. Therefore the question is why the liquid-crystal property of the ordinary cell membrane prevents the generation of the action potential. Naively one could think that the freezing of the membrane means that the mechanical deformation of the membrane occurring during nerve pulse becomes impossible. The presence of noble gas Z^0 ions could induced the freezing. Perhaps they induce a phase transition taking the cell membrane space-time sheet to far from vacuum extremal.

3. Suppose that the phase transition increasing $\hbar$ is induced by the reduction of the voltage over the axonal membrane (assume to be much smaller than cell potential) inducing almost vacuum property and quantum criticality. Somehow the presence of anesthetics would prevent this. Either the voltage over the membrane is increased in magnitude so that the flow of dark ionic currents to the membrane is not enough to induce quantum criticality or the flow of dark currents is completely prevented by the presence of noble gas Z^0 ions. The first option is more economical and could be tested by finding whether the voltage over the axonal membrane (membrane in a solid state) is considerably smaller than that over the ordinary cell membrane (membrane in liquid-crystal state). The first option also predicts that during sleep the increase of cell potential (hyperpolarization) actually corresponds to the increase of the membrane potential.

Could cyclotron transitions of noble exotic ions in theta and delta bands induce lullaby effect?

Just for fun can consider also more exotic explanation for the anesthetic action. If dark weak force is to have any biological role, the cellular environment should induce a generation of anomalous weak isospin due to the charged color bonds inside nuclei of noble gas. This would obviously relate closely to the anomalous properties of water explained in terms of dark matter hierarchy in [19, 16]. The color bonds carry also em charge so that noble gas atom with single charged color bond would behave like an ion with nuclear charge Z+1 or Z-1 and electronically like ion with full electronic shell due to ionization (say Cl^- or K$^+$ in the case of Argon). An important point is that the exotic ions are bosons and can form thermally stable Bose-Einstein cyclotron condensates at $k_d = 47$ flux sheets unlike ordinary ion with mass number differing by one unit.

An interesting question is whether some fraction of Cl^- and K^+ ions are actually exotic Argon ions. Also the long ranged color force and dark weak force with range associated with noble gas nuclei in dark phase could be part of the solution of the mystery.

EEG and ZEG bands above theta band correlate with consciousness. The cyclotron frequencies of ions of anaesthetic noble gases are in theta and delta band as are also EEG frequencies during various stages of sleep but for Ne and He this is not the case. This might not be a mere accident. For instance, one could imagine that the strong resonances in theta and delta bands in EEG induced by Xe, Kr, or A could steal the power otherwise going to higher EEG bands and induce a lullaby effect leading to anaesthesia. This effect of course does not exclude the proposed effect reducing the nerve pulse activity.

According to the general model of EEG [20], the magnetic flux sheets traversing DNA double strands in cell nuclei come in two varieties corresponding to the two possible quantization of magnetic flux as $Z\int BdS = n\hbar(4)$. For $Z=1$ the field strength is very near to B_E and for $Z=2$ to $B_E/2$, with $B_E = .2$ Gauss, the strength of endogenous magnetic field explaining the findings of Blackman and others. For instance, left and right brain hemispheres might correspond to $Z=1$ and $Z=2$ and the scale for cyclotron frequencies for right hemisphere would be half of that for left hemisphere. During sleep $Z=2$ cyclotron frequencies are responsible for EEG via the interaction with Josephson junctions generating the satellites $f_c \pm f_J$ of these frequencies, $f_J = 5$ Hz for $Z = 2$ and $f_J = 2.5$ Hz for $Z = 1$.

The cyclotron frequencies of exotic ions $(Xe^+, Kr^+, Ar^+, Ne^+, He^+)$ are (2.15,3.57,7.5,15,75) Hz for $B = B_E$ and (1.08,1.78,3.75,7.5,37.5) Hz for $B = B_E/2$. It would be interesting to check whether EEG contains narrow bands around these frequencies during anesthesia. Also the satellites $f_\pm = f_c \pm f_J$, $f_J = 5$ Hz, could be present. For all noble gas anaesthetics Xe, Kr, and Ar both frequencies are below 7.5 Hz and thus in theta and delta bands. This would encourage to think that the presence of these bosonic exotic ions amplifies the EEG frequencies usually assigned with the theta and delta bands and in this manner induces anaesthesia.

If this is a correct interpretation then it would be essential that K^+ and Cl^- are fermionic ions: otherwise a lullaby effect would result. Note that the exotic ions of Argon can mimic either Cl^- and K^+. Besides producing the lullaby effect, this mimicry could change the effective concentrations of various ions so that large enough reduction of the resting potential could become impossible.

5.4.7 Further speculations

The following speculations are only loosely related to the model of nerve pulse.

Some aspects of the model of nerve pulse based on charge entanglement

Charge entanglement induced by W MEs seems to provide a highly plausible mechanism of quantum control with nerve pulse generation representing only a particular application of this mechanism.

Already before the ideas about dark matter hierarchy the notion of self hierarchy led to the notion of hierarchy of quantum jumps with increasing average geometric durations assignable to quantum jumps [43, 42]. Also the notion of quantum parallel dissipation occurring at levels below a given level of hierarchy emerged naturally. Dark matter hierarchy together with the p-adic hierarchy define naturally this kind of hierarchy. The descriptions of hadrons as quantum coherent systems on one hand, and in terms of quarks and gluons obeying dissipative dynamics governed by kinetic equations on the other hand, would represent one example of this hierarchy.

The charge entanglement generated by W MEs during generation of nerve pulse would represent second example of quantum parallel dissipation. Ionic currents would flow already during the superposition of ordinary and exotically ionized Bose-Einstein condensates. These currents would correspond to the quantal currents discussed in the previous section made possible by the quantal generation of JABs (by Faraday law the voltage along space-time sheets at lower level of hierarchy is affected by the presence of exotic dark ions in the presence of JABs implying closed many-sheeted loops).

If this is the case, TGD would predict no deviations from Hodgkin-Huxley model except those brought by state function reduction and the fact that Ohmic currents are actually quantal currents. Ionic currents would start to flow in the geometric past and would be perceived only after the quantum jump reducing the state to an exotically ionized state would occur. Also ghostly nerve pulses and even patterns of them could be generated since state function reduction can also lead to the ordinary state. An interesting question is whether these ghostly nerve pulse patterns relate to imagination and whether they could make possible dissipative quantum computation (perhaps during sleep)[33]. The naive expectation is that the probability that quantum jump does not occur during a given time interval decreases exponentially and that the dark time scale in question defines a typical duration for the entangled period.

Could micro-tubule-axon system perform topological quantum computation?

The proposed picture is consistent with the model of DNA as a topological quantum computer [28] and with the idea that also micro-tubules could be involved with tqc. The model of DNA as tqc in its basic form assumes that DNA is connected to the nuclear membrane and cell membranes associated with the cell body by magnetic flux tubes such that each nucleotide is connected to single lipid. Tqc programs are coded to the temporal braiding patters of lipids. This requires that lipid layer is liquid crystal and thus below the critical temperature. The flux tube connecting DNA to inner lipid layer and that beginning from outer lipid layer can form single flux tube or be split. If they form single flux tube braiding and tqc are not possible. During tqc the braid strands going through cell membrane are split and the dance of lipids induced by water flow defining time like braiding (hydrophilic lipid ends are anchored to the cellular water) induces braiding of the magnetic flux tubes which write the tqc program to memory. Furthermore, the lifetimes of flux tubes in the connected state must be short enough to prevent the generation of a nerve pulse. This is the case if the temperature is sufficiently below the critical temperature. The ionic supra currents are identifiable as the observed quantal non-dissipative currents flowing through the cell membrane when tqc is not on.

Centrioles have their own genetic code realized in terms of RNA and they play key role during gene replication when DNA is out of the game. This encourages to think that micro-tubules make possible an independent tqc like process. The question is how micro-tubule-axon system could perform tqc assuming that the recent picture about DNA as tqc [28] is roughly correct. The assumptions of the model relevant for the recent situation are following.

1. Flux tubes consists of pieces between standard plugs represented by hydrogen bond acceptors ($O =$, aromatic rings,...). For instance, XYP molecules, $X = A, T, C, G$, $Y = M, D, T$ would represent standard plugs and that the transformation $XTP \rightarrow XDP + P_i$ represents the splitting of the flux tube and thus of braid strand. The XMPs associated with DNA would represent the ends of the braid strands. The formation of hydrogen bond between water molecule and $O =$ associated with phosphates at the hydrophilic ends of phospholipids would initiate tqc [28].

2. In the model for protein folding [32] free amino-acid corresponds to a codon XYZ in the sense of wobble base pairing meaning that the third nucleotide corresponds to a quantum superposition of colors of nucleotides coding for the same amino-acid. Hydrogen bonds correspond flux tubes also and hydrogen bonds between $N - H$ and $O =$ groups in alpha helices and beta sheets mean a shortcut making it impossible to continue the flux tube from $O =$ further. Only the continuation of the flux tube through non-hydrogen bonded $O =$ acting as a plug is possible. $Y = Z$ rule holds true for the $O = -N - H$ hydrogen bonds and defines folding code. Inside proteins amino-acids correspond to code YZ part of the codon XYZ and inside alpha helices and beta sheets the flux tubes from DNA would end to amino-acids and for them one could have only braiding between DNA and tubulins. Only in the case of non-hydrogen bonded amino-acids the flux tube connection from DNA could continue to the lipid layer and only in this case one could have the generalization of DNA tqc with flux tubes connecting DNA via tubulins to the axonal lipid layer.

Taking this picture as a starting point one can consider several options. For two first options tubulins are basic units. For the third one DNA nucleotides and amino-acids would have this role.

Option I: Tubulins could be connected to the lipid layer of the axonal membrane by flux tubes and the melting of the axonal membrane would induce braiding during the propagation of nerve pulse. α tubulins are accompanied by stable GTPs analogous to single DNA nucleotide so that α tubulin could takes the role of DNA nucleotide with braid strands to lipids having only single color. Compared to DNA tqc this computation would represent much rougher resolution. β tubulins are accompanied by unstable GTPs able to suffer a hydrolysis to GDP. Also this process would correspond to the splitting of flux tube but the connection to tqc remains unclear. One can imagine one/two connected flux tubes to lipid layer represents bit.

Option II: For some years ago I considered the possibility of a gel-sol-gel phase transition proceeding along the surface surface of the micro-tubuli, accompanying nerve pulse, perhaps inducing nerve pulse, and coding for long term sensory memories in terms of 13 13-bit sequences defined by the tubulin helices with bit represented as a conformation of micro-tubule. This hypothesis might be easily shown to be wrong on basis of the available experimental facts already now. Suppose however that this phase transition happens and that the braid strands do not continue from the micro-tubular surface to the cell nucleus. In this case the braiding could be induced by a gel-sol-gel transition accompanying and perhaps generating the nerve pulse at the micro-tubular level and inducing the disassembly of the microtubule to tubulins followed by re-assembly inducing the braiding. Also this braiding would contribute to tqc like process or at least to a memory storage by braiding and options I and II would provide the complete story.

Option III: What about the variant of DNA-membrane tqc for axons? In the model of DNA as tqc these flux tubes continue back to the nucleus or another nucleus: the flux tubes must be split at cell membrane during tqc and this splitting induces the required isolation from the external world during tqc. During nerve pulse the situation would be different and the flow of lipids in liquid phase could induce DNA-lipid layer braiding: the isolation could however fail now. Tqc would explain why the axon melts during nerve pulse.

There are objections against this option.

1. By previous argument only Y-codons of DNA and only non-hydrogen bonded O =s of aminoacids would contribute to the braid strands. This does not look nice.

2. The idea about magnetic flux tubes emanating from DNA and flowing along micro-tubules interiors and radiating to the axonal membrane looks also ugly: in any case, this would not affect tqc and nerve pulse could be seen as a direct gene expression not conforming with the idea that microtubules define an independent computational system.

3. One can wonder why also the magnetic flux tubes from DNA could not end to the space-time sheet of the cell exterior if they do so in the case of axon. The justification for 'No' (besides isolation) could be that also cell soma would possess standing soliton sequence like waves and standing nerve pulses in this kind of situation.

The following considerations do not depend on the option used.

1. What comes first in mind is that the braiding codes memories, with memories understood in TGD sense using the notion of 4-D brain: that is in terms of communications between brain geometrically now and brain in the geometric past. In standard neuroscience framework braiding of course cannot code for memories since it changes continually. Nerve pulse sequences would code for long term sensory memories in a time scale longer than millisecond and micro-tubular phase transition could have a fine structure coding for sensory data in time scales shorter than nerve pulse duration. The fact is that we are able to distinguish from each other stimuli whose temporal distance is much shorter than millisecond and this kind of coding could make this possible. Also the direct communication of the auditory (sensory) input using photons propagating along MEs parallel to axon could also explain this.

2. In the model of DNA as tqc nucleotides A, T, C, G are coded into a 4-color of braid strand represented in terms of quarks u, d and their antiquarks. An analogous coding need not be present also now: rather, all braid strands could have same color represented by G of GTP. Tubulins could be seen as higher level modules consisting of order hundred 500 amino-acids. This corresponds to a DNA strand with length of about .5 μm corresponding to the p-adic length scale $L(163)$ which is one of the four magic p-adic length scales ($k = 151, 157, 163, 167$) which correspond to Gaussian Mersennes. This higher level language character of micro-tubular tqc programs would conform with the fact that only eukaryotes possess them.

3. Cellular cytoskeleton consists of micro-tubules. Could micro-tubular tqc -in either of the proposed forms- take place also at the cell soma level? Could DNA-nuclear membrane system define the primordial tqc and micro-tubular cytoskeleton-cell membrane system a higher level tqc that emerged together with the advent of the multicellulars? Is only the latter tqc performed at the multicellular level? The notions of super- and hypergenome encourage to think that both tqcs are performed in all length scales. One can imagine that ordinary cell membrane decomposes into regions above and below the critical point (the value of the critical temperature can be controlled. Those below it would be connected to DNA by flux tube bundles flowing inside the micro-tubular cylinders. Micro-tubular surfaces would in turn be connected to the regions above the critical point. One should also understand the role of $M_{13} = 2^{13} - 1$ 12-bit higher level "genetic code" assignable naturally to micro-tubules. For instance, could the bit of this code tell whether the module defined by the tubulin dimer strand bundle participates tqc or not?

Could cognitive fermion pairs accompany the nerve pulse?

Cognitive neutrino pairs and memetic code words defined by them are the cornerstone of TGD based quantum model of hearing [18] but the question whether this model really makes sense has remained without answer. Note however that if one accepts the role of exotic W bosons, one cannot exclude cognitive neutrino pairs with interaction range longer than cell membrane thickness.

This highly speculative model whose history is as tortuous as that of nerve pulse model has several variants. Cognitive neutrino pairs could be actually replaced with any wormhole contact involving pair of fermion and antifermion. Only the large Z^0 interaction energy of neutrino wormhole throat making the net rest energy of the pair very small gives cognitive cognitive neutrino pair a preferred position.

An additional support for the notion of wormhole contact has emerged quite recently from the model of DNA as topological quantum computer [28]. The wormhole contacts carrying quark and anti-quark at their throats and located at the ends of wormhole magnetic flux tubes are the key element in the model of DNA as topological quantum computer and lead to a large number of precise predictions about DNA itself (note that gauge bosons quite generally correspond to wormhole contact like structures).

The question which has remained without a satisfactory answer is whether and how nerve pulse generation could induce the generation of memetic code words as temporal sequences of zero energy cognitive neutrino (fermion) pairs. In this representation the existence of fermion would signify "yes" and its absence "no". For an alternative realization the spin of fermion signifies the two different truth values. The model for sensory receptor and qualia discussed in [20] suggests one possible identification for cognitive fermion pair as quark antiquark pair. The net quantum numbers of these airs would also classify fundamentl sensory qualia.

5.5 Many-sheeted neuron

TGD approach allows to make educated guesses concerning the interpretation of various phenomena in neuronal level. This section has been written much before the input from DNA as tqc and the realization that microtubule-cell membrane braids could serve as quantal sensory memory storage based on the braiding of the magnetic flux tubes emanating from the aminoacids of tubulin molecules. This implies obvious updatings of the text of this section left to the reader.

5.5.1 Neuronal consciousness

The fractality of consciousness encourages the view that neurons and corresponding magnetic bodies are conscious organisms having receiving sensory input and forming sensory representations at their magnetic bodies, and generating motor actions. One can see associations at neuronal level as a process in which neuronal sub-self induces mental images inside the postsynaptic neuronal self. Neuron could be seen as a fractally scaled down version of a sensory pathway.

The sensory input of a neuron is determined by the inputs from active pre-synaptic neurons. Postsynaptic receptors are analogs of ordinary sensory receptors and they determine the sensory qualia and primary sensory mental images of the neuron about external world (also ordinary cells have sensory receptors and sensory representations but only about nearby environment). Microtubuli inside dendrites are the analogs of sensory pathways, and cell membrane and cell nucleus could play the role of the neuronal skin and brain. Both could give rise to sensory representations. Sensory representations at the magnetic body of nucleus could be generated by DNA or directly by the communications from cell membrane. Neurons would have sensory qualia and neuronal receptors and receptors at the surface of any cell could give rise to the analogs of tastes and smells. Cells could also see and hear at some wave length ranges and the micro-tubuli associated with the cilia span a length scale range containing visible frequencies.

The general model of how cell membrane acts as a sensory receptor [20] allows to make this vision much more detailed and also allows to understand how the qualia experienced by us emerge.

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 this analogy can be justified 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.

5.5.2 Functions of nerve pulse

Nerve pulses inducing generalized motor action represent pushes and pulls in spin glass energy landscape of brain. These pushes and pulls induce motion in the spin glass landscape and generate somehow both neuronal and our emotions. Transmitters mediate nerve pulses from presynaptic neuron to postsynaptic neuron and modify the properties of the synapse and of the postsynaptic neuron. Fast neurotransmitters controlling directly ion channels are involved with the process and the relevant time scale is one millisecond. No long term change of the postsynaptic neuron is involved. Slow neurotransmitters involving second messenger action are involved with the modulation of the response of the postsynaptic neuron, and the time scales can be of order of minutes. In this case the properties of the postsynaptic neuron are changed. Emotional reactions involve typically slow transmitters and their effect can be regarded as a generalized motor action inducing motion of the neuron in the spin glass energy landscape of the neuron.

What the specialization of sensory pathways to sensory modalities means?

Sensory pathways are specialized to produce some specific sensory qualia. How this specialization correlates with what happens at the neuronal level?

1. If one accepts the notion of magnetic body, it is not too difficult to accept the idea that the magnetic bodies associated with the sensory organs are the seats of the sensory representations whereas higher levels of CNS are responsible for symbolic and cognitive representations accompanying sensory representations. TGD based view about long term memories makes it possible to defend this view against standard objections such as phantom limb phenomenon, projected pain, and the stimulation of sensory hallucinations electrically. One cannot exclude the possibility that even the sharing of mental images with the objects of external world contributes to the conscious experience.

2. An almost diametrically opposite view is that qualia are like colors of a map and coloring is decided at quite high level of sensory processing.

These views need not be mutually exclusive. Sensory qualia seated at sensory organs can serve as the colors of the map if sensory receptors and brain form single quantum system in which entanglement with and back projection to the structures defined by sensory receptors is essential. This back projection could transform the primary mental images. This view would also explain the rapid eye movements during REM sleep and oto-acoustic sounds.

In this picture association areas could be seen not as cognitive areas, where sensory input is transformed to cognitive output, but areas in which the mental images associated with various symbolic and cognitive pathways fuse to a single mental image. Therefore the term association would be somewhat misleading. A genuine association can be seen to result when a sub-self wakes up sub-self by nerve pulse patterns and is experienced by a higher level self as two subsequent mental images.

Could nerve pulse patterns realize the memetic code?

TGD based model of cognition allows to construct a model for memetic code in which sequences of 126 cognitive neutrino pairs of total duration of about .1 second correspond to Boolean statements or also integers in the range $\{1, 12^{126}\}$ in binary representation. The model for the physical realization of the memetic code is discussed in more detail in [24] and here only the basic idea will be described.

The model for the memetic code assumes that antineutrinos resides in the strong Z^0 magnetic field associated with the cell membrane and having the direction of the axon. The antineutrinos have suffered spontaneous Z^0 magnetization. Memetic codons consisting of (almost) 127 bits are realized as temporal sequences of spontaneous Z^0 magnetization of antineutrinos at $k = 151$ cell membrane space-time sheet. The ground state with all bits in the direction of the Z^0 magnetic field does not represent consciously anything so that the number of representable bit sequences is $M_{127} = 2^{127} - 1$ which corresponds to almost 127 bits.

Memetic codons are generated by Z^0 magnetic pulses reversing the direction of local Z^0 magnetization. The magnetic transition frequency is energy difference for states $(n + 1, up)$ and $(n, down)$ for cognitive antineutrinos of opposite spin in the strong Z^0 magnetic field of the axonal membrane. There is however a "miracle" involved. The magnetic transition frequencies of muonic and tau neutrinos for the transitions between states $(n + 1, up)$ and $(n, down)$, are in the range of ELF frequencies and that for the largest possible value of the axonal Z^0 magnetic field this frequency is slightly higher than the maximal frequency of nerve pulses. Hence the duration of nerve pulse implies automatically that it generates harmonic perturbation giving rise to spin flips of neutrinos [24, 18].

The basic objections against the idea that nerve pulses generate memetic codons are following.

1. The minimum time interval between nerve pulses is slightly longer than required by memetic codon.

2. The prediction would be that high level linguistic cognition is everywhere in brain. Rather, higher level cognition should be associated with the neurons at multi-modal associative regions of cortex [24] or with cognitive neural pathways leading to these areas. Only humans possess the parietal-occipital-temporal association region combining somatosensory-, visual- and auditory inputs into associations and giving meaning to the objects of the perceptive field. Perhaps the emergence of this associative region associating Boolean statements with sensory features has led to Homo Sapiens.

3. Ordinary nerve pulse patters suggest strongly frequency coding rather than refined memetic code. In the case of memetic code it would mean roughly 64 nonequivalent codons. This in fact might be enough to understand the basic phonemes of language as expressions of memetic codons.

These arguments suggest that nerve pulse patterns give rise only to a frequency coding such that only the frequency of the bits differing from the standard value is of significance. The intensity of sensory input, motor output, and emotional expression could be coded in this manner. MEs can generate also oscillations of the membrane potential and it is known that this kind of oscillations accompany hearing. These oscillations could also induce reversal of Z^0 magnetization and could allow to realize memetic code in full complexity.

Generation of declarative long term memories at micro-tubular level

The TGD based model of declarative long term memories is based on the mirror mechanism with brain and body effectively serving as time like mirrors from which negative energy MEs are reflected as positive energy MEs. Long term memories would be coded to subjecto-temporal changes of the micro-tubular conformations [42] which allow a huge number of almost degenerate configurations, and the transitions between these configurations generate MEs with ultra-low frequencies determined by the time span of the long term memory. The natural first guess is that the nerve pulse patterns accompanied by MEs are an essential part of the process of building long term memories by inducing the motion of the axonal micro-tubuli in the spin glass energy landscape. Nerve pulse could be also accompanied by a separate wave propagating along the axonal micro-tubuli and containing much more detailed information about the sensory input specifying the content of declarative long term memories.

This would mean huge information storage capacity and also explain why the axonal lengths associated with the sensory pathways are maximized.

A model for the cognitive code associated with with micro-tubuli is discussed in [24]. The model is based on $13 \times 13 = 169$ bits defined by single full turn for 13 helical tubulin strands consisting of 13 tubulins each. Since only the changes of tubulin conformations contribute to the micro-tubular conscious experience, only $2^{169} - 1$ patterns code for conscious experiences. Therefore the code represent only 168 full bits and the remaining almost bit could define some kind of parity bit. The presence of a sufficiently strong external electric field along the micro-tubule would imply that the change of bit is replaced with a pattern of $b \rightarrow b + 1 \rightarrow b$ transitions leading from the ground state to excited state and back to the ground state.

An interesting possibility is that micro-tubuli define a cognitive code above the memetic code in the hierarchy of cognitive codes so that biology would not reduce to neither genetic nor memetic code. The changes of the micro-tubular conformation patterns could be coded to 2^{126} memetic codons represented by field patterns associated with MEs. The $64 \rightarrow 21$ correspondence for DNAs and aminoacids would be generalized to $2^{169} - 1 \rightarrow 2^{127} - 1$ correspondence such that 168 full bits would be mapped to 126 full bits. The degeneracy would be $6log(2)/log(21) \simeq 1.39$ for the genetic code and $168/126 = 1.33$ for the micro-tubular code.

5.5.3 Functions of transmitters

It is an interesting challenge to try to understand the role of various information molecules, in particular neurotransmitters, in TGD inspired conceptual framework.

Information molecules as quantum links in quantum web?

One particular challenge is to find convincing "reason why's" for what happens in the synaptic contacts. Why myriads of neurotransmitters are needed: inhibition, excitation and neuro-modulation could indeed be carried out in much simpler manner?

1. Information transfer is certainly in question and a natural assumption is that the information is conscious quantum information. If so, it is not the transfer of the neurotransmitter molecules which is essential but the transfer of bound state entanglement of these molecules with the environment and thus of conscious information. This is in accordance with the computer metaphor: neurotransmitters would be like links to different pages in the web activated in the transfer process analogous to sending an email containing a list of links plus text. Also a transfer of usable energy could be involved: the positive energy MEs transferred could provide their energy to the postsynaptic cell unless they are used to energize the transfer process. Besides neural transmitters blood cells and various molecules transmitted by blood and lympha could be carriers of quantum links and hormonal action at the deeper level would be quantum communication in this sense.

2. When information molecules and receptors form a quantum bound state, macro-temporal quantum coherence is generated and this correspond at the level of conscious experience a multi-verse state of 'one-ness' and from the point of information processing a quantum computation like process [42]. One could also see information molecules and receptors as representative of opposite molecular sexes. The resulting non-entropic mental image corresponds to sensory qualia of the neuron analogous to smells and tastes. In principle, each neurotransmitter gives to a distinct neuronal taste or smell. Also neuronal analogs of vision and hearing are possible. Micro-tubuli indeed give rise to infrared vision in the case of bacterial cells.

3. This picture is consistent with the interpretation of neurotransmitter induced experiences as kind of chemical qualia analogous to tastes and odors and giving rise to emotions at our level of self hierarchy.

Excitation and inhibition

Excitation and inhibition are seen as basic functions of neurotransmitters. More precisely, the attribute excitatory/inhibitory can be assigned with a given transmitter-receptor combination. Gardener metaphor states that brain is a gardener allowing particular plants, now mental images having neural firing patterns as neurophysiological correlates, to flourish. One could argue that this kind of selection is reasonable in order to use metabolic resources optimally. One must be however very cautious here. Paradoxically, the metabolism during synchronous firing does not seem to increase [121]. This finding has two mutually non-exclusive explanations.

a) Remote metabolism involving the generation of negative energy MEs received by glial cells serving as a storage of metabolic energy is involved.

b) Inhibition could require actually more energy than excitation: neural firing would occur spontaneously when the energy feed to the system is subcritical. At least for the inhibition caused by hyperpolarization this view might make sense. One can say that the gardener would actively prevent the growth of some plants. Inhibition would be censorship preventing a spontaneous generation of mental images in accordance with the vision of Huxley about brain as a filter which prevents conscious experience rather than creates it. The hypothesis that bio-control is quite generally based on this principle is attractive since it is easier to prevent a complex process to occur spontaneously than to force a complex process to occur in a desired manner.

Option b) would explain several paradoxical looking findings about the correlation of inhibition with the level of self control. The amount of inhibition increases and the behavior becomes more controlled and "civilized" as one climbs up in the evolutionary tree being highest for humans. Inhibition is higher for adults than for children as is also the level of self control. Inhibition is dramatically reduced during the process of physical death. In all these cases the reduced inhibition would naturally correlate with the reduction of the metabolic feed. Inhibition is also reduced during several altered states of consciousness and these states of consciousness involve also a high level of relaxation.

If the reduced inhibition means a reduction of energy feed, a depletion of energy resources is an unavoidable outcome. This leads to a spontaneous generation of negative energy MEs by starving neurons making possible remote entanglement and remote metabolism. In particular, synchronous neural firing would involve also remote metabolism so that option a) is not excluded by b). The generation of episodal long term memories and various kinds of remote mental interactions would be an automatic side product. The memory feats of synesthetics indeed correlate with a dramatic reduction of metabolism in left cortex; various remote mental interactions are reported to occur during altered states of consciousness; and there are reports about the association of telepathy, precognition and poltergeist type phenomena with the physical death of a close relative or intimate friend.

On the other hand, if inhibition means heightened metabolic energy feed, it also reduces the need to generate negative energy MEs. The reduction of entanglement with the environment means among other things fewer shared mental images. Therefore the increase of inhibition would be a correlate for the increasing privacy of conscious experience. Ironically, the physical well-being would more or less unavoidably lead to the alienation and unhappiness suffered by so many members of post-modern society.

5.5.4 Negentropic entanglement and the role of neurotransmitters

Soon after starting to develop TGD inspired theory of consciousness, I somehow ended up to an email correspondence with Gene Johnson who insistently emailed me links to abstracts about neuroscience. I read the classic Bible about brain by Kandel *et al* [111] and tried to make sense of it in my own conceptual framework. This was of course hopeless task since I had only the notions of quantum jump and self. The feeling that something very simple -about which I do not and perhaps cannot ever have a slightest clue- must be behind this incredible complexity made the situation really frustrating. The deeper meaning of EEG, nerve pulse neurotransmitters, hormones- actually of entire brain chemistry and also biochemistry- remained a total mystery.

Development of ideas

After the required number of years however some concrete ideas began to emerge.

1. The notion of magnetic body with fractal onionlike structure meant a decisive step of progress. Also the hierarchy of Planck constants and dark matter as controller of visible matter in living systems emerged. The function of EEG as communication and control tool of magnetic body using biological body as a motor instrument and sensory receptor looked very natural. This led also to a proposal that there is an entire hierarchy of EEGs and their variants. After several

trials a vision about nerve pulses as concomitants of quantum level communications emerged as also a vision about DNA as topological quantum computer based on the flux tubes connecting DNA nucleotides with the lipid layers of cell membrane emerged and providing a function for the intronic portions of genome as carriers of quantum computer programs [28].

2. Also a vision about the biochemical role of dark matter evolved. In particular, phase transitions reducing Planck constant for a magnetic flux tube would induce its contraction and force biomolecules near to each other. This would explain the miracles of DNA replication, translation, and transcription and quite generally the processes known as aggregation of proteins. The reconnection of magnetic flux tubes changing the topology of the biological Indra's net would be also a central mechanism.

3. The model of nerve pulse and the vision about living matter as a kind of dynamical Indra's net led to a first clear idea about the role of neural transmitters. Transmitters are classified to inhibitory or excitatory depending on whether they increase or reduce the magnitude of the membrane potential. This property is however a property of the receptor rather than that of the transmitter. The same transmitter can have both excitatory and inhibitory receptors although often either receptor type dominates. The proposal was that neural transmitters are associated with the ends of the links of the 4-dimensional web connecting neurons to each other. Neurotransmitter attaches to the plug defined by the receptor connecting the communication wire from presynaptic neuron to the flux tube leading to the passive portion of postsynpatic DNA strand acting as sensory receptor. This would make possible rapid communications to DNA. The corresponding active portion of DNA strand could then respond by generating an activity at the level of cell membrane. This conforms with the general idea that proteins represent only one particular outcome of the gene expression. This left open the question whether the excitatory-inhibitory dichotomy could have some deeper meaning.

4. Also it became clear the emotions and information are closely related and that peptides acting both as neurotransmitters and hormones are crucial for emotions [125]. I proposed that emotions are "entropic" qualia. Although I realized the importance of negentropic entanglement I did not have time or I was not able to realize how far reaching this notion actually is.

Is genome a fractal counterpart of brain?

Fractality replaces standard reductionism in TGD Universe. An old idea inspired by p-adic length scale hypothesis is that the binary structures associated with p-adic scales $L(k) \propto 2^{k/2}$ and $L(k+2)$ define a fractal hierarchy. Brain hemispheres would represent one example of this kind of pair, lipid layers ofe cell mebrane second one, and DNA double strand third one. Just for fun one could assume that the structure and functions of brain hemispheres have fractal analogs at the level of DNA double strand and vice versa and look what kind of questions this inspires.

1. Could the identical structures of DNA strands correspond to the anatomical similarity of right and left brain and could the functional asymmetry of the strands correspond to the laterizalization of brain function? Could the genome act as the brain of cell? Could various brain areas have counterparts at the level of DNA? Could the hydrogen bonds between nucleotides serve as the counterpart of corpus callosum? Could the splitting of these bonds during transcription and replication correspond to what happens to a split brain patient?

2. Before continuing it must be made clear that the global identification of right-left dichotomy with holistic-reductionistic dichotomy is wrong. One can however consider its local variant with holism and reductionism assigned do the pairs of right and left brain areas. For instance, in contrast to the naive rule the emotional right (left) brain (amygdala) would be reductionistic (holistic,negentropic) whereas the intellectual right (left) would be holistic (reductionistic,entropic). The practical reason to the division to the entropic and negentropic pieces could relate to the metabolism. The entropic regions could provide the binding energy as a usable energy to the positive energy negentropic entanglement. Good is not possible without Evil! There are no winners without loosers!

   Right brain is specialized in spatial thinking and left brain to verbal thinking and arithmetics: the geometry-algebra division of mathematics! Right brain is not so good in motor actions as left brain as any right-handed person knows. Right brain is however better in tactile sensing: right handed persons tend to use left hand for touching objects to get an idea about their shape. Also this can be understood in holistic-reductionistic picture.

3. Apart from reflex actions almost all activities of the body seem to be controlled to a high degree by brain. Could also the activitites of cell be regarded as motor actions of the genome acting as the brain of cell receiving sensory imput from the cell membrane? Could one identify the analogs of sensory areas receiving information from cell membrane, processing, and sending it to the association areas? Could the analogs associative areas be identified as intronic portions of DNA performing topological quantum computations and communicating the outcome to the higher motor areas at the intronic portions of the of the complementary strand, wherefrom they would be communicated to the primary motor areas identifiable as the regions of DNA expressing themselves either chemically (RNA and proteins), as activitites generated directly at the level of cell membrane, or electromagnetically? For instance, could neurotransmitter in the receptor generate the feed of sensory input to the genome inducing the change of the membrane potential as the counterpart of motor action. Could prokaryotes without introns be analogous to brain with only primary sensory and motor areas or to mere ladder-like nervous system?

   One could argue that the analogy between DNA are brain fails because second DNA strand is completely passive whereas both brain hemispheres express themselves via motor actions. This is not the case! Both DNA strand has regions expressing themselves but the transcription takes place in opposite directions. Hence DNA strands have motor and sensory areas as also brain does, and the natural guess is that primary motor areas correspond to the areas expressing themselves in terms of RNA, proteins, and possibly also as actions at the level of cell membrane. Primary sensory areas would correspond to to regions complementary to the primary motor regions.

4. What right brain sings-left brain talks metaphor could mean in this picture? Pitch-rhythm dichotomy is more technical expression for this dichotomy. Function providing local data and its Fourier transform providing global data is more abstract representation for this dichotomy and Uncertainty Principle for momentum and position relates closely to these two representations of information. This dichotomy could reflect the presence of two different natural time scales and millisecond time scale for nerve pulses and .1 second time scale for moments of sensory experience are the natural candidates.

   If so, this dichotomy could directly reflect the different time scales assignable to u and d type quarks (1 millisecond) and to electron (100 ms) and reduce to the level of elementary particle physics. This dichotomy would also have fractally scaled up variants made possible by the hierarchy of Planck constants. The analog of Fourier transform would be the negentropic unentanglement of sub-CDs (assignable to quarks) to single mental image inside electron's CD. The analog of function itself would be a collection of sub-CDs representing separate unentangled mental images assignable to individual nerge pulses in millisecond time scale. Also the topological quantum computations assigned to the intronic portions correspond to different time scales due and reflect quark-lepton dichotomy. The quarks in question could be the quarks assigned to the ends of flux tubes in the model of DNA as topological quantum computer.

5. This raises some questions. Could the gene expressions of the two strands somehow reflect this dichotomy? For instance, could the flux tube structures assignable to the aminoacid sequences correspond to the millisecond and 100 ms scales assignable to quarks and electron have the property that also the functioning of these proteins is characterized by these typical time scales? According to [85] the time scales of protein folding vary from .1 s to 10^3s. According to Wikipedia [87] the typical time scale is 1 millisecond which suggests that the time scales correspond to two ranges beginning from ms and 100 ms respectively. There are also short proteins for which the folding takes place in microsecond time scales which might relate to the CD of proton.

What can one say about the function of neurotransmitters?

Can one say anything interesting about the the function of neurotransmitters if one combines this highly speculative picture- which can be defended only by the belief on fractality as universal principle-with the idea that bound state and negentropic entanglement make possible the fusion of mental images.

1. Suppose that the fusion of neuronal mental images is required to build higher level mental images that we experience. Suppose that neuronal mental images involve DNA in an essential manner. Suppose that magnetic flux tubes serve as correlates for the entanglement so that the transmission of nerve pulse from pre-synaptic neuron to post-synaptic one creates a flux tube connection between neurons possibly extending to the genome of the post-synaptic neuron. The transmitter at the end of flux tube attached to the receptor acting as a plug would build this connection to some part of DNA specialized to receive particular kind of sensory data from a particular region of cell membrane with complementary strand activating as a response a motor function inducing gene expression at cell membrane level. Gene expression as build-up of proteins would not be necessary and is also too slow for neural activities.

2. Suppose that the entanglement between neurons generated in this process is always negentropic as the interpretation as the idea about neural correlate for a conscious association suggests. One could also ask whether the neurons could entangled entropically and whether the entropic-inhibitory association could make sense. This does not lead to anything interesting and entropic entanglement between neurons should be regarded as a pathological condition. Note that neuron-neuron entanglemement would be naturally time-like and in this case only negentropic entanglement might be meaningful.

    (a) To gain some perspective consider the activation of cell in general by some external perturbation from the resting state to the active state (here I have learned a lot from email correspondence with Vladimir Mateev) In the resting state the proteins inside cell are passive -or rather, forced to be passive- as one might expect on basis of the general vision about homeostasis. The unfolded proteins and unfolded portions of the folded proteins are connected by hydrogen bonds to ordered water so that the folding occurring otherwise spontaneously is prevented. One can say that the cellular winter prevails. The situation is however nearly critical and if external perturbation occurs cell liberates metabolic energy melting the ice and spring comes. Also the outer surfaces of globular proteins are hydrogen bonded and when the ordered water melts, spontaneous melting of the protein takes place leading to a partial unfolding.

    The resulting folded proteins and partially unfolded globular proteins interact by forming aggregates and this activity would naturally involve $\hbar$ reducing phase transitions and flux tube reconnections. In TGD based model the mechanism of both folding and melting would be the liberation of metabolic energy destroying the hydrogen bonds and the energy for this comes from the ATP containing positive energy negentropic bond between O=s of phosphates.

    (b) Similar situation could prevail at the cell membrane. One can imagine that cell membrane is like a particle at the bottom of a small potential well. At the other side there is a deep well representing the generation of nerve pulse and at the other side a high wall corresponding to hyper-polarization requiring energy. Both polarization and hyperpolarization are prevented by the freezing of protein activities needed to induce them. The flux tubes connecting the presynaptic neuron and receptor and possibly genome are always negentropic and their formation can as such serve as the signal leading to the partial melting of the ordered water making possible to generate action leading to either depolarization or hyperpolarization. The signal could be just the additional metabolic energy making it possible for these transitions to occur.

    (c) This picture does not require any communications from the receptor to the genome and in the simplest situation the resulting action could be seen as the analog of reflex action. These communications could of course be present and the negentropic entanglement could make it easier to induce depolarization also now. Also the question whether excitatory-inhibitory dichotomy for the receptors has some deeper meaning apart from taking the neuron nearer to or farther from criticality for firing remains unanswered.

5.6 A model for the effective electronic super-conductivity in axons

Also the following model for axonal electronic super-conductivity was constructed before the progress induced by the model of DNA as tqc and the inspiration coming from the model of nerve pulse by Danish researches [61] and is not completely consistent with the new model. I however decided to keep the text because it reflects the development of ideas and with a reasonable amount of work could be modified to the new situation.

Hafedh Abdelmelek and collaborators [107] have found evidence for effective super-conductivity in the sciatic nerves of both endotherms (rabbit) and poikilotherms (frog). The basic finding is that the resistance of the sciatic nerve is reduced by a factor of about ten below a critical temperature at the lower edge of the range of the physiological temperatures. The reduction of the temperature occurs inside a narrow temperature range ΔT, $\Delta T/T_c \sim .04$. This suggests effective super-conductivity. Furthermore, the critical temperature T_c for the breaking of the effective super-conductivity raises from 240 K to 300 K in the transition from poikilotherms (say frog) to endotherms (say rabbit).

These findings seem to be consistent with the following view.

1. Nerve pulse generation involves a mechanism inducing a flow of ions between axonal interior and exterior and induces at the same time the breaking of super-conductivity [44]. At too low temperatures nerve pulses cannot be generated because the breaking of the super-conductivity is not possible. Therefore the critical temperature must be below the range of physiological temperatures and explains the difference between poikiloterms and endotherms.

2. In myelin sheathed regions the breaking of the effective super conductivity does not occur or the critical temperature is higher and the signal carried by the nerve pulse is transformed to an effective or genuine supra current. A small pulse like perturbation of the membrane potential could propagate still.

3. Poikilotherms can survive only if nerve pulse conduction is possible down to about 240 K which represents lower bound for the temperature of environment. Endotherms can keep the body temperature above 300 K and so that T_c can be as high as 300 K. This is good for survival purposes since high T_c minimizes ohmic losses related to nerve pulse conduction.

The recent model for nerve pulse generation favors somewhat different view. The melting temperatures T_m of the axon and microtubular surface and quantum critical temperature T_c of high T_c super-conductivity are the critical parameters. The generation of the nerve pulse is possible only if T is slightly above T_m. T_m can vary in a wide range and can be controlled genetically. Same could be true for T_c since external perturbations amplified by quantum criticality are expected to affect it. This would explain different values of T_c for poikilotherms and endotherms. The critical temperature for super-conductivity would pose only an upper bound for the temperatures at which organisms can survive whereas quantum criticality of various membranes would constrain this temperature to a narrow range.

5.6.1 Many-sheeted space-time and connection between thermal de Broglie wavelength and size of the space-time sheet

The concept many-sheeted space-time is needed to understand super-conductivity and breaking of super-conductivity. 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

$$L(k) = 2^{(k-151)/2} \times L(151) \ , \qquad (5.6.1)$$

$L(151) \simeq 10$ 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.

The characteristic temperature scale for particles of mass M in a thermal equilibrium at the space-time sheet characterized by $L(k)$ is given in terms of the zero point kinetic energy associated with the space-time sheet

$$T(k) = n \times E_0(k) = n \times n_1 \times \frac{\pi^2}{2ML^2(k)} , \tag{5.6.2}$$

where n and n_1 are numerical constants not far from unity (for convenience the units $k_B = 1$, $\hbar = 1$, $c = 1$ are used). $T(k)$ decreases very rapidly as a function of the p-adic length scale $L(k)$. This equation relates the p-adic prime of space-time sheet to T and M of particles present in the sheets forming join along boundaries condensate. Of course, the size L of space-time sheet characterized by k can vary in the range $[L(k), L(k_>]$ and $T \propto 1/L^2$ is an attractive guess for the dependence of the temperature on the size of the space-time sheet. One can interpret $T(k)$ as a critical temperature at which the p-adic prime characterizing the space-time sheet changes.

5.6.2 Magnetic flux tubes as effective super-conductors and breaking of super-conductivity

The model for bio-superconductivity and its breaking relies on the following picture.

1. Magnetic flux tubes of Earth's magnetic field (in particular) characterized by $k = 169$ and having a minimal thickness about 5 μm correspond to tubular space-time sheets. The magnetic flux tubes of endogenous magnetic field $B = .2$ with $n = 5$ characterizing the value of the scaled up Planck constant $\hbar = n\hbar_0$ [20] and the unit nh_0 of magnetic field magnetic flux and $k = 169$ characterizing the p-adic length scale define second option consistent with the identification of 15 Hz as cyclotron frequency of Ca^{+2}. In this case the value of magnetic flux is $2h_5$ and the scaled down magnetic field $B_{end}/2$ required by the sleep time EEG would correspond to single flux quantum. Flux tubes would have thickness of about 25 μm corresponding to a size of a large neuron.

   In the absence of both larger and smaller space-time sheets, the flux quanta can act as 1-D super-conductors since cyclotron energy scale, which by the quantization of the magnetic flux behaves also as $1/L^2(k)$, is larger than de Broglie temperature for sufficiently high values n of the magnetic flux (implying thicker flux tube). More generally, one can consider the possibility of a hierarchy of magnetic flux tubes inside magnetic flux tubes corresponding to the sequence $k = 167, 163, ...$ as especially interesting candidate since $k = 151, 157, 163, 167$ define Gaussian Mersennes $(1+i)^k - 1$. Each of these flux tubes can be a super-conductor. Bio-super-conductivity is assumed to be due to this mechanism. Of course, only space-time sheets corresponding to only some of these p-adic length scales could be present and this would be crucial as far as super-conductivity and its breaking is considered. The study of the effects of external magnetic fields on the axonal conductivity might provide valuable information about the role of magnetic fields.

2. Super-conductivity can be broken by a temporal leakage of the Cooper pairs to larger space-time sheets if present. These Cooper pairs are kicked back by thermal photons. System is an effective super-conductor in the sense that Cooper pairs are not destroyed in the breaking of super-conductivity and an effective ohmic conductor in the sense that dissipation is present. Super-conductivity can be also broken by thermal kicking of the Cooper pairs to smaller space-time sheets. In this case there is however a restriction posed by the fact that the zero point kinetic energy of the particle increases from $E_0(k)$ to $E_0(k_<)$, where $k_<$ ($k_>$) is the largest (smallest) the prime smaller (larger) than k. Thermal energy is needed to achieve this. For the leakage to occur, one must have

   $$T > nE_0(k) = T(k) . \tag{5.6.3}$$

   Some numerical constant n is involved here. Note that the temperature at super-conducting space-time sheets is much lower than the critical temperature and the temperature at atomic space-time sheets.

3. The prediction is that the conductivity decreases in a stepwise manner at temperatures $T = T(k)$ as the temperature increases, and that the smallest value of k for current carrying space-time sheets gradually decreases as $k = 169 \rightarrow 167 \rightarrow 163 \rightarrow 157 \rightarrow 151 \rightarrow ....$ The behavior of the conductivity in the sciatic nerve seems to represent one particular step of this kind. The primes $k = 167, 163, 157, 151$ are expected to be especially important in living matter since they corresponds to the so called Gaussian Mersennes and p-adic length scales in the range 10 nm-2.56 μm [29, 23].

4. For a space-time sheet having $k = k_0$, the leakage of supra-current is induced by the formation of join along boundaries bonds between $k = k_0$ space-time sheets and $k \geq k_0$ space-time sheets. The leakage to the smaller space-time sheets can be also induced by radiation with frequency corresponding to the increment of the zero point kinetic energy and the transversal electric field involved with radiation can be regarded as inducing the force driving the particles to smaller space-time sheets or back.

5. The strange findings indicating that DNA can behave like a super-conductor [83], an ohmic conductor [84], or an insulator could be perhaps understood in terms of the local architecture of the many-sheeted space-time. If only atomic space-time sheet is present, DNA would behave as insulator. If larger space-time sheets are present DNA behaves as an effective ohmic conductor in the sense that dissipative effects are present. If only single larger space-time sheet is present, super-conductivity is possible so that the manufacturing of super-conductors should reduce to space-time engineering.

5.6.3 Quantitative model for the breaking of super-conductivity

The dropping (or leakage) of electronic Cooper pairs from $k = k_0$ (say $k_0 = 151$ corresponding to cell membrane thickness) space-time sheet to larger space-time sheets possibly present and followed by a thermal kicking back to $k = k_0$ space-time sheet is a good candidate for the mechanism causing the breaking of magnetic super-conductivity.

The conductivity as a function $\sigma(k)$ of the p-adic length scale $L(k)$ should characterize the mechanism quantitatively. If the thermal energy $E_{th} = T$ satisfies the condition

$$E_0(k) - E(k_>) < T < E_0(k_<) - E(k) \ ,$$
$$E_0(k) = n_1 \times \frac{\pi^2}{4m_e L^2(k)} \ , \tag{5.6.4}$$

one can say that the space-time sheet k is the effective carrier of the current.

The mechanism predicts that the increase of the temperature is accompanied by a sequence of phase transitions in which the value of k characterizing the effective carrier of the current decreases in a stepwise manner: $k = 169 \rightarrow 167 \rightarrow 163 \rightarrow 157 \rightarrow 151 \rightarrow ....$ These transitions occur at temperatures $T(k) = n \times E_0(k)$, n a numerical constant. This picture is consistent with the observation that the reduction of resistance occurs in a very short temperature interval ΔT: $\Delta T/T \sim .04$.

A more concrete picture is obtained by decomposing the friction force to a sum of forces resulting from dropping from say $k = 151$ to $k = 157163, 167, ...$ and being kicked back. This gives

$$\begin{aligned} F &= K(k)v \ , \\ K(k) &= \sum_{k_i > k} \kappa(k_i) = \kappa(k_>) + K(k_>) \ . \end{aligned} \tag{5.6.5}$$

The condition $F = qE$, $q = 2e$, gives for the conductivity defined by $j = nv = \sigma(k)E$, E electric field, the expression

$$\frac{1}{\sigma(k)} = \frac{K(k)}{nq} = \frac{\kappa(k_>)}{nq} + \frac{1}{\sigma(k_>)} \ . \tag{5.6.6}$$

What this means that the space-time sheets correspond effectively to resistors in series.

From the experimental findings for frog, for the transition from $k = 157$ to $k = 151$ the term $\kappa(157)$ must be by about a factor 10 larger than the sum of terms term $\kappa(k)$, $k > 157$. The fractal scaling

$$K(k) \quad \propto \quad \frac{1}{L^{\alpha}(k)} \propto 2^{-\alpha k/2} \tag{5.6.7}$$

with $\alpha \simeq 1.1$, suggests itself.

The standard classical model for the dissipative force implies that the force is inversely proportional to the free path $l(k)$ of the particle and by naive scaling symmetry l would be naturally proportional to the p-adic length scale $l \propto L(k)$ giving $\alpha = 1$. $\alpha > 1$ for $K(k)$ means that the free path has a fractal dimension slightly larger than one. The anomalous dimension is due to the many-sheeted nature of the free paths implying the presence of the higher order terms in the expansion of $K(k)$. Indeed, in the lowest order the model based on the naive scaling dimension -1 for $\kappa(k)$ predicts

$$\frac{\sigma(151)}{\sigma(157)} \simeq 1/8 - 1/64 \simeq .11 \tag{5.6.8}$$

in consistency with the measured reduction of the resistivity. Needless to say, this prediction provides a strong support for the p-adic length scale hypothesis and the notion of many-sheeted space-time.

5.6.4 Application at axonal level

It is interesting to apply the model for the breaking of super-conductivity in the case of axon.

Understanding the critical temperature

The model for the nerve pulse generation predicts that "bridges" are formed between $k = k_0 > 151$ (say $k_0 = 169$) and $k = 151$ space-time sheets making possible the flow of ions between cell interior and exterior. Super conductivity is broken provided that the temperature is sufficiently high. For electron Cooper pairs ($M = 2m_e$) the zero point kinetic energy at the cell membrane space-time sheet is from Eq. 5.6.4

$$E_0(k = 151) = n_1 \times 312.25 \ \text{K} \ . \tag{5.6.9}$$

n_1 is some numerical constant not too far from unity. $n_1 = 1$ corresponds to a temperature 42.25 C. The identification as the critical temperature gives quite satisfactory agreement with the experimental values varying from 240 K to 300 K. Note that the requirement $T > T_{cr}$ for the physiological temperatures means that $k = 151$ cell membrane space-time sheet is the effective current carrier in the presence of larger space-time sheets.

If the join along boundaries bond connecting $k = 169$ and $k = 151$ space-time sheets contains a strong enough transversal electric field, the supra current can flow only in one direction. It seems that in the case of cell membrane the leakage of electronic Cooper pairs to the negatively charged cell interior is forbidden by this mechanism. The absence of the join along boundaries bonds between cell membrane and cell exterior assumed to be generated during the nerve pulse in the TGD based model of the nerve pulse [44] in turn implies that the leakage cannot occur to or from $k = 169$ space-time sheets at all. Therefore both $k = 151$ and $k = 169$ space-time sheet might be genuinely super-conducting and only nerve pulse conduction would be accompanied by the breaking of super-conductivity.

Predictions for the critical temperature and resistance

Fractality allows to make definite quantitative predictions for the critical temperature.

1. For $k = 163$ conductivity the critical temperature is predicted to be by a factor $2^{157-151} = 64$ lower than for $k = 157$ conductivity. This gives $T_c(163) = 4.9$ K for $T_c(157) = 300$ K. The upper bound $T_c = 4$ K for the critical temperature for super-conductivity in molecular crystals is reported in [63]. This would correspond to $T(157) = 240$ K measured in the case of frog. The predicted lowering of the resistance at this critical temperature for nerve conduction might be testable.

2. The observation that DNA attached between carbon and rhenium electrodes becomes super-conducting below the critical temperature of about 1 K for rhenium [83] allows the possibility that DNA becomes super-conducting already at about $T_c(163) \simeq 4-5$ K but that the rhenium acts as the weak link in the super-conducting circuit.

3. Cell membrane thickness L might vary and the natural guess is that the critical temperature is inversely proportional to $1/L^2$. If this is the case, the ratio of cell membrane thicknesses for frog and rabbit should be

$$\frac{L(frog)}{L(rabbit)} = \sqrt{\frac{T(rabbit)}{T(frog)}} = \sqrt{5/4} = 1.12 \tag{5.6.10}$$

for $T(rabbit) = 300$ K and $T(frog) = 240$ K.

4. A further prediction following from the fractal model for the conductance (Eq. 5.6.7) is that also the $k = 157 \rightarrow 163$ at about 4-5 K involves a 10-fold reduction of resistance. Also this prediction might be testable for nerves.

What happens in saltation?

An interesting question is what happens in the saltation over the myelin sheathed portions of the nerve. According to the TGD based model of nerve pulse [44], the ME ("massless extremal", "topological light ray" moving with effective velocity equal to the conduction velocity of nerve pulse acts as a bridge between cell membrane ($k = 151$) and cell exterior ($k = 169$) space-time sheets and in this manner allows the leakage of ions from cell interior to exterior and vice versa inducing the physiological effects of nerve pulse. ME could propagate along the myelin sheath rather than along the axon inside. Therefore nerve pulse would not be generated. The following picture about saltation suggests itself.

1. The transformation of the nerve pulse to an electronic $k = 151$ or $k = 169$ supra current propagating rapidly through the myelin sheathed portion would make possible a rapid signal transmission without physiological effects. Inside myelin sheathed portions of the axon the leakage to $k = 169$ space-time sheets would be impossible by the mechanism described above irrespective of the value of the critical temperature.

2. Nerve pulse conduction involves also communication and interaction between different space-time sheets and therefore necessitates the leakage of electronic Cooper pairs from $k = 151$ cell membrane space-time sheet. Therefore the critical temperature must be below the range of the physiological temperatures. Endotherms have an evolutionary advantage since the higher critical temperature implies that the dissipative effects associated with the nerve pulse conduction are weaker.

   Whether electronic supra current in the myelin sheathed portions of the axon propagates along $k = 151$ or $k = 169$ space-time sheet or along both plus possibly along some other space-time sheets, remains unclear. Note that the critical temperature in myelin sheathed regions could be higher than the physiological temperature. The endogenous magnetic field $B = .2$ Gauss suggested by the work of Blackman and others corresponds to a flux tube radius $L = sqrt5/2 \times L(169) \simeq 1.58L(169)$. $nL(167)$ with $n = F_0 = 3$ would give $L = 1.5L(169)$. $k = 167$ in turn corresponds to Gaussian Mersenne $(1+i)^k - 1$, $k = 167$. If one scales only in one direction then the scaling factor is $5/2$ and $5L(167)$ would give the correct result. $n = 5$ corresponds the minimum value of n making possible topological quantum computation [33].

It is interesting to notice that Evan Harris Walker [120] has developed a quantitative theory in which the tunnelling of electrons through the synaptic contact is the basic step of synaptic transfer. The theory applies also to ephapses in which electric transfer of the nerve pulse takes place. Theory explains the differences between ephapses and synapses and also the morphology of synapses and ephapses finds natural explanation. This kind of tunnelling might be induced by the formation of 151-169 ME contacts at presynaptic cell and 169-151 ME contacts at the postsynaptic cell.

5.7 Relating the model of nerve pulse with the micro-tubular level

The relationship of the presumed quantum dynamics of the cell interior to the nerve pulse is the basic topic of quantum consciousness theories. Micro-tubular conformational dynamics; gel-sol phase transition of the cytoplasmic water inducing the depolymerization of the actin polymers; the parallelization of micro-tubuli possibly making possible a coherent generation of infrared em radiation; and Mg^{+2} and Ca^{+2} ions as controllers of polymer stability, are some of the most important pieces of the jigsaw. The hierarchical model of Alex Kaivarainen emphasizing these aspects provided crucial pieces of information [127] allowing to construct many-sheeted view about this process. The hierarchy of condensed matter excitations introduced by Kaivarainen corresponds in TGD framework to the hierarchy of space-time sheets whereas the molecular Bose-Einstein condensates of Kaivarainen correspond to BE condensates of various bosonic ions and Cooper pairs at various cold space-time sheets. The classical article of Nanopoulos summarizing basic facts and various ideas about micro-tubuli [116] has been a continual source of information and inspiration and is warmly recommended.

One important element are negative energy IR MEs having phase conjugate laser beams [70] as physical counterparts. First of all, they make possible intentional action at the micro-tubular level: even the TGD based model of mRNA-protein translation involves intentional aspects. Negative energy MEs are crucial for the understanding of the macro-temporal quantum coherence and have inspired the notions of remote metabolism and quantum credit card. The notion also leads to what might be called seesaw mechanism of energy metabolism, and allows to understand how micro-tubular surfaces provide dynamical records for the cellular sol-gel transitions and thus define fundamental micro-tubular representation of declarative long term memories.

The vision about dark matter hierarchy brings in perhaps the most decisive new elements.

1. Dark matter hierarchy leads to the identification of big leaps of evolution in terms of the emergence of new levels of dark matter hierarchy. Magnetic bodies are the intentional agents in this picture and it is possible to understand the control of logistics and declarative memory as basic functions associated with micro-tubules.

2. Synchronous neuron firing involves parallelization of microtubules. This coherent action can be understood in terms of macroscopic quantum coherence realized in terms of super-genes and the more general notion of multi-neuron with neurons organized to linear structures analogous to the lines of text on the pages of book defined by magnetic flux sheets.

3. Ca^{+2} and Mg^{+2} ions are known to be important for the depolymerization of microtubules and actin molecules occurring during nerve pulse. This conforms with the central role of the Bose-Einstein condensates of dark bosonic ions Ca^{+2} and Mg^{+2} and their exotically ionized counterparts in the generation of pulse in the proposed model, and more generally, in quantum bio-control based on charge entanglement between cell and magnetic body.

4. The ordered water associated with gel phase was earlier modelled in terms of dropping of protons to $k = 139$ space-time sheets. In the new framework this phase can be identified as a partially dark water. The response of cells to IR radiation is maximal at photon energy .1 eV. What makes bells ringing is that the model of high T_c conductivity based on dark matter hierarchy leads to the identification of the cell membrane as a Josephson junction generating ordinary IR photons with energy $2eV = .1$ eV at the membrane potential corresponding to threshold for nerve pulse generation kicking protons to $k = 139$ space-time sheet associated with ordered water.

This section was written much before the breakthrough induced by the model of DNA as tqc and the inspiration coming from the model of nerve pulse as acoustic soliton by Danish researchers [61]. Hence a lot is lacking and the contents of section are not necessarily completely consistent with the new vision. For instance, the phase transitions changing the value of $\hbar$ and tqc using 4-colored braids provide a general explanation for the selectivity of the catalytic action [28]. I have however decided to leave the section as it is.

5.7.1 Dark matter hierarchy and big leaps in evolution

Dark matter hierarchy leads to an amazingly concrete picture about evolutionary hierarchy allowing to identify the counterparts for concepts like mineral, plant, and animal kingdom that we learned during schooldays and ceased to take seriously as students of theoretical physics as we learned that other sciences are just taxonomy. Even more, a view about what distinguishes between prokaryotes, eukaryotes, animal cells, neurons, EEG, and even about what makes cultural evolution, becomes possible. This view is also very useful when one tries to understand the role of microtubules.

The appearance of CDs scaled up in size by $r = \hbar/\hbar_0$ and space-time sheets scaled up in size by $\sqrt{r}$ means the emergence of new levels of structure and it is natural to identify big leaps in evolution in terms of emergence of new larger matter carrying space-time sheet magnetic flux sheets and corresponding magnetic bodies. If magnetic flux quanta are scaled by r magnetic flux quantization conditions remain unaffected if magnetic field strengths scale down by $1/r$ so that the energies of cyclotron photons are not affected. The thickness of flux tubes can remain unchanged if the currents running at the boundaries of the flux quantum cancel the magnetic flux. As already found, this mechanism must be at work inside living organisms wheras in far away region flux quanta are scaled up in size.

The attractive hypothesis is that the leaps in evolution correspond to the emergence of dark variants of weak and possibly also color interactions in dark p-adic length scales which correspond to ordinary p-adic length scales characterized by Mersenne primes. These leaps would be quantum leaps but in different sense as thought usually. The emergence of higher dark matter levels would basically mean the integration of existing structures to larger structures. A good metaphor are text lines at the pages of book formed by magnetic flux sheets whose width is scaled up by r as the new level of dark matter hierarchy emerges. The big leaps can occur both at the level of organism and population and organisms with rather low individual dark matter level can form societies with high dark matter levels and high collective intelligence (honeybees and ants are good example in this respect).

Certainly also other scalings of Planck constant than those summarized in tables are possible but these scalings are of primary interest. This intuition is supported by the observation that electron is completely exceptional in this framework. Electron's dark p-adic length scales corresponds to p-adic length scales $L(k)$, $k = 167, 169$, assignable to atomic and molecular physics and to the Gaussian Mersennes $M_{G,k} = (1+i)^k - 1$, $k \in \{151, 157, 163, 167\}$, assignable to the length scale range between cell membrane thickness 10 nm and nucleus size 2.58 μm. The corresponding p-adic length scales, the number of which is 23, are excellent candidates for the scales of basic building brickes of living matter and vary from electron's p-adic length scale up to 1.25 m ($k = 167$ defining the largest Gaussian Mersenne in cell length scale range) and defining the size scale of human body. The corresponding p-adic time scales are also highly interesting and vary from .1 seconds for electron defining the fundamental biorhythm to 9.6×10^{14} years which is by 4-5 orders longer than the age of the observed Universe. For $k = 167$ the time scale is 1.1×10^{11} years and is by one order of magnitude longer than the age of the observed Universe estimated to be 1.37×10^{10} years [41].

This conceptual framework gives rather strong guidelines for the identification of the levels of evolutionary hierarchy in terms of dark matter hierarchy. The outcome is a more detailed vision about big evolutionary leaps. Note that in the sequel only the general option is considered: the justification for this is that for this option electron appears as a dark particle for all length scales defined by Gaussian Mersennes as well as in atomic length scales. The basic vision in nutshell is that evolution means the emergence of dark weak and gluonic physics in both dark and ordinary length scales and that the size scales of the basic biostructures correspond to Mersenne primes and their Gaussian variants.

A sketch about basic steps in evolution

The vision about evolution depends on what one assumes about the initial state.

1. If one assumes that weak bosons with ordinary value of Planck constant were present in the begining, evolution would mean a steady growth of k_d. The problem is that small values of $k_d = k_1 - k_2$ correspond to the Gaussian Mersennes defining cellular length scales. If these exotic weak physics were present from the beginning, large parity breaking in cellular length scales would have been present all the time.

2. An alternative and perhaps more realistic view is that the evolution means the emergence of exotic weak physics corresponding almost vacuum extremals in increasingly longer length scales. A possible mechanism could have been the induction of exotic $\hbar_0$ variant of weak physics at the nearest Mersenne length scale k_{next} by the dark variant of weak physics at level k so that one would have $k_d = k_{next} - k$. The simplest induction sequence would have been $89 \rightarrow 107 \rightarrow 113 \rightarrow 127 \rightarrow 151 \rightarrow 157 \rightarrow 163 \rightarrow 167$ corresponding to $k_d \in \{18, 6, 14, 24, 6, 6, 4\}$. A possible interpretation of exotic $\hbar_0$ physics is in terms of almost vacuum extremals and non-standard value of Weinberg angle: also weak bosons of this physics would be light. This sequence defines the minimal values for k_d but also larger values of k_d are possible and would correspond to steps between neighbours which are not nearest ones.

The following sketch about the basic steps of evolution relies on the latter option.

1. Elementary particle level

Magnetic bodies with size scale defined by the sizes of CDs assignable to quarks and leptons and possibly also weak bosons (already now the size of big neuron emerges) corresponds to the lowest level of hierarchy with the sizes of the basic material structures corresponding to the Compton lengths of elementary particles. The fundamental bio-rhythms corresponding to frequencies 10, 160, and 1280 Hz appear already at this level in zero energy ontology which suggests that elementary particles play a central and hitherto unkown role in the functioning of living matter.

2. $89 \rightarrow 107$ *step with* $k_d = 18$

The first step would have been the emergence of $k_{eff} = 107$ weak bosons inducing $\hbar_0$ weak physics in $k = 107$ length scale characterizing also ordinary hadrons. This in turn would have led to the emergence of exotic nucleons possibly corresponding to almost vacuum extremals. The reduction of the model for the vertebrate genetic code to dark hadron physics [23] is one of the most unexpected predictions of quantum TGD and assumes the existence of exotic- possibly dark- nucleons whose states with a given charge correspond to DNA, RNA, mRNA, and tRNA. The $\hbar_0$ variants of these nucleons would interact via weak bosons with hadronic mass scale. The exotic variants of the ordinary $k = 113$ nuclei would correspond to the nuclear strings consisting of exotic nucleons [22, 23] and define nuclear counterparts for DNA sequences. Their dark counterparts could define counterparts of DNA sequences in atomic physics length scales. Therefore a justification for the previous observation that genetic code could be realized at the level of hadron physics and that chemical realization would be higher level realization finds justification. The anomalous properties of water could be also partly due to the presence of dark nucleons and the proposal was that the presence of exotic nuclei is involved with water memory [16]. The possible existence of the the analog of DNA-RNA transcription between ordinary DNA and its nuclear counterpart would have dramatic implications. For instance, one can imagine a mechanism of homeopathy based on this kind of transription process which would also allow a modification of genome by using dark nuclei to communicate the DNA sequences through the cell membrane to the target nuclei.

3. $107 \rightarrow 113$ *step with* $k_d = 6$

The next step would have been the emergence of $k_{eff} = 113$ weak bosons inducing $\hbar_0$ weak physics in $k = 113$ length scale characterizing also ordinary hadrons. Exotic variants of the ordinary nuclei possibly corresponding to almost vacuum extremals could have emerged interacting weakly (or actually relatively strongly!) via the exchange of weak bosons with mass scale of order 100 MeV. Also dark variants of the exotic $k = 107$ nucleons could have have emerged and formed exotic nuclei of size scale $k = 119$.

4. $113 \rightarrow 127$ *step with* $k_d = 14$

At this step weak bosons in electron mass scale would have emerged. Whether these weak bosons could have induced large parity breakings in atomic and molecular length scales is not clear. Viruses, which do not yet possess cell membrane could correspond to this level of hierarchy.

5. $127 \rightarrow 151$ *step with* $k_d = 24$

This step would have been fundamental since weak bosons in cell membrane length scale would have appeared. Note that by $113 - 89 = 24$ this step also leads from $k = 89$ weak bosons to

$k = 113$ weak bosons. The weak bosons assignal to $k = 151$ could correspond to the weak interactions associated with almost vacuum extremals and $sin^2(\theta_W) = .0295$ could correspond to the weak physics in question.

$k_d = 24$ step for $k = 113$ $\hbar_0$ weak bosons would have produced them in $k_{eff} = 137$ atomic length scale with $L(137) \simeq .78$ Angstrom This could have naturally led to large parity breaking effects and chiral selection.

Dark $k_{eff} = 151$ electrons appearing in the TGD inspired model of high T_c super-conductivity would have been a by-product of this step. Whether dark electrons could have transformed to light $\hbar_0$ electrons (of mass .25 keV) with a common mass scale of order 10^2 eV with exotic weak bosons is an interesting question. The model of high T_c super-conductivity predicts the presence of structures analogous to cell membrane. This would suggest that cell membranes emerged and chiral selection emerged at this step so that one could not distinguish the emergence of molecular life as a predecessor for the emergence of cell membrane like structures. This would conform with the fact that DNA molecules are stable only inside cell nucleus. Note that for $k_{eff} = 151$ electron's CD has time scale $2^{24} \times .1$ seconds -that is 19.419 days (day=24 hours).

The smallest nanobes [48] appearing in rocks have size 20 nm and could have emerged at this step. The size of the viruses [53] is between 10-300 nm covers the entire reange of length scales assignable to Gaussian Mersennes, which suggests that smallest viruses could have emerged at this step. Also the smallest nannobacteria [50], which by definition have size smaller than 300 nm could have appeared at this stage.

6. The remaining steps

The remaining steps $k = 151 \rightarrow 157 \rightarrow 163 \rightarrow 167$ could relate to the emergence of coiling structure DNA and other structures inside cell nucleus. $k = 167$ would correspond to $k_d = 167 - 89 = 68$ to be compared with the value $k_d = 47$ required by 5 Hz Josephson frequency for the neuronal membrane for -70 mV resting potential. Note that $k_d = 48$ (state 1-2 of deep sleep) corresponds to $k = 163$.

By their smallness also double and triple steps defined by $k_d = k_{i+n} - k_i$, $n > 1$, are expected to be probable. As a consequence, electrons can appear as dark electrons at all the Gaussian Mersenne levels. At these steps the dark electrons corresponding to primes $k_{eff} = 137, 139$ would appear. For $k = 137$ dark electron appears with CD time scale equal to 128 seconds- rather precisely two minutes. The model for EEG suggests that the exotic weak bosons appear in the scales $k_{eff} = 136, 137, 138$.

Further multisteps from the lower levels of hierarchy would give structures with size scales above the size of cell nucleus possibly assignable to organs and structural units of brain. The dark levels assignable to electron are expected to be of special interest. It is encouraging that the longest scale assignable to electron in this manner corresponds to $k = 205$ and length scale of 1.28 m defining body size. As a consequence dark electrons are predicted at levels $k = 137, 139, 141, 143, 145, 147$ coming as octaves.

Prokaryotic cells (bacteria, archea) without cell nucleus for which cell membrane is responsible for metabolic functions and genome is scattered around the cell could have emerged at this step. This would mean that the emergence of the cell membrane thickness as a fundamental scale is not enough: also the size scale of membrane must appear as p-adic length scale. The sizes of most prokaryotes vary between 1 μm and 10 μm: the lower bound would require $k = 163$. There also prokaryotes with sizes between .2 μm ($k = 157$ corresponds to .08 μm) and 750 μm. Cell nuclei, mitochondria, and other membrane bounded cell nuclei would have evolved from prokaryotes in this framework. The sizes of eukaryote cells are above 10 μm and the fact that multicellular organisms are in question strongly suggests that the higher multisteps giving rise to weak bosons and dark electrons in length scales above $L(167)$ are responsible for multi-cellular structures.

This scenario leaves a lot of questions unanswered. In particular, one should understand in more detail the weak physics at various length scales as well as various exotic nuclear physics defined by dark nucleons and dark variants of nuclei.

Division of the evolution to that of biological body and magnetic body

Electron's Mersenne prime M_{127} is the highest Mersenne prime, which does not correspond to a completely super-astrophysical p-adic length scale. In the case of Gaussian Mersennes $M_{G,k}$ one has besides those defined by k in $\{113, 151, 157, 163, 167, \}$ also the ones defined by k in $\{239, 241, 283, 353, 367, 379,$

$457, 997\}$ [38]. The appropriately extended model for evolution allows to distinguish between three kinds of values of k_{eff}.

1. The values of k_{eff} for which electron can appear as dark particle and thus satisfying $k_{eff} \leq 205$ (Table 5). These levels would correspond to structures with size below 1.25 m defined roughly by human body size and it is natural to assign the evolution of super-nuclear structures to the levels $167 < k_{eff} \leq 205$.

2. The values of of k_{eff} for which dark gauge bosons are possible in the model. This gives the condition $k_{eff} \leq 235$. These levels correspond to structures in the range 1.25 m-40 km. The identification as parts of the magnetic body can be considered.

3. The values of k_{eff} obtained by adding to the system also the Gaussian Mersenne pair $k \in \{239, 241\}$ allowing also the dark electrons. The lower size scale for these structures is 640 km.

4. The higher levels corresponding to k_{eff} in $\{283, 353, 367, ...\}$. The lower size scale for these structures is 3 AU (AU is the distance from Earth to Sun).

$k_{eff} > 205$ levels would correspond to the emergence of structures having typically size larger than that of the biological body and not directly visible as biological evolution. This evolution could be hidden neuronal evolution meaning the emergence of extremely low Josephson frequencies of the neurons modulating higher frequency patterns and being also responsible for the communication of long term memories.

Biological evolution

In principle the proposed model allowing multisteps between hierarchy levels defined by Mersenne primes and their Gaussian counterparts could explain the size scales of the basic structures below the size scale 1.25 m identified in terms of the $k_{eff} \leq 205$ levels of the hierarchy.

1. The emergence of cells having organelles

The appearance of the structures with $k_{eff} > 167$ (possibly idetifiable as magnetic body parts) should correlate with the emergence of simple eukaryotic cells and organisms, in particular plant cells for which size is larger than 10 μm, which could correspond to $k_{eff} = 171$ for electron and dark variants of weak gauge bosons. $k_{eff} = 177$ is the next dark electron level and corresponds to 80 μm scale. It seems natural to assume that these dark weak bosons do not transform to their $\hbar_0$ counterparts at these space-time sheets.

Cell nucleus would be the brain of the cell, mitochondria would be the energy plant, and centrioles generating microtubules would define the logistic system. Also other organelles such as Golgi apparatus, ribosomes, lysosomes, endoplasmic reticulum, and vacuoles would be present. These organelles would live in symbiosis by topologically condensing to $k_{eff} \geq 171$ magnetic body controlling their collective behavior. Centrosomes associated with animal cells would not be present yet but microtubule organizing centers would already be there.

The recent observations show that centrioles are not always in the characteristic T shaped conformation. Daughter centrioles resulting during the replication of mother centriole use first ours of their lifetime to roam around the cell before becoming mature to replicate. A possible interpretation is that they are also life forms and that magnetic body utilizes daughter centrioles to perform some control functions crucial for the future development of the cell. For instance, centrioles visit the place where axonal growth in neurons starts.

Cytoskeleton would act as a counterpart of a central nervous system besides being responsible for various logistic functions such as transfer of proteins along microtobuli. Centrioles give also rise to basal bodies and corresponding cilia/flagella used by simple cells to move or control movement of air or liquid past them. Centriole pair would be also used by the magnetic body to control cell division.

The logistic functions are the most obvious functions of microtubules. Magnetic body would control cell membrane via signals sent through the cell nucleus and communicated to the cell membrane along microtubuli. Basal bodies below the cell membrane and corresponding cilia/flagella would serve as motor organs making possible cell motion. Tubulin conformations representing bits would allow microtubule surface to represent the instructions of the magnetic body communicated via via cell nucleus to various proteins moving along the microtubular surface so that they could perform their functions.

TGD based view about long memory recall as communication with geometric past allows also the realization of cellular declarative memories in terms of the conformational patterns. Memory recall corresponds to a communication with geometric past using phase conjugate bosons with negative energies reflected back as positive energy bosons and thus representing an "image" of microtubular conformation just like ordinary reflected light represents ordinary physical object. There would be no need for a static memory storage which in TGD framework would mean taking again and again a new copy of the same file.

Receptor proteins would communicate cell level sensory input to the magnetic body via MEs parallel to magnetic flux tubes connecting them to the magnetic body. We ourselves would be in an abstract sense fractally scaled up counterparts of receptor proteins and associated with dark matter iono-lito Josephson junction connecting the parts of magnetosphere below litosphere and above magnetosphere. The communication would be based on Josephson radiation consisting of photons, weak bosons, and gluons defining the counterpart of EEG associated with the level of the dark matter hierarchy in question.

3. The emergence of organs and animals

The emergence of magnetic bodies with k_{eff} in the range $(177, 181, 183, 187, 189, 195, 201, 205)$ allowing both dark electron and weak bosons could accompany the emergence of multicellular animals. Magnetic body at this level could give rise to super-genome making possible genetic coding of organs not yet possessed by plant cells separated by walls from each other. The super structures formed from centrosomes and corresponding microtubuli make possible complex patterns of motion requiring quantum coherence in the scale of organs as well as memories about them at the level of organs.

4. The emergence of nervous system

k_{eff} in the range $(187, 189, 195, 201, 205)$ allowing dark electrons and weak bosons gives size scales $(.25, .5, 4, 32, 128)$ cm, which could correspond to the scales of basic units of central nervous system. What would be of special interest would be the possibility of charged entanglement based on classical W fields in macroscopic length scales. The emergence of the new level means also the integration of axonal microtobuli to "text lines" at the magnetic flux sheets making possible logistic control at the multineuronal level. The conformational patterns of the microtubular surface would code nerve pulse patterns to bit patterns representing declarative long term memories. An interesting question is whether the reverse coding occurs during memory recall.

The evolution of magnetic body

For mammals with body size below 1.25 m the levels $k_{eff} > 205$ cannot correspond to biological body and the identification in terms of magnetic body is suggestive. The identification of EEG in terms of Josephson frequencies suggests the assignment of EEG with these levels.

1. The emergence of EEG

EEG in the standard sense of the word is possessed only by vertebrates and one should understand why this is the case. The value of Josephson frequency equal to 5 Hz requires only $k_d = 47$ so that something else must be involved. A possible explanation in the framework of the proposed model comes from the following observations.

1. Besides the maximal p-adic scale $k = 205$ for which electron and weak bosons appears as dark variants the model allows also levels at which only gauge bosons appear as dark particles. From Table 9 one finds that levels $k \in \{207, 211, 213, 217, 219, 221, 223, 225, 229, 235\}$ are allowed. Could it be that these levels and possibly some highest levels containing both electrons and gauge bosons as dark particles are a prerequisite for EEG as we define it. Its variants at higher frequency scales would be present also for invertebrates. The lowest Josephson frequency coded by the largest value of $\hbar$ in the cell membrane system determins the Josephson frequency.

2. The membrane potentials -55 mV (criticality against firing) correspond to ionic Josephson energies somewhat above 2 eV energy ((2.20,2.74,3.07,2.31) eV, see Table 1). For 2 eV the wavelength 620 nm is near to $L(163) = 640$ nm. Therefore the Josephson energies of ions can correspond

to the p-adic length scale $k = 163$ if one assumes that a given p-adic mass scale corresponds to masses half octave above the p-adic mass scale so that the opposite would hold true at space-time level by Uncertainty Principle. Josephson frequencies $f_J \in \{5, 10, 20, 40, 80, 160\}$ Hz correspond to $k_d \in \{47, 46, 45, 44, 43, 42\}$ giving $k_{eff} \in \{210, 209, 208, 207, 206, 205\}$.

(a) Cerebellar resonance frequency 160 Hz would correspond to $k = 205$ -the highest level for for which model allows dark electrons (also 200 Hz resonance frequency can be understood since several ions are involved and membrane potential can vary).

(b) The 80 Hz resonance frequency of retina would correspond to $k_{eff} = 206$ -for this level dark electrons would not be present anymore.

(c) 40 Hz thalamocortical frequency would correspond to $k_{eff} = 207$.

(d) For EKG frequencies are EEG frequencies below 20 Hz 12.5 and heart beat corresponds to .6-1.2 second cycle (the average .8 s corresponds to $k_{eff} = 212$).

3. Even values of k_{eff} are not predicted by the model based on Mersenne primes allowing only odd values of k_{eff} so that the model does not seem to be the the whole truth. The conclusion which however suggests itself strongly is that EEG and its variants identified as something in the range 1-100 Hz, are associated with the levels in at which only dark weak bosons are possible in the proposed model. Note that the size scales involved with EEG would be above the size scale of human body so that we would have some kind of continuation of the biological body to be distinguished from the magnetic body. The time scales assignable to the dark CDs would be huge: for instance, $k = 205$ would correspond to $T = 2^{42} \times .1$s making about 1395 years for electron.

2. Does magnetic body correspond to the space-time sheets carrying dark weak bosons?

The layers of the magnetic body relevant for EEG have have size of order Earth size. Natural time scale for the moment of sensory consciousness is measured as a fraction of second and the basic building blocks of our sensory experience corresponds to a fundamental period of .1 seconds. This scale appears already at $\hbar_0$ level for electron CD. The natural question concerns the relationship of the magnetic body to the $k > 205$ space-time sheets carrying only gauge bosons in the model and having size scale larger than that of biological body. Do they correspond to an extension of biological body or should they be regarded as parts of the magnetic body? The following observations suggest that they could correspond to layers of the magnetic body responsible for the fractal variant of EEG.

1. The primary p-adic time scales (Compton times) $T(239)$ and $T(241)$ correspond to frequencies, which are $2^{\pm 1/2}$ kHz. The geometric average $k = 240$ corresponds to kHz frequency. Is the appearance of kHz scale a mere accident or do the frequencies assignable to the quark CDs correspond to Compton times $\propto \sqrt{2^{k_{eff}/2}}$?

2. One can apply scalings by 2^{k_d} to the triplet $(239, 240, 241)$ to get a triplet $(239 + k_d, 240 + k_d, 241 + k_d)$. The results are summarized in Table 10. Clearly the frequencies in question cover also the EEG range. Note that these frequencies scale as $\sqrt{1/r}$ whereas Josephson frequencies scale as $1/r$.

k_d	f_1/Hz	f_2/Hz	f_3/Hz
0	707	1000	1412
4	177	250	354
6	89	1250	177
10	22.1	31.3	44.2
12	11.1	15.6	22.1
14	5.5	7.8	11.1
16	2.8	3.9	5.5
18	1.4	2.0	2.8
20	0.7	1.0	1.4
24	0.2	0.2	0.3

Table 10. The Compton frequencies obtained by scaling $2^{k_d/2}$ from the basic triplet $k_{eff} = (239, 240, 241)$. The values of k_d correspond to those predicted by the model based on Mersenne primes.

Also ZEG and WEG would appear but in much shorter scales dictated by k_{eff} and might accompany EEG. Somehow it seems that the effective masslessness of weak bosons below given scale is highly relevant for life. One can of course ask whether some larger Gaussian Mersenne could change the situation. There is a large gap in the distribution of Gaussian Mersennes after $k = 167$ and the next ones correspond to $M_{G,k}$, with k in $(239, 241, 283, 353, 367, 379, 457, 997)$ [38]. The twin pair $k = (239, 241)$ corresponds to a length scales $(1.6, 3.2) \times 10^2$ km and the minimum value for k_d are (72,74) ($167 \rightarrow (239, 241)$ transition).

3. Long term memory and ultralow Josephson frequencies

What determines the time scale associated with long term memory is a crucial question if one really wants to understand the basic aspects of consciousness.

1. Does the time scale correspond to the size scale of CD assignable to electron scaled by $r = \hbar/\hbar_0$? In this case relatively small values of r would be enough and $r = 2^{47}$ would give time scale of 10^{13} s for for electron's CD, which is about 3×10^5 years. This does not make sense.

2. Does Josephson frequency define the relevant time scale? In this case the long term memory would require the analog of EEG in the time scale of memory span. $k_{eff} = 205$ would give 6 ms time scale for memory from the assigment of $k_{eff} = 163$ to the Josephson photons at V=-50 mV implying $k_d = 42$. Minute scale would require $k_{eff} = 217$. The highest level $k_{eff} = 235$ allowed by the model involving only Gaussian Mersennes with $k \leq 167$ would correspond to a time scale of 77.67 days (day is 24 hours). For Gaussian Mersennes defined by $k_{eff} = (239, 241)$ the time scales become about (41.4,82.8) months (3.4 and 6.8 years). These scales should also define important biorhythms. The claimed 7 years rhythm of human life could relate to the latter rhythm: note that the precise value of the period depends on the membrane potential and thus varies. The presence of the scaled up variants of the by $k_d \leq 78$ allows longer time spans of long term memory and the scaling defined by $k_d = 167 - 163 = 4$ scales up the span of long term memories to (54.4,108.8) years.

4. Cultural evolution

Higher levels in the hierarchy would correspond mostly to the evolution of hyper-genome coding for culture and social structures. Introns are good candidate for the nucleodes involved. The development of speech faculty is certainly a necessary prerequisite for this breakthrough. Already EEG seems to correspond to dark layers of biological body larger than biological body so that one can cask whether the weak bosons and dark electrons in the length scales $k = 239, 241, 283, 353, 367, ...$ could be relevant for the collective aspect of consciousness and cultural evolution. Maybe the size scales $(175, 330)$ km and their scaled up variants by $k_d \leq 78$ might have something to do with the spatial scale of some typical social structure (not city: the area of New York is only 790 km^2).

5.7.2 Some TGD inspired new ideas about biochemistry

TGD provides several new physics concepts whose role in biochemistry is now relatively well understood thanks to the insights provided by the construction of the model of pre-biotic evolution [26]. Hence there are hopes of understanding the basic principles of cellular control at macromolecular level, and to apply these principles to understand what happens during nerve pulse in the interior of neuron. It is not possible to overestimate the importance of the fact that p-adic length scale hypothesis makes the model quantitative and reduces the number of alternatives dramatically.

Increments of zero point kinetic energies as universal metabolic currencies

The protons and also various other ions and possibly even electrons liberate their zero point kinetic energy while dropping to larger space-time sheets. This process and its reversal define metabolism as a universal process present already during the pre-biotic evolution rather than as an outcome of a long molecular evolution [26]. ATP-ADP transformation, polymerization by dehydration, and its reversal are key examples of the many-sheeted dynamics involving the dropping of protons from

$k = 137$ space-time sheet liberating about .4-.5 eV of zero point kinetic energy and the reversal of this process. In TGD framework metabolism generalizes to a fractal metabolism involving a large number of metabolic currencies.

Negative energy MEs make possible remote metabolism realizing what might called quantum credit card. This makes energetic economy extremely flexible. F-actin polymerization [127] is an interesting application of this notion.

1. Each G-actin unit of F-actin is stabilized by Ca^{+2} ion and contains one ATP molecule. The polymerization of G-actin molecule is accompanied by an ATP-ADP transformation involving the dropping of a proton to a larger space-time sheet.

2. The fact that F-actin polymerization does not require energy [127] suggests that the zero point kinetic energy liberated in this manner is used to kick one proton to an atomic space-time sheet in G-actin molecule needed in dehydration inducing the polymerization.

3. This is achieved if the G-actin molecule emits a $.4 - .5$ eV negative energy photon inducing the hopping of proton to an atomic space-time sheet associated with G-actin. The negative energy photon is received by the ATP molecule and induces the dropping of proton from atomic space-time sheet associated with the ATP molecule. This energetic seesaw could be controlled by a precisely targeted intentional action of the G-actin molecule by the generation of p-adic ME transformed then to negative energy ME. The seesaw mechanism can be generalized to a mechanism controlling the occurrence of sol-gel transitions.

A natural guess is that the emergence of larger space-time sheet with sizes characterized by p-adic length scales is a correlate for the evolution of more refined control and information processing structures utilizing smaller energy currencies. The situation is essentially quantal: the longer the length scale, the smaller the quantum of the metabolic energy. Micro-tubuli and other intracellular organelles represent excellent candidates for this kind of higher level metabolism refining the standard metabolism based on .4-.5 eV energy currency.

Since negative energy MEs with energies above thermal energy scale cannot induce transitions to lower energy states, a good guess is that negative energy MEs corresponding to metabolic currencies above the thermal energy $T_{room} \sim .03$ eV can be utilized for entanglement purposes. This is only a rough rule of thumb since the energy spectrum of systems at a given space-time sheet is expected to have an energy gap. Therefore negative energy MEs, even those below the ELF frequency range, are expected to be important.

Allowing n-ary p-adic length scales, this would mean in the case of hydrogen atom the upper upper bound $L(3,47)" = "L(141) = 2L(139)$ for the p-adic length scales in the hierarchy of water clusters. For electron the upper bound is cell membrane thickness $L(151) \simeq 10$ nm, which corresponds to the effective axonal electronic super-conductivity with the metabolic currency $.025 - .03$ eV. Interestingly, the water at room temperature contains flickering structures of size of order 20-30 nm with lifetime of order .1 ns [75]. MEs at energy $\simeq .03$ eV could stabilize these structures by kicking the dropped Cooper pairs back to k=151 space-time sheets. One can also ask whether micro-wave MEs at GHz frequency, perhaps generated in the rotational transitions of water molecules, modulate the generation of .03 eV MEs and are thus responsible for the flickering.

Liquid crystal phase of water as a stabilizer of biopolymers

The second key element is the understanding of the role of the liquid crystal [71] water in the stabilization of various bio-polymers. The reason is that the water molecules making possible depolymerization by hydration (also other means, say by the addition of heavy water or the increase of salt concentration, of reducing water activity have a stabilizing effect) are frozen to the liquid crystal. Thus the control at the level of bio-polymers could reduce to the control of whether cellular water is in sol or gel phase and to the understanding of what sol-gel difference means in the many-sheeted space-time.

Local gel-sol transitions could also provide a fundamental mechanism of cellular locomotion applied by, say, amoebae. Quite generally, various conformational changes needed in the cellular control are made possible by a local melting of the gel to sol followed by the conformational change in turn followed by a local sol-gel transition stabilizing the resulting conformation. The technological counterpart of this process is welding. The ME-controlled local melting and solidification of metals might in future technology make possible machines changing their structure routinely.

Local sol-gel transitions could also make possible the control of the conformations of the tubulin dimers expected to be sensitive to the di-electric constant of the water between the alpha and beta tubulin. This would mean that sol-gel phase transition and its reversal could define the bit of the declarative long term memory. Em MEs inducing gel-sol phase transition could provide a precisely targeted control of this kind. This would mean that coherent BE condensed photons associated with MEs could induce the sol-gel phase transition.

What distinguishes between sol and gel phases?

Sol-gel transition is crucial for the polymerization of actin molecules and micro-tubuli, and this dynamics probably involves something more refined than the molecular $k = 137$ metabolism. The dropping of protons/hydrogen atoms or of protonic Cooper pairs from $k = 139$ space-time sheet to larger space-time sheets is thus a unique candidate for what is involved with sol-gel transition.

The liberated zero point kinetic energy would be .1 eV for the dropping of proton or hydrogen atom (if .4 eV is the fundamental metabolic quantum whose value varies roughly in the range .4-.5 eV). For protonic Cooper pairs the energy would be .05 eV. According to the findings of Albrecht-Buehler [79], the response of cells to IR radiation at .1 eV photon energy is maximal.

The presence of protonic Bose-Einstein condensate at $k = 139$ space-time sheet might thus distinguish between the liquid-crystalline gel phase from sol phase. The particles of this effectively 2-dimensional liquid would be loosely bound tubular structures having a radius of about $L(139)$ and the BE condensate of the dropped proton would bind the water molecules to form this structure. Ordinary water would result when protons at $k = 139$ space-time sheet drop to larger space-time sheets. $k = 139$ space-time sheets would be also associated with small sized water clusters.

This phase could be interpreted in terms of the partially dark water whose existence is suggested by the empirical finding that the chemical formula of water seems to be $H_{1.5}O$ in attosecond scale in the sense that neutron diffraction and electron scattering see only 1.5 protons per oxygen molecule [67, 64, 68, 69]. As proposed in [19], every fourth proton would be in dark phase, the lowest dark matter phase and protons would form string like structure which could be regarded as scaled up nuclei consisting of protons (also ordinary nuclei correspond to nuclear strings in TGD framework and exotic $k = 127$ quarks play a key role in the model [18]).

Attosecond suggests itself as the scale for the average time T_d spent by proton in dark phase in this case. In ordered water the lifetime of this phase might be considerably longer. If a dark variant of $k = 139$ space-time sheet is in question, T_d is scaled up by $r = \hbar/\hbar_0$. Zero point kinetic energy and the energy of photons would remain invariant, which makes possible quantum coherent control in multi-neuron length scale.

IR radiation as a stabilizer of gel phase?

The model for the effective electronic super-conductivity generalizes to the case protonic Cooper pairs and ionic Bose Einstein condensates, and allows to develop a more precise picture. At the room temperature the thermal photons have energy lower than the zero point kinetic energy .1 eV so that the BE condensate can be maintained only by feeding IR photons kicking the hydrogen atoms back to $k = 139$ space-time sheet with a high enough rate. Therefore the stabilization of the gel phase requires an expenditure of metabolic energy. The simplest view is that in the ground state the entire interior of the cell is in gel phase so that the cell interior would have tonus analogous to muscular tonus.

By stopping the feed of the energy by IR photons to a particular region of cell, gel-sol transition with its various outcomes would occur spontaneously. A faster and energetically more economic manner to achieve the same outcome is to generate negative energy IR photons which induce the dropping of the hydrogen atoms from $k = 139$ space-time sheets. This mechanism also guarantees the stability of polymers by making hydration impossible. A more clumsy manner to guarantee this is to feed protons back to $k = 137$ space-time sheet where they induce dehydration: this process would probably cost much more energy.

Note that the gel-sol transition of the peripheral cytoskeleton assumed to occur during nerve pulse would rely on different different mechanism. Ca^{+2} ions act as cross links between actin molecules and the lengthening of the cytoskeleton-membrane flux tubes in $\hbar$ increasing phase transition makes possible the flow of dark monovalent ions from cell exterior to peripheral cytoskeleton and induces gel-sol phase transition. This phase transition is initiated with the voltage over membrane is reduced to very small value inducing quantum criticality. The proposal is that dark ionic currents from microtubules to axonal membrane induces this reduction.

One can of course ask whether the mere influx of monovalent ions is enough to induce the gel-sol phase transition in the required millisecond time scale. The reduction of cell potential to about .05 V, quite near to the value inducing action potential, implies that the photons of Josephson radiation have energy .05 eV. At this energy a resonant absorption of phase conjugate IR photons by the peripheral cytoskeleton inducing in turn the dropping protons to larger space-time sheet could induce the gel-sol transition.

Cell membrane Josephson junction as a generator IR coherent light

What is then the mechanism generating IR MEs acting as space-time correlates for coherent IR photons? The crucial observation is that the Josephson energy $E_J = ZeV$ for $Z = 2$ for cell membrane Josephson junction is .1 eV at threshold $V = 50$ mV for nerve pulse generation. The value of the metabolic energy quantum varies in certain range and the value .13 eV for the resting potential 65 mV would correspond to .052 eV metabolic quantum. Hence Josephson radiation could take care of kicking protons back to $k = 139$ space-time sheet thus stabilizing gel phase above the threshold for nerve pulse generation. The IR photons generated by Josephson current tend to propagate parallel to the axon and axon could act as a waveguide. When nerve pulse is generated at axonal hillock the frequencies of Josephson radiation are reduced below the threshold allowing stability of gel phase in region near axonal hillock and gel-sol transition should occur.

During nerve pulse the Josephson frequency varies in a wide range and has also negative values during the period when membrane voltage is positive (below 35 meV). A possible interpretation is that a phase conjugate IR radiation with energies $|E| < .07$ eV is generated. These photons could draw protons to large space-time sheet but with kinetic energy $E_0 - E$ rather than at rest.

The scaled up variants of IR photons at higher levels of dark matter hierarchy de-cohering into ordinary IR photons could make possible coherent quantum control in length scales given by $\lambda^n \times \lambda_{IR}$. For instance, EEG photons with frequency of about 5 Hz would correspond to the large $\hbar$ variants of IR photons with the same energy.

What happens in gel-sol phase transition?

The minimal model for the gel-sol transition could be following. When the membrane potential falls below the threshold value, Josephson radiation does not take anymore care of the stability of gel phase in the zone in the radiation zone directed parallel to the axon and gel-sol phase transition is generated in cellular water. The gel-sol transition occurs also at the level of micro-tubules and destabilizes them unless they take care of themselves by generating negative energy IR radiation received by cellular water. This might quite well occur.

How Ca^{+2} ions are involved with gel-sol phase transition?

Besides IR MEs also Ca^{+2} ions are involved with the gel-sol transition and if these ions act as cross links between proteins in gel, their role can be understood. Ca^{+2} waves are indeed known to be a fundamental cellular control mechanism. Ca^{+2} ions are known to induce a depolymerization of micro-tubules even in micro-molar concentrations whereas Mg^{+2} ions having much smaller ionic radius are known to favor the polymerization of the actin molecules [127]. Ca^{+2} ions which are more abundant in the cell exterior have a large ionic radius of order .099 nm whereas Mg^{+2} ions, which are abundant in the cell interior, have much smaller ionic radius. This supports the view that these ions have dual roles in cellular control.

As positive ions both Ca^{+2} and Mg^{+2} ions tend to increase the probability of the dropping of protons from the atomic $k = 139$ space-time sheets by repelling the protons from $k = 139$ space-time sheets to larger space-time sheets. This could mean gel-sol phase transition and the transformation of ordered water to ordinary water and the increase in the rate of depolymerization by hydration. On the other hand, both Ca^{+2} and Mg^{+2} tend to bind with themselves water molecules which lowers depolymerization rate. For Mg^{+2} with a small ionic radius the latter tendency wins: one can also say that Mg^{+2} is too small to act as a seed for depolymerization.

Bose-Einstein condensates of bosonic ions are key element of the proposed quantum control mechanism involving charge entanglement induced by W MEs connecting magnetic body and cell interior or exterior. The question is whether depolymerization involves the charge entanglement of Ca^{+2} and Mg^{+2} ions. One could argue whether the low amount of Ca^{+2} (Mg^{+2}) in cell interior (exterior) actually means that most of Ca^{+2} (Mg^{+2}) ions are in dark phase in cell interior (exterior). If so then at least sol-gel phase transition would be initiated by Josephson radiation and only at the later stages as Ca^{+2} rush into neuronal interior Ca^{+2} take the lead.

5.7.3 Nerve pulses and microtubules

As an application of above general view one can consider a model for what might happen during the nerve pulse inside axon and neuronal soma (this time interval can be as long as .5 seconds). The known pieces of information [127] indeed fit nicely with the above general principles and one ends up with the following scenario. Note again that this scenario has not been updated to correspond to the most recent view about nerve pulse.

Propagating sol-gel transitions as representations of declarative memories

The propagation of nerve pulse along axon means a propagation of gel-sol-gel phase transition along microtubule. Declarative long term memories could correspond to the temporal sequences of nerve pulses represented as propagating gel-sol-gel phase transitions. The representation of memories would be rather rough as compared to the capacity of microtubular conformations to represent bits: for a conduction velocity $v = 10$ m/s and duration of pulse about 1 ms single pulse would correspond to an axonal length of 10^{-5} meters meaning that 10^3 conformational bits would lumped to single bit

What happens inside neuron soma as nerve pulse is generated?

Consider first what could happen inside neuronal soma as nerve pulse is generated.

1. The positive energy Josephson radiation at IR frequency generated by cell membrane Josephson junction ceases temporarily and induces gel-sol transition in cellular water. Ca^{+2} ions flowing into the neuronal interior favor further the depolymerization of actin molecules. The microtubules of cytoskeleton receive the stabilizing IR radiation still from parts of neuronal membrane other than the throat of axon. They can also take care of themselves by sending phase conjugate IR radiation received by cellular ordered water.

2. The hydration of actin molecules in the vicinity of axonal hillock means that the activity of the water is reduced inside cell and water molecules from the cell exterior rush to the cell interior. The resulting swelling of the cell tears the positively charged ends of the micro-tubuli from the cell membrane. The micro-tubuli are now free to change their conformations and the micro-tubuli associated with different cells can arrange themselves in parallel configurations temporarily. Therefore they could act as quantum antennas generating coherent IR light needed to re-establish the gel phase very effectively: in an ideal case the power radiated is proportional to N^2, N the number of synchronously firing neurons. Also the return of membrane potential to the resting value brings back the IR radiation stabilizing the gel phase.

3. Gel phase is re-generated. Actin molecules re-polymerize and micro-tubuli stick again to the cell membrane. Synaptic contacts and the distribution of the ionic channels in neuronal membrane are re-structured in the process and this means that learning occurs in the sense that cell begins to respond slightly differently to neuronal inputs. This does not correspond to conscious long term memories, which are represented as temporal conformational patterns of tubulin dimers. These memories are in the geometric past, and can change, and are re-experienced by sharing of mental images or communicating the memories classically as field patterns associated with MEs using memetic code.

4. Tubulin dimers are electrets and can be regarded as miniature capacitor plates containing 18 Ca^{+2} ions at the other plate and 18 electrons at the other plate [127, 116]. The average increments of the configuration space zero modes in the quantum jump sequence giving rise to the change of the conformation defines a two-valued geometric quale characterizing single bit of

the long term memory. In [24] a micro-tubular spatial cognitive code based on 13×13 bits is discussed. Temporal pattern extends this code to $13 \times 13 \times 126$ bit code.

5.7.4 Magnetic bodies, MEs and microtubules

It would seem that magnetic bodies are the intentional agents and the most natural assumption is that micro-tubuli are used by the magnetic body of cell for logistic purposes as well as to represent memories. First p-adic MEs representing the intention to suck energy and momentum from a particular part of the gel phase and transformed then to negative energy IR MEs by p-adic-to-real transition. Negative energy IR MEs would also serve as space-time correlates for the bound state quantum entanglement responsible for the generation of a multi-neuron macroscopic and -temporal quantum state.

Phase conjugate laser beams are the most plausible standard physics analogs for negative energy MEs and the coherent photons generated and Bose-Einstein condensates of photons contained by them. Since the energy .1 eV is above the range of the thermal energies, one can argue that negative energy photons can be absorbed only resonantly and thus very selectively. This view is supported by the demonstration of Feinberg showing that it is possible to see through chicken using phase conjugate laser beam [62].

Still an open question is whether laser beams actually correspond to dark photons having thus large value of $\hbar$ and scaled up wavelength. Scaled up wave lengths for .1 eV IR photons would be very natural concerning the control in length scales longer than that of single neuron and synchronous neuronal firing might involve the de-coherence of these dark photons to ordinary IR photons.

Could memes express themselves in terms of modulated IR radiation?

In TGD framework cell nucleus is the brain of the cell and acts as the fundamental controller of the cellular dynamics. Genetic expression is the slow part of this dynamics analogous to a rebuilding of the computer hardware. Software corresponds to memes, sequences of memetic codons realized as sequences of 21 DNA triplets in the intronic part of the DNA. Memetic codons would be the language with which the cellular programs are written. Super-genes or at least hyper-genes would naturally correspond to the sequences of memetic codons.

Memes could express themselves as temporal patterns of IR radiation amplified by micro-tubuli of length ~ 12.4 micrometers. Of course, in accordance with the fractality, also wavelengths corresponding to other metabolic currencies are probably realized. Single memetic codon carries 126 bits and single bit has a duration of about 1/1026 s, the basic time scale of the neuronal dynamics. Both the frequency for the occurrence of sol gel transition and the duration of memetic codon in turn corresponds to 10 Hz frequency in alpha band, which suggests that $k_d = 46$ hierarchy level of dark matter hierarchy is involved with the periodically occurring sol-gel phase transition. The general framework would suggest that this phase transition occurs with this frequency only in vertebrate neurons.

These patterns of IR radiation at $\sim .1$ eV energy induce temporal sequences of sol-gel transitions representing memes physically. The beauty of MEs is that as topological field quanta of radiation they allow a precisely targeted local control not possible in Maxwellian electrodynamics. In particular, temporal sequences of micro-tubulin conformations could represent long term declarative memories expressed in a universal language using memetic codons as basic units.

Seesaw mechanism as a general manner to generate long term memories?

Micro-tubuli can act as quantum antennae producing IR photons by the dropping of proton Cooper pairs and amplified resonantly, when the micro-tubule has a length of about 12.4 micrometers. The absorption of these photons would in turn re-establish the gel phase in receiving system. This energetic gel-sol seesaw would be obviously ideal for the minimization of the dissipative losses.

The seesaw mechanism for the cellular control by micro-tubuli means that sol-gel transition in tubulin induces a gel-sol transition in the controlled part of the cell. Thus it would automatically construct micro-tubular declarative long term memory representation as a record about sol-gel transition history in various parts of the cell or cell substructure coded by the positions of tubulin dimers at the tubulin cylinder.

These dynamical maps about the active structures in the cell interior would be analogous to neuronal maps in cortex. If cell nucleus is the fundamental controller, also chromosomes might be seen as structures analogous to brain hemispheres forming dynamical sensory and motor maps about the interior of the cell. The static conformations would not represent memory bit. Rather, the changes of the conformations would represent the bit in accordance with the view that moments of consciousness correspond to quantum jumps between histories, and that the sequence of quantum jumps effectively integrates to a single quantum jump during macro-temporal quantum coherence.

5.8 Self hierarchy and hierarchy of weakly coupled super conductors

The realization that bio-systems are full of macroscopic quantum phases led to the general idea about the dynamical realization of the self-hierarchy as a master-slave hierarchy formed by weakly coupled super conductors. It is now clear that mere Josephson currents are not enough: the breaking of super-conductivity due to leakage of supra currents from the super-conducting space-time sheets might also be an essential part of bio-control. A possible general conclusion is that Josephson currents are responsible for coordination whereas dissipative currents are related with the control aspect. The idea about charge entanglement made possible by W MEs and generating the dissipative currents makes this vision more precise.

One of the great ideas was that soliton sequences associated with the Josephson currents underly nerve pulse sequences. This idea turned out be be wrong as such: as a matter, soliton sequences correspond to various bio-rhythms such as kHz resonance frequency and various EEG rhythms in the recent model and nerve pulses could be understood as a perturbation of this sequences when rotational motion of some pendulum in the sequence of penduli becomes oscillatory. Since homeostasis as a many-sheeted ionic flow equilibrium involves also Josephson currents in an essential manner, it would be however light hearted to assume that Josephson currents and the dynamics at the level of cell membrane were totally uncorrelated. The model for sol-gel phase transition indeed demonstrates that Josephson currents generate Josephson photons crucial for stabilizing gel phase.

The hierarchy of favored Planck constants predicted by the Mersenne hierarchy implies a hierarchy of Josephson junctions defined by cell membranes and the value of Planck constants defines the evolutionary level of cell. As already noticed, EEG radiation and its fractal generalization and bio-photons can be identified as decay products of dark Josephson radiation in the case that the cell membrane space-time sheet is almost vacuum extremal. The frequency of the possible Josephson currents associated with the atomic space-time sheets of the cell membrane (or some larger space-time sheets with the same potential difference by the average many-sheeted ir-rotationality of the cell membrane electric field) corresponds in the resting potential of about -70 mV. For almost vacuum extremal option the Josephson currents could define bio-rhythms in extremely wide range from 10^{-15} s time scale to time scales comparable to the duration of life cycle.

Also hierarchies with levels characterized by the size scale of the membrane like structure involved can be considered but experimentally the situation remains open. Potential differences are in any case limited by the condition that Josephson energies are above thermal threshold. One possibility is that pairs or parallel super-conducting magnetic flux tubes form Josephson junctions. Indeed, at the higher levels of dark matter hierarchy one obtains both time-like and space-like soliton sequences and their Lorentz boosts.

What remained open in the earlier picture was the relationship between Josephson current circuitry and EEG, and nerve pulse generation and the possible analogs of EEG, ZEG (and WEG) and nerve pulse generation in various other frequency scales. The possibiity of generalized EEG hierarchy associated with dark matter hierarchy lead to a general quantitative picture in this respect and allows to interpret the components of generalized EEG in terms of cyclotron radiation and Josephson radiation as a response to cyclotron radiation. The general manner to code information about sensory input and motor actions is in terms of frequency modulation of the EEG frequencies defining EEG rhyths. A fascinating possibility is that scaled up variants of nerve pulses with typical time scale of about 2 seconds instead of millisecond associated with say neuronal bi-layers are realized in higher vertebrates. At the next level the "nerve pulses" would have duration of order 1.1 hours.

Supra currents running parallel to the axon suggest an important additional piece to the picture about of quantum control. Constructive interference of supra currents leads to a large net Josephson current and various biological clocks could rely on this mechanism. When reference supra current representing the expected sensory input and a current representing real sensory input and flowing in parallel manner in weakly coupled super conductors, are sufficiently near to each other, constructive interference of the Josephson currents occurs and can give rise to a synchronous firing. This makes possible conscious comparison circuits. Conscious novelty detectors can be build easily from comparison circuits using inhibitory and excitatory synaptic connections.

It must be emphasized that detailed models cannot be taken too seriously. There are simply quite too many new physic mechanisms to be considered. The following considerations actually represent the first general vision about the role of super conductivity in living matter, and also this is a good reason for not taking them too literally. As in the case of other similar sections, I have made the decision to keep it as such since the general vision might apply also in the recent framework although it failed in the original model of nerve pulse and EEG. The replacement of the representation of Josephson junction by magnetic flux tubes carrying dark variants of electrons and ions might provide a general realization of the vision. For instance, standing wave solitons associated with the Josephson currents between cytoskeletal microtubules and regions of the cell membrane could be involved with DNA - cell membrane tqc. These currents - at least in the case of axons- might be also responsible for ordinary EEG (note that a hierarchy of fractal variants of EEG are predicted [20].

5.8.1 Simple model for weakly coupled super conductors

Several kinds of Josephson currents between cell interior and exterior are possible. Solitons represent quantized Josephson currents which are large and able to facilitate the generation of nerve pulse in the case of Na_+ and Ca_{++}. Soliton sequences are the simplest solutions of Sine-Gordon equation for the Josephson junctions associated with a linear structure such as axon idealized as an infinitely long and thin cylindrical surface and are mathematically equivalent with a rotating gravitational pendulum.

The most general formulation starts from the Klein-Gordon equation for the order parameters Ψ_i, $i = 1, 2$ for the super-conductors coupled linearly to each other in the junction

$$\begin{aligned} D\Psi_1 &= m^2\Psi_1 + m_{12}^2\Psi_2 \ , \\ D\Psi_2 &= m^2\Psi_2 + m_{12}^2\Psi_1 \ , \\ D &= (\partial_\mu + iZeA_\mu)(\partial_\mu - iZeA_\mu) \end{aligned} \tag{5.8.1}$$

Here m denotes the charge of the super-conducting particle (say Cooper pair) and m_{12}^2 is real parameter characterizing the coupling between the super conductors. A_μ denotes electromagnetic vector potential associated with the super conductors. D denotes d'Alembert operator $\partial_t^2 - \nabla^2$.

Weakly coupled super conductors are assumed to possess cylindrical symmetry and can regarded as inner and out cylinder with Josephson junctions idealized with smooth distribution of them. If ME acts as Josephson junctions this assumption is exact. Weak coupling means that that the densities of charge carriers are same at the two sides of the junction in a good approximation:

$$\Psi_i = \sqrt{n} exp(i\Phi_i) \ , \ i = 1, 2 \ . \tag{5.8.2}$$

Under these assumptions one obtains for the phase difference $\Phi \equiv \Phi_1 - \Phi_2$ the Sine-Gordon equation with a coupling to the vector potential

$$\partial^\mu \left[\partial_\mu \Phi - q\Delta A_\mu\right] = m_{12}^2 sin(\Phi) \tag{5.8.3}$$

ΔA_μ denotes the difference of the vector potential over the junction. q denotes the charge of the super-conducting charge carrier.

Note that Lorentz gauge condition

$$\partial_\mu A^\mu = 0 \tag{5.8.4}$$

does not trivialize the coupling to the vector potential since the equation holds true only in 3-dimensional surface defining the junction and the contribution from the direction of the normal is not present.

Josephson current J_J can be identified as the divergence of the 4-current $j_\mu = Ze\rho = Ze\Psi^*(\partial_\mu^{\rightarrow} - \partial_\mu^{\leftarrow})\Psi$ at the either side of the junction.

$$J_J = \partial_\mu J^\mu = Ze \times \frac{n}{m} \times m_{12}^2 sin(\Phi) \ . \tag{5.8.5}$$

The Josephson current per unit length of axonal membrane of radius R and thickness d is given by

$$J = Ze \times \frac{n2\pi Rd}{m} \times m_{12}^2 sin(\Phi) \ . \tag{5.8.6}$$

The parameter m_{12}^2 is analogous to the inverse of the magnetic penetration length squared ($\hbar = c = 1$) for the super-conductors involved.

$$m_{12}^2 = \frac{1}{\Lambda^2} \ . \tag{5.8.7}$$

If one can regard the Josephson junction region as a defect in a super-conductor, Λ is apart from a numerical constant of order unity equal to the thickness of the Josephson junction. In the case of the cell membrane this would mean that the small oscillations associated with the Josephson junction have frequencies of order 10^{16} Hz and correspond to quanta with energies of order 100 eV.

The covariant constancy conditions

$$\begin{aligned} \partial_t \Phi &= ZeV(t,z) \ , \\ \partial_z \Phi &= ZeA_z(t,z) \ . \end{aligned} \tag{5.8.8}$$

are mutually consistent only if the electric field in the axial direction vanishes. They are not however consistent with the right hand side of the equation and only one of the conditions can be satisfied. The condition effectively reduces the equation to an ordinary differential equation. Of course, one cannot assume the condition for general solutions.

For a constant potential difference V_0 the Josephson current is sinusoidal for $\partial_t\Phi = ZeV_0$ ansatz with the basic frequency given by $\omega = eV_0$. An exact treatment replaces the sinusoidal time dependence of Φ with the time dependence of the angle coordinate of gravitational pendulum so that higher harmonics are involved. In the case of cell membrane $V(t)$ is typically a sum of constant part and time dependent part giving rise to frequency modulation of the basic Josephson current:

$$\omega(t) = eV = eV_0 + eV_1(t) \ .$$

Entire hierarchy of frequency modulations is possible since also eV_1 can be frequency modulated by Josephson currents.

5.8.2 Simplest solutions of Sine-Gordon equation

Free Sine-Gordon equation resulting, when the coupling to the em field can be neglected, gives a good view about the solutions of full equation. In cylindrical geometry Sine-Gordon equation becomes effectively 2-dimensional under rather natural conditions. This is rather nice since two-dimensional Sine-Gordon equation is completely integrable and thus allows an infinite number of conserved charges[52].

Sine-Gordon equation allows two kinds of vacua. The vacua of first type correspond to $\Phi = 2n\pi$ ground state configuration and vacua second type to $\Phi = (2n+1)\pi$. The small perturbations around these vacua correspond to massive 1+2 dimensional free field theory with field equations

$$\begin{aligned}
D\Phi &= \epsilon\frac{1}{\Lambda^2}\Phi \ ; \\
D &= \partial_t^2-\nabla^2 \ , \\
\epsilon &= -1 \ \text{ for } \ \Phi=n2\pi \ , \\
\epsilon &= 1 \ \text{ for } \ \Phi=(2n+1)\pi \ .
\end{aligned} \tag{5.8.9}$$

In the language of quantum field theory, the small perturbations around $\Phi = n2\pi$ describe particle with mass squared $m^2 = \frac{1}{\Lambda^2}$ whereas the small perturbations of the $\Phi = (2n+1)\pi$ vacuum describe tachyons with negative mass squared $m^2 = -\frac{1}{\Lambda^2}$. Therefore these vacua will be referred to as time like and space-like respectively.

One might argue that the space-like vacua are un-stable in the case that the continuous sheet of the Josephson junctions consists actually of discrete Josephson junctions, whose dynamics is given by the differential equation

$$\frac{d^2\Phi}{dt^2} = -\frac{sin(\Phi)}{\Lambda^2}$$

allowing only $\Phi = n2\pi$ as stable ground state. For MEs acting as Josephson junction the situation is different. On the other hand, the ground state at which soliton generation is possible should be quantum critical and hence very sensitive to external perturbations. Note that time like and space-like sectors in axonal portion of neuron are permuted by a duality transformation $z \leftrightarrow vt$ (v=c=1), $\Phi \rightarrow \Phi + \pi$, which is exact symmetry of the 1+1-dimensional Sine-Gordon equation.

The propagating waves are of form $sin(u)$, where one has

$$\begin{aligned}
u &= \gamma_P(t-\frac{v_Pz}{v^2}) \ , \ \text{ time like case} \\
u &= \gamma_P(z-v_Pt) \ , \ \text{ space-like case} \\
\gamma_P &= \sqrt{\frac{1}{1-(\frac{v_P}{v})^2}} \ .
\end{aligned} \tag{5.8.10}$$

Here v_P is the velocity parameter characterizing the boost. The frequency of these small propagating oscillations (plane waves) is in two cases given by

$$\begin{aligned}
\Omega &= \frac{\gamma_P v}{\Lambda} \ , \ \text{ time like case } \ , \\
\Omega &= \frac{\gamma_P v_P}{\Lambda} \ , \ \text{ space-like case } \ .
\end{aligned} \tag{5.8.11}$$

The frequency is very high for time like waves, of order 10^{10} Hz and therefore a typical time scale for the conformational dynamics of proteins. In space-like case the phase velocity of the propagating waves is $v_P < v$ and frequencies are small and one could consider the possibility of identifying these oscillations as propagating EEG waves. For the time like excitations phase velocity is $v_p = v^2/v_P > v$ and larger than light velocity. For ordinary elementary particles the situation is same but since phase velocity is in question, there are no interpretational problems.

One-dimensional solutions of the Sine-Gordon equation give quite satisfactory picture about the situation as far as the physical interpretation is considered. The simplest solutions of this type correspond to solutions depending on time or spatial coordinates only. For time like vacua one-dimensional solutions depend on time only: note that these solutions are possible for arbitrary geometry of the Josephson junction. For space-like like vacua one-dimensional solutions are possible in the axonal portions of the neuron: the simplest one-dimensional solutions depend on the axonal coordinate z only.

Field equations reduce to the equations of motion for gravitational pendulum:

$$\frac{d^2\Phi}{du^2} = -\frac{1}{\Lambda^2}sin(\Phi) \ . \tag{5.8.12}$$

$u = vt$ holds true in time like case ($v = c \equiv 1$ is good approximation). $u = z$ holds true in space-like case (in this case equation makes sense for axonal portions only). Energy conservation for the gravitational pendulum gives

$$\frac{1}{2}v^2(\frac{d\Phi}{du})^2 + \frac{v^2}{\Lambda^2}\left[1 - cos(\Phi)\right] = K\frac{2v^2}{\Lambda^2} \ , \tag{5.8.13}$$

where K is dimensionless constant analogous to energy. There are two kinds of solutions: oscillating solutions ($K < 1$) and rotating solutions ($K > 1$): single soliton solution corresponds to $K = 1$.

One can integrate the conservation law for energy to give the time/spatial period of oscillation or rotation (T/λ). For oscillating solutions one has

$$T = \frac{\lambda}{v} = \frac{\Lambda}{v}\int_{-\Phi_0}^{+\Phi_0} d\Phi \frac{1}{\sqrt{2\left[-cos(\Phi_0) + cos(\Phi)\right]}} \ . \tag{5.8.14}$$

Here Φ_0 is maximum value of the phase angle for oscillating solution. For the rotation period one obtains

$$T = \frac{\lambda}{v} = \frac{\Lambda}{v}\int_{0}^{2\pi} d\Phi \frac{1}{\sqrt{(\frac{d\Phi}{dt})^2(\Phi=\pi) + 2\left[1 - cos(\Phi)\right]}} \ . \tag{5.8.15}$$

By Lorentz-boosting space-like axonal solutions to move with velocity v_p one obtains propagating soliton sequences.

Sine-Gordon equation is completely integrable and thus allows an infinite number of conserved charges. In quantum theory the eigenvalues of mutually commuting charges characterize the quantum state and these charges are basic quantum observables. Does it make sense to quantize Sine-Gordon and could one characterize the state of the axonal membrane in terms of these charges? Here one must point out the similarity to the ideas of Nanopoulos [116], who speculates with the possibility that certain 2-dimensional conformal field theory characterizes the state of micro-tubule and the infinite number of conserve charges characterize the information content of the micro-tubule. It is perhaps also worth of mentioning that the quantum group $SU(2)$ appears in the quantization of the Sine-Gordon equation [53]: could quantum groups have important applications in biology?

5.8.3 Are both time like and space-like soliton sequences possible ground states?

The model for the Josephson junction predicts the existence of both time like and space-like soliton sequences. Mathematician would expect that both ground states of coupled super conductors are realized in brain. The presence of space-like and time like modes could provide general insights to brain functioning and could relate to the fundamental dichotomies of brain consciousness.

Time like soliton sequences do not in general propagate and if they propagate, the phase velocity exceeds light velocity (due to $t - vx/c^2$ dependence). The size of coherence region in the case of gap junction connected neurons can be rather large. Also micro-tubuli could form large coherent regions.

The time scales involved with the time like soliton sequence are however very fast, much faster that the time scales of EEG. This suggests that soliton sequences and oscillations are responsible for a synchronization in various scales defined by p-adic and dark matter hierarchies. One cannot exclude the possibility that the appearance of time like soliton sequences correlates with the emergence of standing EEG waves and synchronous firing whereas propagating space-like soliton sequences could accompany nerve pulse conduction. Since non-propagating collective firing does not occur, standing soliton sequences could be associated with glial cells and propagating soliton sequences with neuronal axons.

Soliton sequences could provide a general realization of biological clocks and facilitate the generation of macroscopic quantum systems. Also the gap junction connected neuron groups associated with primary sensory organs, various organs and brain could correspond to time like solitons.

For ordinary value of $\hbar$ the small oscillations for time like ground state have period of order 10^{-10} seconds: this follows solely from the spatial extension of nerve pulse of order $\Lambda \sim 10^{-2}$ meters and involves no assumptions about the detailed properties of the super conductor. These oscillations could coordinate protein dynamics. I do not know whether endoplasma membranes inside cells have resting potential: if not, they are good candidates for the carriers of time like ground states with oscillating voltage.

For cell membrane situation is different and the only possible interpretation is that the resting potential for ordinary value of Planck constant and for far-from-vacuum ground state corresponds to the 10^{-13} second time scale determined by the membrane voltage and the mechanical analog is very rapidly rotating gravitational pendulum. Almost vacuum extremal property and large values of Planck constant change the sitution and $k_d = 47$ level would correspond to 5 Hz oscillation frequency. These time-like soliton sequences could indeed be interpreted as standing EEG waves whereas space-like soliton sequences would correspond to propagating EEG waves. The presence of perturbations appearing at multiples of cyclotron frequencies of biologically important ions means that standing and moving waves at other frequencies are possible. Nerve pulse patterns induces frequency modulations of the corresponding Josephson currents and Josephson radiation.

Glial cells [95] form a considerable fraction of cell population of brain are glial cells and are connected to each other by gap junctions, which can serve as Josephson junctions. In glial cells large amplitude oscillations with longer oscillation period could be present. The ciliar beating of monocellular animals [95] could be coordinated to coherent motion (making possible swimming of the monocellular organism) by the "EEG" waves.

Gap junctions between the nerve cells are not common but are encountered in the large coherently firing groups of nerve cells in the brain, in the sensory organs and other organs such as heart. The value of the parameter K is only slightly larger than the critical value $K = 1$ for EEG since the period of EEG oscillations is typically by a factor of order 10^8 longer than the period of small oscillations. The problem disappears when higher levels of dark matter hierarchy are allowed. Of course, if the potential difference in question corresponds to the membrane potential, one must have $K \gg 1$. One can wonder whether the criticality might have some deeper significance: perhaps phase transitions between EEG:s corresponding to rotating and oscillating gravitational penduli are possible.

5.8.4 Quantum tools for bio-control and -coordination

Coordination and control are the two fundamental aspects in the functioning of the living matter. TGD suggests that at quantum level deterministic unitary time evolution of Dirac equation corresponds to coordination whereas time evolution by quantum jumps corresponds to quantum control. More precisely, the non-dissipative Josephson currents associated with weakly coupled super conductors would be the key element in coordination whereas resonant dissipative currents between weakly coupled super conductors would make possible quantum control.

This view allows to consider more detailed mechanisms. What is certainly needed in the coordination of the grown up organism are biological clocks, which are oscillators coupled to the biological activity of the organ. Good examples are the clocks coordinating the brain activity, respiration and heart beat [41]. For example, in the heart beat the muscle contractions in various parts of heart occur in synchronized manner with a well defined phase differences. Various functional disorders, say heart fibrillation, result from the loss of this spatial coherence. For a control also biological alarm clocks are needed. An alarm clock is needed to tell when the time is ripe for the cell to replicate during morphogenesis. Some signal must tell that is time to begin differentiation to substructures during morphogenesis: for example, in the case of the vertebrates the generation of somites is a very regular process starting at certain phase of development and proceeding with a clockwise precision.

Homeostasis as many-sheeted ionic flow equilibrium

The experimental work of Ling, Sachs and Qin [91, 93] and other pioneers [100, 102] challenges the notions of ionic channels and pumps central to the standard cell biology. Ling has demonstrated that the ionic concentrations of a metabolically deprived cell are not changed at all: this challenges the notion of cell membrane ionic pumps. The work of Sachs and Qin and others based on patch-clamp technique shows that the quantal ionic currents through cell membrane remain essentially as such when the membrane is replaced by a silicon rubber membrane or by a cell membrane purified from channel proteins! this challenges the notion of cell membrane ionic channels. A further puzzling observation is much more mundane: ordinary hamburger contains roughly 80 per cent of water and is thus like a wet sponge: why it is so difficult to get the water out of it?

These puzzling observations can be understood if the homeostasis of cell and its exterior is regarded as an ionic flow equilibrium in the many-sheeted space-time. Ionic super currents from super-conducting controlling space-time sheets flow to controlled atomic space-time sheets and back. Currents are of course ohmic at the atomic space-time sheets. One can understand how extremely small ionic densities and super currents at cellular space-time sheets can control ionic currents and much higher ionic densities at atomic space-time sheets. Immense savings in metabolic energy are achieved if the ohmic currents at the atomic space-time sheets flow through the cell membrane region containing the strong electric field along super-conducting cell membrane space-time sheet (rather than atomic space-time sheets) as a non-dissipative supra current. This clever energy saving trick makes also the notion of ionic channels obsolete for weak ionic currents at least.

Super-conducting space-time sheets contain a plan of the bio-system coded to ion densities and magnetic quantum numbers characterizing the super currents. Bio-control by em fields affects these super currents and one can understand the effects of ELF em fields on bio-system in this framework. The model relies crucially on the liquid crystal property of bio-matter (hamburger mystery!) making possible ohmic current circuitry at the atomic space-time sheets as a part of the many-sheeted control circuitry. There is a considerable evidence for this current circuitry, Becker is one of the pioneers in the field [128]: among other things the circuitry could explain how acupuncture works.

Quantum model for pattern recognition

Time translation invariant pattern recognition circuit can be realized by using two coupled super-conductors. The first super-conductor contains the reference supra current and second super-conductor contains the supra current determined by the sensory input. Supra currents are assumed to have same spatially and temporally constant intensity. If the supra currents have spatially constant phase difference, also Josephson currents are in the same phase and sum up to a large current facilitating synchronous firing. The temporal phase difference of supra currents does not matter since it affects only the overall phase of the Josephson current. Therefore patterns differing by time translations are treated as equivalent. Quite generally, the requirement of time translational invariance, favors the coding of the sensory qualia to transition frequencies.

The destructive interference of supra currents provides an tool of pattern cognition in situations when the precise timing is important. The pattern to be recognized can be represented as a reference current pattern in some neuronal circuit. Input pattern determined by sensory input in turn is represented by supra current interfering with the reference current. If interference is destructive, synchronous generation of nerve pulses in the circuit occurs and leads to a conscious pattern recognition. Obviously the loss of time translation invariance makes this mechanism undesirable in the situations in which the precise timing of the sensory input does not matter. One can however imagine situations when timing is important: for instance, the deduction of the direction of the object of the auditory field from the phase difference associated with signals entering into right and left ears could correspond to this kind of situation.

In both cases one can worry about the regeneration of reference currents. The paradigm of four-dimensional quantum brain suggests that sensory input leads by self-organization to a stationary spatial patterns of supra-currents and this process depends only very mildly on initial values. Thus self-organization would generate automatically pattern recognizers.

General mechanism making possible biological clocks and alarm clocks, comparison circuits and novelty detectors

Weakly coupled super conductors and auantum self-organization make possible very general models of biological clocks and alarm clocks as well as comparison circuits and novelty detectors.

The Josephson junction between two super-conductors provides a manner to realize a biological clock. Josephson current can be written in the form [60]

$$\begin{aligned} J &= J_0 sin(\Delta\Phi) = J_0 sin(\Omega t) \ , \\ \Omega &= ZeV \ , \end{aligned} \tag{5.8.16}$$

where Ω is proportional to the potential difference over the Josephson junction. Josephson current flows without dissipation.

In BCS theory of super-conductivity the value of the current J_0 can be expressed in terms of the energy gap Δ of the super conductor and the ordinary conductivity of the junction. When the temperature is much smaller than critical temperature, the current density for a junction is given by the expression [60]

$$J_0 = \frac{\pi}{2e}\frac{\sigma_s \Delta}{d} \ . \tag{5.8.17}$$

Here σ_s is the conductivity of the junction in the normal state assuming that all conduction electrons can become carriers of the supra current. d is the distance between the super conductors. The current in turn implies a position independent(!) oscillation of the Cooper pair density inside the two super conductors. By the previous arguments the density of the Cooper pairs is an ideal tool of bio-control and a rhythmic change in biological activity expected to result in general. Josephson junctions are therefore good candidates for pacemakers not only in brain but also in heart and in respiratory system.

In the presence of several parallel Josephson junctions quantum interference effects become possible if supra currents flow in the super conductors. Supra current is proportional to the gradient of the phase angle associated with the order parameter, so that the phase angle Φ is not same for the Josephson junctions anymore and the total Josephson current reads as

$$J = \sum_n J_0(n) sin(\Omega t + \Delta\Phi(n)) \ . \tag{5.8.18}$$

It is clear that destructive interference takes place. The degree of the destructive interference depends on the magnitude of the supra currents and on the number of Josephson junctions.

There are several options depending on whether both super conductors carry parallel supra currents or whether only second super conductor carries supra current.

1. If both super conductors carry supra currents of same magnitude but different velocity, the phases associated with the currents have different spatial dependence and destructive interference occurs unless the currents propagate with similar velocity. This mechanism makes possible comparison circuit serving as a feature detector. What is needed is to represent the feature to be detected by a fixed supra current in the second super conductor and the input as supra current with same charge density but difference velocity. The problem is how the system is able to generate and preserve the reference current. If case that feature detector 'wakes-up' into self state when feature detection occurs, the subsequent quantum self-organization should lead to the generation of the reference current representing the feature to be detected.

2. If only second super conductor carries supra current and of this supra current for some reason decreases or becomes zero, constructive interference occurs for individual Josephson currents and net Josephson current increases: current causes large gradients of Cooper pair density and can lead to the un-stability of the structure. When the supra current in the circuit dissipates below a critical value, un-stability emerges. This provides a general mechanism of biological alarm clock.

   Assume that the second super conductor carriers a supra current. As the time passes the reference current dissipates by phase slippages[59, 60]. If the reference current is large enough, the dissipation takes place with a constant rate. This in turn means that the Josephson current increases in the course of time. When the amplitude of the Josephson current becomes large enough, the density gradients of the charge carriers implied by it lead to a un-stability of the controlled system: the clock rings. Since the dissipation of (a sufficiently large) Josephson current takes place at constant rate this alarm clock can be quite accurate. It will be found that a variant of this mechanism might be at work even in the replication of DNA. The un-stability itself can regenerate the reference current to the clock. If the alarm clock actually 'wakes-up' the alarm clock to self state, self-organization by quantum jumps must lead to an asymptotic self-organization pattern in which the supra current in the circuit is the original one. Actually this should occur since asymptotic self-organization pattern depends only weakly on the initial values.

3. Novelty detector can be build by feeding the outputs of the feature detectors to an alarm clock circuit. In alarm clock circuit only the second super conductor carries supra current, which represents the sum of the outputs of the feature detectors. Since the output of a feature detector is non-vanishing only provided the input corresponds to the feature to be detected, the Josephson current in additional circuit becomes large only when the input does not correspond to any familiar pattern.

How MEs could generate soliton sequences?

MEs could as bio-controllers using the same general mechanism which underlies remote mental interactions and this aspect of bio-control could be seen as endogenous remote mental interactions between cells and other parts of organism. Pairs of low and high frequency MEs are involved. Low frequency MEs, say EEG MEs, serve as correlates for quantum entanglement between body parts: already this is enough for remote viewing regarded as sharing of mental images by fusion of mental images. The psychokinesis aspect is possible by high frequency MEs propagating like massless particles inside low frequency MEs. These MEs induce bridges and thus leakage of ions between various space-time sheets at the receiving end. This means self-organization by dissipation.

MEs can also act as Josephson junctions connecting super-conducting space-time sheet characterized by p-adic primes which can be different. This kind of Josephson junction contains the em field associated with ME as an external field and the mathematical description of this coupling follows from the model for the coupling of electromagnetic field to super conducting order parameters. In Minkowski coordinates the modification of the Sine-Gordon equation is simple:

$$\partial^{\mu}\left[\partial_{\mu}\Phi - Ze\Delta A_{\mu}\right] = m_{12}^2 sin(\Phi) \ . \tag{5.8.19}$$

Here Φ denotes the phase difference over the Josephson junction, which is idealized with a continuous Josephson junction, and actually is a continuous Josephson junction in the case of ME. ΔA_{μ} denotes the difference of the vector potential over the junction.

The coupling to the vector potential can in the lowest order described by the condition

$$\partial_{\mu}\Phi_0 = Ze\Delta A_{\mu}$$

assumed to hold for a maximal number of components of vector potential. Here of course integrability conditions pose restrictions. One can develop perturbation series for Φ by substituting Φ_0 to the right hand side and calculating Φ_1 using the right hand side as a source term, and so on.

If the transversal em field associated with ME contains time independent radial electric field this gives rise to a constant potential term giving rise to a generation of soliton sequences. The period Ω of rotation for the soliton satisfies $\Omega = eV$, where eV corresponds to the potential difference defined by the constant part of the electric field of ME. It can also happen that ME contains only the oscillatory electromagnetic field: if the frequency is same as the frequency associated with small oscillations of the Sine-Gordon pendulum a resonant coupling is expected to result. In this case the frequency is in radio frequency range.

Also noise is present and it is quite possible that the noise provides the energy needed to amplify the weak periodic signal provided by ME to a soliton sequence by stochastic resonance. The mechanism is discussed in detail in the chapter "Quantum model for EEG and nerve pulse". This suggests that MEs could basically control small very fast oscillations of the membrane potential.

Acknowledgements

I am grateful for Hafedh Abdelmelek and his collaborators for sharing their experimental data about effective super-conductivity in sciatic nerves as for collaboration. I want to thank also Lian Sidoroff for very fruitful discussions.

Bibliography

Books about TGD

[1] M. Pitkänen (2006), *Topological Geometrodynamics: Overview*.
http://tgd.wippiespace.com/public_html/tgdview/tgdview.html.

[2] M. Pitkänen (2006), *Quantum Physics as Infinite-Dimensional Geometry*.
http://tgd.wippiespace.com/public_html/tgdgeom/tgdgeom.html.

[3] M. Pitkänen (2006), *Physics in Many-Sheeted Space-Time*.
http://tgd.wippiespace.com/public_html/tgdclass/tgdclass.html.

[4] M. Pitkänen (2006), *p-Adic length Scale Hypothesis and Dark Matter Hierarchy*.
http://tgd.wippiespace.com/public_html/paddark/paddark.html.

[5] M. Pitkänen (2006), *Quantum TGD*.
http://tgd.wippiespace.com/public_html/tgdquant/tgdquant.html.

[6] M. Pitkänen (2006), *TGD as a Generalized Number Theory*.
http://tgd.wippiespace.com/public_html/tgdnumber/tgdnumber.html.

[7] M. Pitkänen (2006), *TGD and Fringe Physics*.
http://tgd.wippiespace.com/public_html/freenergy/freenergy.html.

Books about TGD Inspired Theory of Consciousness and Quantum Biology

[8] M. Pitkänen (2006), *TGD Inspired Theory of Consciousness*.
http://tgd.wippiespace.com/public_html/tgdconsc/tgdconsc.html.

[9] M. Pitkänen (2006), *Bio-Systems as Self-Organizing Quantum Systems*.
http://tgd.wippiespace.com/public_html/bioselforg/bioselforg.html.

[10] M. Pitkänen (2006), *Quantum Hardware of Living Matter*.
http://tgd.wippiespace.com/public_html/bioware/bioware.html.

[11] M. Pitkänen (2006), *Bio-Systems as Conscious Holograms*.
http://tgd.wippiespace.com/public_html/hologram/hologram.html.

[12] M. Pitkänen (2006), *Genes and Memes*.
http://tgd.wippiespace.com/public_html/genememe/genememe.html.

[13] M. Pitkänen (2006), *Magnetospheric Consciousness*.
http://tgd.wippiespace.com/public_html/magnconsc/magnconsc.html.

[14] M. Pitkänen (2006), *Mathematical Aspects of Consciousness Theory*.
http://tgd.wippiespace.com/public_html/mathconsc/mathconsc.html.

[15] M. Pitkänen (2006), *TGD and EEG*.
http://tgd.wippiespace.com/public_html/tgdeeg/tgdeeg.html.

References to the chapters of the books about TGD

[16] The chapter *Dark Forces and Living Matter* of [6]. http://tgd.wippiespace.com/public_html/paddark/paddark.html#darkforces.

[17] The chapter *Nuclear String Model* of [6]. http://tgd.wippiespace.com/public_html/paddark/paddark.html#nuclstring.

[18] The chapter *TGD and Nuclear Physics* of [6]. http://tgd.wippiespace.com/public_html/paddark/paddark.html#padnucl.

[19] The chapter *Dark Nuclear Physics and Condensed Matter* of [6]. http://tgd.wippiespace.com/public_html/paddark/paddark.html#exonuclear.

[20] The chapter *Does TGD Predict the Spectrum of Planck Constants?* of [3]. http://tgd.wippiespace.com/public_html/tgdquant/tgdquant.html#Planck.

[21] The chapter *Cosmic Strings* of [4]. http://tgd.wippiespace.com/public_html/tgdclass/tgdclass.html#cstrings.

[22] The chapter *Was von Neumann Right After All* of [3]. http://tgd.wippiespace.com/public_html/tgdquant/tgdquant.html#vNeumann.

References to the chapters of the books about TGD Inspired Theory of Consciousness and Quantum Biology

[23] The chapter *Macro-Temporal Quantum Coherence and Spin Glass Degeneracy* of [11]. http://tgd.wippiespace.com/public_html/hologram/hologram.html#macro.

[24] The chapter *p-Adic Physics as Physics of Cognition and Intention* of [8]. http://tgd.wippiespace.com/public_html/tgdconsc/tgdconsc.html#cognic.

[25] The chapter *Homeopathy in Many-Sheeted Space-Time* of [11]. http://tgd.wippiespace.com/public_html/hologram/hologram.html#homeoc.

[26] The chapter *Evolution in Many-Sheeted Space-Time* of [12]. http://tgd.wippiespace.com/public_html/genememe/genememe.html#prebio.

[27] The chapter *Genes and Memes* of [12]. http://tgd.wippiespace.com/public_html/genememe/genememe.html#genememec.

[28] The chapter *About the New Physics Behind Qualia* of [10]. http://tgd.wippiespace.com/public_html/bioware/bioware.html#newphys.

[29] The chapter *The Notion of Wave-Genome and DNA as Topological Quantum Computer* of [12]. http://tgd.wippiespace.com/public_html/genememe/genememe.html#gari.

[30] The chapter *Quantum Model for Hearing* of [13]. http://tgd.wippiespace.com/public_html//tgdeeg/tgdeeg/tgdeeg.html#hearing.

[31] The chapter *Dark Matter Hierarchy and Hierarchy of EEGs* of [13]. http://tgd.wippiespace.com/public_html/tgdeeg/tgdeeg.html#eegdark.

[32] The chapter *A Model for Protein Folding and Bio-catalysis* of [12]. http://tgd.wippiespace.com/public_html/genememe/genememe.html#foldcat.

[33] The chapter *Bio-Systems as Conscious Holograms* of [11]. http://tgd.wippiespace.com/public_html/hologram/hologram.html#hologram.

[34] The chapter *Biological Realization of Self Hierarchy* of [9]. http://tgd.wippiespace.com/public_html/bioselforg/bioselforg.html#bioselfc.

[35] The chapter *Topological Quantum Computation in TGD Universe* of [12].
http://tgd.wippiespace.com/public_html/genememe/genememe.html#TQC.

[36] The chapter *DNA as Topological Quantum Computer* of [12].
http://tgd.wippiespace.com/public_html/genememe/genememe.html#dnatqc.

[37] The chapter *Bio-Systems as Super-Conductors: part II* of [10].
http://tgd.wippiespace.com/public_html/bioware/bioware.html#superc2.

[38] The chapter *Bio-Systems as Super-Conductors: part I* of [10].
http://tgd.wippiespace.com/public_html/bioware/bioware.html#superc1.

[39] The chapter *Three new physics realizations of the genetic code and the role of dark matter in bio-systems* of [12].
http://tgd.wippiespace.com/public_html/genememe/genememe.html#dnatqccodes.

[40] The chapter *Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin* of [11].
http://tgd.wippiespace.com/public_html/hologram/hologram.html#metab.

[41] The chapter *General Theory of Qualia* of [11].
http://tgd.wippiespace.com/public_html/hologram/hologram.html#qualia.

[42] The chapter *Macro-Temporal Quantum Coherence and Spin Glass Degeneracy* of [11].
http://tgd.wippiespace.com/public_html/hologram/hologram.html#macro.

[43] The chapter *Time, Spacetime and Consciousness* of [11].
http://tgd.wippiespace.com/public_html/hologram/hologram.html#time.

[44] The chapter *Quantum Model of EEG* of [13].
http://tgd.wippiespace.com/public_html/tgdeeg/tgdeeg.html#eegII.

Appendices and references to some older books

[45] M. Pitkänen (2006) *Basic Properties of CP_2 and Elementary Facts about p-Adic Numbers*
http://tgd.wippiespace.com/public_html/pdfpool/append.pdf.

[46] The chapter *Quantum Model for Nerve Pulse* of "Genes, Memes, Qualia and Semitrance".
http://tgd.wippiespace.com/public_html//cbookII/cbookII.html#nervepulse.

Articles related to TGD

[47] M. Pitkänen (2007), *Further Progress in Nuclear String Hypothesis*, http://tgd.wippiespace.com/public_html/articles/nuclstring.pdf.

[48] M. Pitkänen (2003), *Macro-temporal quantum coherence, quantum spin glass degeneracy, and number theoretic information concept* and *Bio-systems as conscious holograms*, Journal of nonlocality and remote mental interactions, issue 2.
http://www.emergentmind.org/journal.htm.

[49] M. Pitkänen (2003), *Time, Space-Time, and Consciousness*, *Quantum Model for Sensory Receptor*, and *Quantum Model for Nerve Pulse, EEG, and ZEG*. Journal of nonlocality and remote mental interactions, issue 3.
http://www.emergentmind.org/journal.htm.

Mathematics

[50] *Gaussian Mersenne*. http://primes.utm.edu/glossary/xpage/GaussianMersenne.html.

[51] E. C. Zeeman (ed.)(1977), *Catastrophe Theory*. Addison-Wessley Publishing Company.

Theoretical physics

[52] A. Das(1989), *Integrable Models*, World Scientific.

[53] P. Kulish and Yu. Reshetikhin (1983), J. Sov. Math. 23, p. 2345.

[54] *Sine-Gordon equation*. http://en.wikipedia.org/wiki/Sine-Gordon.

Condensed matter physics

[55] G. Pollack, X. Figueroa, Qing Z. (2009), *Molecules, water, and radiant energy: new clues for the origin of life*. International journal of molecular sciences 2009;10(4):1419-29.

[56] Mae-Wan Ho (2009), *Making Fuel from Water*. Institute of Science in Society report. http://www.i-sis.org.uk/makingFuelFromWater.php.

[57] *Burning salt water*. http://www.youtube.com/watch?v=aGgOATfoBgo.

[58] *Spontaneous burning*. http://www.ncbi.nlm.nih.gov/sites/entrez?cmd=Retrieve&db=PubMed&list_uids=6149513&dopt=AbstractPlus.

[59] Anderson, P., W.(1966), Rev. Mod. Phys. 38, 298.

[60] Tilley, D., R. and Tilley, K. (1986): *Super Fluidity and Super Conductivity*. Adam Hilger Ltd..

[61] Mae-Wan Ho (2009), *Water electric*. Institute of Science in Society report. http://www.i-sis.org.uk/WaterElectric.php.

[62] http://www.usc.edu/dept/ee/People/Faculty/feinberg.html.

[63] J. H. Schön, Ch. Kloc and B. Batlogg *et al* (2000), *super-conductivy in molecular crystals induced by charge injection*. Nature, vol. 406, 17 August.http://www.nature.com.

[64] J. K. Borchardt(2003), *The chemical formula H2O - a misnomer*. The Alchemist 8 Aug (2003).

[65] Mae-Wan Ho (2009), *Can Water burn*. Institute of Science in Society report. http://www.i-sis.org.uk/canWaterBurn.php.

[66] Mae-Wan Ho (2009), *The body does burn water*. Institute of Science in Society report. http://www.i-sis.org.uk/theBodyDoesBurnWater.php.

[67] M. Chaplin (2005), *Water Structure and Behavior*. http://www.lsbu.ac.uk/water/index.html.
For 41 anomalies see http://www.lsbu.ac.uk/water/anmlies.html.
For the icosahedral clustering see http://www.lsbu.ac.uk/water/clusters.html.

[68] R. A. Cowley (2004), *Neutron-scattering experiments and quantum entanglement*. Physica B 350 (2004) 243-245.

[69] R. Moreh, R. C. Block, Y. Danon, and M. Neumann (2005), *Search for anomalous scattering of keV neutrons from H2O-D2O mixtures*. Phys. Rev. Lett. 94, 185301.

[70] D. M. Pepper (1982), *Nonlinear Optical Phase Conjugation*. in *Optical Engineering*. vol. 21, no. 2, March/April.
http://www.usc.edu/dept/ee/People/Faculty/feinberg.html.

[71] *Liquid crystals on line*. http://www.lcionline.net/.

[72] Mae-Wan Ho (2009), *Living with Oxygen*. Institute of Science in Society report.http://www.i-sis.org.uk/livingWithOxygen.php.

[73] Zheng, Jian-ming, Pollack, G. (2003), *Long-range forces extending from polymer-gel surfaces*. http://arxiv.org/abs/cond-mat/0305093.

[74] *Spontaneous human combustion.* http://www.alternativescience.com/spontaneous-human-combustion-burning-issue.htm.

[75] G. P. Gordeyev nd T. Khaidarov (1983) in *Water in biological systems and their components.* Leningrad University Press, Leningrad. p. 3 (Russian) See also A. Kaivarainen (1995), *Hierarchical Concept of Matter and Field.* p. 225.

Cosmology and astrophysics

[76] *Age of the universe.* http://en.wikipedia.org/wiki/Age_of_the_universe.

Biology related references

[77] C. Smith (2001), *Learning From Water, A Possible Quantum Computing Medium.* talk in CASYS'2001, 5th international conference on Computing Anticipating Systems held in Liege, Belgium, August 13-18. Abstract book published by Chaos.

[78] L. Montagnier, J. Aissa, S. Ferris, J.-L. Montagnier, and C. Lavall'e (2009). *Electromagnetic Signals Are Produced by Aqueous Nanostructures Derived from Bacterial DNA Sequences.* Interdiscip. Sci. Comput. Life Sci.. http://www.springerlink.com/content/0557v31188m3766x/.

[79] G. Albrecht-Buehler (1991), *Surface extensions of 3T3 cells towards distant infrared sources.* J. Cell Biol. (1991)114:493-502.
Ibid (1994), *The cellular infrared detector appears to be contained in the centrosome.* Cell Motiltiy and the Cytoskeleton 27:262-271.

[80] *Nanobacterium.* http://en.wikipedia.org/wiki/Nanobacterium.

[81] Volkenstein, M., V. (1983): *Biophysics* . Mir Publishers, Moscow.

[82] *Free radical theory.* http://en.wikipedia.org/wiki/Free-radical_theory.
Free radicals and your health. http://www.healingdaily.com/conditions/free-radicals.htm.

[83] A. Yu. Kazumov *et al* (2001), *Proximity-Induce super-conductivity in DNA*. Science, vol. 291, 12 January April. http://www.sciencemag.org.

[84] H.-W. Fink and C. Schönenberger (1999), *Electrical conduction through DNA molecules.*Nature, vol. 398, 1 April. http://www.nature.com.

[85] T. E. Creighton (1993), *Proteins: Structures and Molecular Properties.* W. H. Freeman and Company. New York.

[86] G. Pollack (200?), *Cells, Gels and the Engines of Life.* Ebner and Sons. http://www.cellsandgels.com/.

[87] *Protein folding.* http://en.wikipedia.org/wiki/Protein_folding.

[88] D. Robson (2008), *Researchers Seek to Demystify the Metabolic Magic of Sled Dogs.* New York Times. http://www.nytimes.com/2008/05/06/science/06dogs.html?_r=1&ex=1210737600&en=313979157c777587&ei=5070&emc=eta-1.

[89] B. Sakmann and B. Neher (1983): *Single-channel recording.* Plenum Press, New York & London.

[90] M. W. Ho (1993), *The Rainbow and the Worm.* World Scientific, Singapore.

[91] G. N. Ling (1962) *A physical theory of the living state: the association-induction hypothesis; with considerations of the mechanics involved in ionic specificity.* New York: Blaisdell Pub. Co..
Ibid(1978):*Maintenance of low sodium and high potassium levels in resting muscle cells.* Journal of Physiology (Cambridge), July: 105-23.
Ibid(1992): *A revolution in the physiology of the living cell.* Malabar, FL: Krieger Pub. Co..

[92] W. K. Purves and G. H. Orians (1987): *Life: The Science of Biology.* Sunderland, Massachusetts: Sinauer.

[93] F. Sachs, F. Qin (1993), *Gated, ion-selective channels observed with patch pipettes in the absence of membranes: novel properties of a gigaseal.* Biophysical Journal, September: 1101-7.

[94] G.N. Ling *et al*: *Experimental confirmation, from model studies, of a key prediction of the polarized multilayer theory of cell water.* Physiological Chemistry and Physics, 10:1, 1978: 87-8.

[95] B. Alberts *et al*(1989), *Molecular Biology of the Cell.* Garland Publishing, Inc.. New York & London.

[96] Fröhlich, H. (1975) *The extraordinary dielectric properties of biological materials and the action of enzymes.* Proc. Natl. Acad. Sci. 72:4211-4215.
Ibid (1968), Int. J. Quantum Chem. 641-649.
Ibid (1970), Nature 316, 349-351.
H. Fröhlich and F. Kremer (1983), *Coherent Excitations in Biological Systems.* Springer Verlag, New York.

[97] H. R. Chinnery, E. Pearlman, and P. G. McMenamin (2008), *Cutting Edge: Membrane Nanotubes In Vivo: A Feature of MHC Class II+ Cells in the Mouse Cornea.* J. Immunol., May 2008; 180: 5779 - 5783. A. Anantaswamy (2008), *Tunnelling nanotubes: Life's sectret network.* `http://www.newscientist.com/article/mg20026821.400-tunnelling-nanotubes-lifes-secret-network.html`. See also `http://matpitka.blogspot.com/2008/11/tunnelling-nanotubes-lifes-secret.html`.

[98] P. P. Gariaev *et al*(2002), *The spectroscopy of bio-photons in non-local genetic regulation.* Journal of Non-Locality and Remote Mental Interactions, Vol 1, Nr 3. `http://www.emergentmind.org/gariaevI3.htm`.

[99] *Nanobe.* `http://en.wikipedia.org/wiki/Nanobe`.

[100] A.A. Lev *et al* (1993), *Rapid switching of ion current in narrow pores: implications for biological ion channels.* Proceedings of the Royal Society of London. Series B: Biological Sciences, June, 187-92.

[101] Z. Merali (2006), *Water gave life on Earth a guiding hand.* New Scientist, issue 2540, 25 February.

[102] D.J. Woodbury (1989): *Pure lipid vesicles can induce channel-like conductances in planar bilayers.* Journal of Membrane Biology, July 1989: 145-50.

[103] *Virus.* `http://en.wikipedia.org/wiki/Virus`.

[104] M. W. Ho and P. T. Saunders (1994), *Liquid Crystalline Mesophase in living organisms.* in *Bioelectrodynamics and Biocommunication* (M. W Ho, F. A. Popp and U. Warnke, eds), World Scientific, Singapore.

Neuroscience

[105] *Retinal Transduction: Hyperpolarization of Primary Photoreceptors by Ligh.* `http://www.acbrown.com/neuro/Lectures/NrVisn/NrVisnRtnlHprp.htm`.

[106] *Action potential.* `http://en.wikipedia.org/wiki/Action_potential`.

[107] H. Abdelmeik, S. Amara, A. M′Chirgui, M. Ben Salem, M. Sakly (2003) *Impact of evolution on the electrical properties of sciatic nerves: super-conductivity-like.* Journal of Physical & Chemical News (in press).

[108] L. F. Jaffe (2001), *Calcium Waves.*`http://waves.mbl.edu/calcium.waves.html`.
Calcium waves. `http://waves.mbl.edu/calcium.waves.html`.

[109] *Photoreceptor cell.* http://en.wikipedia.org/wiki/Photoreceptor_cell.

[110] K. Graesboll (2006), *Function of Nerves-Action of Anesthetics.* Gamma 143, An elementary Introduction. http://www.gamma.nbi.dk.

[111] E.R. Kandel. J.H. Schwartz, T. M. Jessel (1991), Principles of neural science, Prentice-Hall International Inc..

[112] T. Heimburg and A. D. Jackson (2005),*On soliton propagation in biomembranes and nerves.* PNAS vol. 102, no. 28, p.9790-9795.

[113] T. Heimburg and A. D. Jackson (2005), *On the action potential as a propagating density pulse and the role of anesthetics.* arXiv : physics/0610117[physics.bio-ph].

[114] *Soliton model.* http://en.wikipedia.org/wiki/Soliton_model.

[115] K. W. Miller, W. D. M. Paton and E. B. Smith (1962), Brit. J. anesthesia, 39, 910.

[116] D.V. Nanopoulos (1995) *Theory of Brain function, Quantum Mechanics, and Superstrings.* CERN-TH/95-128, hep-ph/9505374.

[117] *Saltation.* http://en.wikipedia.org/wiki/Saltation.

[118] *Color vision.* http://en.wikipedia.org/wiki/Color_vision.

[119] *Physicists challenge notion of electric nerve impulses; say sound more likely.* http://www.scienceblog.com/cms/physicists-challenge-notion-of-electric-nerve-impulses-say-sound-more-html.

[120] E. H. Walker (1977),*Quantum Mechanical Tunnelling in Synaptic and Ephaptic Transmission.* Int. J. Quantum Chemistry, 11, 103-127.

[121] P. E. Roland (1993), *Brain Activation.* Wiley.

[122] *Goldman equation.* http://en.wikipedia.org/wiki/Goldman_equation.

Consciousness related references

[123] B. Libet, E. W. Wright Jr., B. Feinstein, and D. K. Pearl (1979), *Subjective referral of the timing for a conscious sensory experience* Brain, 102, 193-224.

[124] N. Cherry (2000), Conference report on effects of ELF fields on brain, http://www.tassie.net.au/emfacts/icnirp.txt.

[125] C. B. Pert (1997), *Molecules of Emotion.* Simon & Schuster Inc..

[126] B. Libet(1982), E. W. Wright, C. A. Gleason (1982), *Readiness potentials preceding unrestricted spontaneous and preplanned voluntary acts.* Electroencephalography and Clinical Psychology 54, 322-325.
See also the article *Libet's Research on Timing of Conscious Intention to Act: A Commentary* of Stanley Klein. http://cornea.berkeley.edu/pubs/ccog_2002_0580-Klein-Commentary.pdf.

[127] A. Kaivarainen (2002), *Hierarchic model of consciousness: From molecular bose condensation to synaptic re-organization.* Journal of Non-Locality and Remote Mental Interactions, Vol. I Nr. 2. http://www.emergentmind.org/kaivarainenI2.htm.

[128] R. O. Becker and G. Selden (1990) *The Body Electric: Electromagnetism and the Foundation of Life.* William Morrow & Company, Inc., New York.

Chapter 6

Dark Matter Hierarchy and Hierarchy of EEGs

6.1 Introduction

The emergence of zero energy ontology, the explanation of dark matter in terms of a hierachy 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.

Also long range weak forces 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. This leads to a correct prediction for the frequencies of peak sensitivity for photoreceptors - something highly non-trivial remembering that also the large parity breaking effects in living matter find a natural explanation. Second quantitative key observation was that for electrons and quarks the time scales of causal diamonds correspond to fundamental biorhythms assignable to central nervous system.

The general model for EEG follows neatly from this picture combined with the general model of high T_c superconductivity. A fractal hierarchy of EEGs and its generalizations identified in terms of Josephson radiation is predicted with levels labeled by p-adic length scales and the value of $\hbar$ at various levels of dark matter hierarchy: the recent view about the generalization of the notion of imbedding space realizing this hierarchy is discussed in the Appendix. Cell membrane would represent only one level in this hierarchy. The analogs of EEG would exist for various organs, organelles and even cell. Also the possibility of ZEG, WEG and QEG corresponding to Z^0 bosons, W bosons, and gluons must be considered.

6.1.1 Background ideas

Zero energy ontology

Zero energy ontology meant a breakthrough in the understanding of TGD and TGD inspired theory of consciousness and biology.

In zero energy ontology the S-matrix is generalized to M-matrix defining entanglement coefficients between positive and negative energy parts of zero energy states [16]. M-matrix has interpretation as a "complex square root" of density matrix and thus provides a unification of thermodynamics and quantum theory. S-matrix is analogous to the phase of Schrödinger amplitude multiplying positive and real square root of density matrix analogous to the modulus of Schrödinger amplitude.

The notion of finite measurement resolution realized in terms of inclusions of von Neumann algebras allows to demonstrate that the irreducible components of M-matrix are unique and possesses huge symmetries in the sense that the hermitian elements of included factor $\mathcal{N} \subset \mathcal{M}$ defining the measurement resolution act as symmetries of M-matrix, which suggests a connection with integrable quantum field theories.

Zero energy ontology is consistent with the ordinary positive energy ontology when the time scale T characterizing CD is long as compared to the time scale of observations. For shorter times scales however creation of matter from vacuum having in standard QFT framework interpretation as quantum fluctuations becomes possible and this process might occurs routinely in living matter unless the values of Planck constant assignable to CDs are very large. Also CDs can be created in quantum jump and a possible interpretation for a creation of CD is in terms of imbedding space correlates of selves and of directed attention generating mental images. This interpretation leads to a model explaining how the arrow of psychological time emerges and why the contents of sensory experience are in so narrow time interval. The unexpected prediction is that zero energy ontology assigns to elementary particles macroscopic times scales. In particular, the time scales assignable to electron, d, and u quarks correspond to the frequencies 10 Hz (fundamental biorhythm), 1280 Hz (kHz cortical synchrony), and 160 Hz (cerebellar synchrony).

Zero energy ontology and p-adic coupling constant evolution

p-Adic coupling constant evolution and origins of p-adic length scale hypothesis have remained for a long time poorly understood. The progress made in the understanding of the S-matrix of the theory (or rather, its generalization M-matrix) [16] has however changed the situation. The basic question is whether the time scale hierarchy $T_n = 2^n T_0$ assignable to the hierarchy of CDs and defining a hierarchy of measurement resolutions in time variable could induce p-adic coupling constant evolution and explain why p-adic length scales correspond to $L_p \propto \sqrt{p}R$, $p \simeq 2^k$, R CP_2 length scale. This idea looks attractive but there is a problem. p-Adic length scales come as powers of $\sqrt{2}$ rather than 2 and the strongly favored values of k are primes and thus odd so that $n = k/2$ would be half odd integer. This problem can be solved.

1. The observation that the distance traveled by a Brownian particle during time t satisfies $r^2 = Dt$ suggests a solution to the problem. p-Adic thermodynamics applies because the partonic 3-surfaces X^2 are as 2-D dynamical systems random apart from light-likeness of their orbit. For CP_2 type vacuum extremals the situation reduces to that for a one-dimensional random light-like curve in M^4. The orbits of Brownian particle would now correspond to light-like geodesics γ_3 at X^3. The projection of γ_3 to a time=constant section $X^2 \subset X^3$ would define the 2-D path γ_2 of the Brownian particle. The M^4 distance r between the end points of γ_2 would be given $r^2 = Dt$. The favored values of t would correspond to $T_n = 2^n T_0$ (the full light-like geodesic). p-Adic length scales would result as $L^2(k) = DT(k) = D2^kT_0$ for $D = R^2/T_0$. Since only CP_2 scale is available as a fundamental scale, one would have $T_0 = R$ and $D = R$ and $L^2(k) = T(k)R$.

2. p-Adic primes near powers of 2 would be in preferred position. p-Adic time scale would not relate to the p-adic length scale via $T_p = L_p/c$ as assumed implicitly earlier but via $T_p = L_p^2/R_0 = \sqrt{p}L_p$, which corresponds to secondary p-adic length scale. For instance, in the case of electron with $p = M_{127}$ one would have $T_{127} = .1$ second which defines a fundamental biological rhythm. Neutrinos with mass around .1 eV would correspond to $L(169) \simeq 5$ μm (size of a small cell) and $T(169) \simeq 1. \times 10^4$ years. A deep connection between elementary particle physics and biology becomes highly suggestive.

3. In the proposed picture the p-adic prime $p \simeq 2^k$ would characterize the thermodynamics of the random motion of light-like geodesics of X^3 so that p-adic prime p would indeed be an inherent property of X^3.

p-Adic length scale hypothesis and biology

The basic implication of zero energy ontology is the formula $T(k) \simeq 2^{k/2}L(k)/c = L(2,k)/c$. This would be the analog of $E = hf$ in quantum mechanics and together hierarchy of Planck constants would imply direct connection between elementary particle physics and macroscopic physics. Especially important this connection would be in macroscopic quantum systems, say for Bose Einstein condensates of Cooper pairs, whose signature the rhythms with $T(k)$ as period would be. The presence of this kind of rhythms might even allow to deduce the existence of Bose-Einstein condensates of hitherto unknown particles.

1. For electron one has $T(k) = .1$ seconds which defines the fundamental $f_e = 10$ Hz bio-rhythm appearing as a peak frequency in alpha band. This could be seen as a direct evidence for a Bose-Einstein condensate of Cooper pairs of high T_c super-conductivity. That transition to "creative" states of mind involving transition to resonance in alpha band might be seen as evidence for formation of large BE condensates of electron Cooper pairs.

2. TGD based model for atomic nucleus [36] predicts that nucleons are connected by flux tubes having at their ends light quarks and anti-quarks with masses not too far from electron mass. The corresponding p-adic frequencies $f_q = 2^k f_e$ could serve as a biological signature of exotic quarks connecting nucleons to nuclear strings . $k_q = 118$ suggested by nuclear string model would give $f_q = 2^{18} f_e = 26.2$ Hz. Schumann resonances are around 7.8, 14.3, 20.8, 27.3 and 33.8 Hz and f_q is not too far from 27.3 Hz Schumann resonance and the cyclotron frequency $f_c(^{11}B^+) = 27.3$ Hz for $B = .2$ Gauss explaining the effects of ELF em fields on vertebrate brain.

3. For a given $T(k)$ the harmonics of the fundamental frequency $f = 1/T(k)$ are predicted as special time scales. Also resonance like phenomena might present. In the case of cyclotron frequencies they would favor values of magnetic field for which the resonance condition is achieved. The magnetic field which in case of electron gives cyclotron frequency equal to 10 Hz is $B_e \simeq 3.03$ nT. For ion with charge Z and mass number A the magnetic field would be $B_I = \frac{A}{Z}(m_p/m_e)B_e$. The $B = .2$ Gauss magnetic field explaining the findings about effects of ELF em fields on vertebrate brain is near to B_I for ions with f_c alpha band. Hence the value of B could be understood in terms of resonance with electronic B-E condensate.

4. The hierarchy of Planck constants predicts additional time scales $T(k)$. The prediction depends on the strength of the additional assumptions made. One could have scales of form $nT(k)/m$ with m labeling the levels of hierarchy. $m = 1$ would give integers multiples of $T(k)$. Integers n could correspond to ruler and compass integers expressible as products of first powers of Fermat primes and power of 2. There are only four known Fermat primes so that one has $n = 2^n \prod_i F_i$, $F_i \in \{3, 5, 17, 257, 2^{16}+1\}$. In the first approximation only 3- and 5- and 17-multiples of 2-adic length scales would result besides 2-adic length scales. In more general case products m_1m_2 and ratios m_1/m_2 of ruler and compass integers and their inverses $1/m_1m_2$ and m_2m_1 are possible.

5. Mersenne primes are expected to define the most important fundamental p-adic time scales. The list of real and Gaussian (complex) Mersennes M_n possibly relevant for biology is given by n=89, 107, 113*, 127, 151*,157*, 163*, 167* ('*' tells that Gaussian Mersenne is in question).

$$\begin{array}{lllll}
n & 89 & 107 & 113 & 127 \\
f/Hz & 2.7\times 10^{12} & 1.0\times 10^{7} & 1.6\times 10^{5} & 10 \\
n & 151 & 157 & 163 & 167 \\
T & 19.4\ d & 3.40\ y & 218.0\ y & 3.49\times 10^{3}\ y
\end{array} \qquad (6.1.1)$$

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 exists a stronger correlation betweeen 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 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 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.

DNA and topological quantum computation

The model of DNA as topological quantum computer led to a dramatic progress in the understanding of how magnetic body interacts with the biological body. The model which looks the most plausible one relies on two specific ideas.

1. Sharing of labor means conjugate DNA would do tqc and DNA would "print" the outcome of tqc in terms of RNA yielding amino-acids in the case of exons. RNA could result in the case of introns. The experience about computers and the general vision provided by TGD suggests that introns could express the outcome of tqc also electromagnetically in terms of standardized field patterns. Also speech would be a form of gene expression. The quantum states braid would entangle with characteristic gene expressions.

2. The manipulation of braid strands transversal to DNA must take place at 2-D surface. The ends of the space-like braid are dancers whose dancing pattern defines the time-like braid, the running of classical tqc program. Space-like braid represents memory storage and tqc program is automatically written to memory during the tqc. The inner membrane of the nuclear envelope and cell membrane with entire endoplasmic reticulum included are good candidates for dancing halls. The 2-surfaces containing the ends of the hydrophobic ends of lipids could be the parquets and lipids the dancers. This picture seems to make sense.

One ends up to the model also in top-down manner.

1. Darwinian selection for which standard theory of self-organization provides a model, should apply also to tqc programs. Tqc programs should correspond to asymptotic self-organization patterns selected by dissipation in the presence of metabolic energy feed. The spatial and temporal pattern of the metabolic energy feed characterizes the tqc program - or equivalently - sub-program call.

2. Since braiding characterizes the tqc program, the self-organization pattern should correspond to a hydrodynamical flow or a pattern of magnetic field inducing the braiding. Braid strands must correspond to magnetic flux tubes of the magnetic body of DNA. If each nucleotide is transversal magnetic dipole it gives rise to transversal flux tubes, which can also connect to the genome of another cell.

3. The output of tqc sub-program is probability distribution for the outcomes of state function reduction so that the sub-program must be repeated very many times. It is represented as four-dimensional patterns for various rates (chemical rates, nerve pulse patterns, EEG power distributions,...) having also identification as temporal densities of zero energy states in various scales. By the fractality of TGD Universe there is a hierarchy of tqcs corresponding to p-adic and dark matter hierarchies. Programs (space-time sheets defining coherence regions) call programs in shorter scale. If the self-organizing system has a periodic behavior each tqc module defines a large number of almost copies of itself asymptotically. Generalized EEG could naturally define this periodic pattern and each period of EEG would correspond to an initiation and halting of tqc. This brings in mind the periodically occurring sol-gel phase transition inside cell near the cell membrane.

4. Fluid flow must induce the braiding which requires that the ends of braid strands must be anchored to the fluid flow. Recalling that lipid mono-layers of the cell membrane are liquid

crystals and lipids of interior mono-layer have hydrophilic ends pointing towards cell interior, it is easy to guess that DNA nucleotides are connected to lipids by magnetic flux tubes and hydrophilic lipid ends are stuck to the flow.

5. The topology of the braid traversing cell membrane cannot not affected by the hydrodynamical flow. Hence braid strands must be split during tqc. This also induces the desired magnetic isolation from the environment. Halting of tqc reconnects them and make possible the communication of the outcome of tqc.

6. There are several problems related to the details of the realization. How nucleotides A,T,C,G are coded to strand color and what this color corresponds to? The prediction that wormhole contacts carrying quark and anti-quark at their ends appear in all length scales in TGD Universe resolves the problem. How to split the braid strands in a controlled manner? High T_c super conductivity provides the mechanism: braid strand can be split only if the supra current flowing through it vanishes. A suitable voltage pulse induces the supra-current and its negative cancels it. The conformation of the lipid controls whether it it can follow the flow or not. How magnetic flux tubes can be cut without breaking the conservation of the magnetic flux? The notion of wormhole magnetic field saves the situation now: after the splitting the flux returns back along the second space-time sheet of wormhole magnetic field. The model inspires several testable hypothesis about DNA itself: in particular, the notion of anomalous em charge of DNA leads to several predictions of this kind. Also new mechanisms of catalytic action based on phase transitions reducing the value of Planck constant emerge.

Summary of basic ideas leading to the model of EEG

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 [28]. 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 (CDs). For u and d quarks and electron these time scales are (6.5, .78, 100) ms respectively, and correspond to fundamental biorhythms. As already noticed, electron time scale corresponds to 10 Hz fundamental biorhythm defining also the fundamental frequency of speech organs, .78 ms to kHz cortical synchrony [68], and 160 Hz to cerebrellar synchrony [72]. 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-CDs 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 [17] remain to be disentangled.

3. The understanding of the Negentropy Maximization Principle [27] 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 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 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 [17]. 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) [55] 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.

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 this analogy can be justified 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.

6.1.2 Vision about EEG

The general model for EEG relies on the idea that EEG frequencies correspond to Josephson frequencies defined by membrane potentials and provide cognitive and one might also say emotional representation of the sensory input at the magnetic body in terms of cyclotron transitions. The perturbations of the membrane potentials caused by spikes, neurotransmitters affecting alertness reducing the magnitude of the resting potential induced frequency modulations of the membrane potentials and one can say that the cell is like a singing whale with evoked potentials and nerve pulse patterns coded to the varying frequency. Song is expression of this singing but also speech involves frequency modulation as one learns by playing slowly recorded spoken language.

The scale of the frequency 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.

The hypothesis that Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1+i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241..\}$ (the number theoretical miracle is that all the four p-adic length scales sith $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm) define scaled up copies of electro-weak and QCD type physics with ordinary value of $\hbar$ and that these physics are induced by dark variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$, and the resulting picture finds support from the ensuing models for biological evolution and for EEG.

An essential assumption is that cell membrane corresponds to almost vacuum extremal so that classical Z^0 field proportional to em field is present and leads to the replacement of ionic charges with effective charges much larger than ionic charges so that that membrane voltage corresponds to a photon energy in visible or UV range and the energies of biologically most important ions span half octave. From this it follows that for given ion and membrane voltage the value of r fixes completely the Josephson frequency. For instance 5 Hz frequency corresponds to $r = 2^{k_d}$, $k_d = 47$.

Armed with this picture one ends upd with a rather detailed quantitative model for EEG. In this chapter this model is applied in more detail. Features, synchronization, stochastic resonance, temporal codings, and what I have used to called scaling will be discussed.

6.1.3 Fractal hierarchy of EEGs

EEG is replaced with a fractal hierarchy of EEGs corresponding to various values of Planck constants involved.

1. There are three contributions to EEG besides the contributions due to the neural noise and evoked potentials. These contributions correspond to Schumann frequencies, cyclotron frequencies f_c of biologically important ions in magnetic field $B_{end} = .2$ Gauss and its $1/\hbar$ scaled counterparts, and to the Josephson frequencies f_J associated with Josephson junctions assigned with cell membranes. If Josephson radiation modulates cyclotron radiation also the frqequencies $mf_J \pm nf_c$ appear in the spectrum.

2. In standard model $f_J = ZeV/\hbar$ would determined by the membrane potential and would correspond to energy in infrared. This sounds completely reasonable. TGD however suggests that cell membrane as a critical system correspond to an almost vacuum extremal. This predicts classical Z^0 field proportional to em field to which nuclei and neutrinos are assumed to couple. This would explain chiral selection in living matter and predict correctly the frequencies of peak sensitivity for photoreceptors as Josephson frequencies assignable to the biologically most important ions. The effective couplings of ions to membrane potential are modified and the Josephson frequencies correspond to energies in visible and UV range. Bio-photons and EEG could be seen as manifestations of one and same thing: Josephson radiation with a large value of Planck constant with energies of biophotons and frequencies of EEG.

3. An important point is that the ions involved must behave like bosons. For cyclotron condensates either Cooper pairs of ordinary fermionic ions or exotic ions chemically similar to their standard counterparts obtained from neutral bosonic atom by making one or more neutral color flux tubes connecting nucleons charged. For Josephson radiation only the latter option works. TGD based nuclear physics indeed predicts this kind of nuclei and there is experimental evidence for their existence [36].

4. For cyclotron frequencies the extremals are assumed to be far from vacuum extremals carrying very small classical Z^0 fields but nonvanishing classical W fields and color fields (with $U(1)$ holonomy). The corresponding flux quanta would naturally correspond to flux sheets traversing through DNA strands while Josephson radiation would propagate along flux tubes parallel to the cell membrane. Far from biological body one expects both kinds of flux quanta to fuse to form larger ones so that one has parallel space-time sheets carrying cyclotron *resp.* Josephson radiation. Wormhole contacts between Josephson and cyclotron flux sheets would induce a non-linear interaction giving rise to a superposition of harmonics of Josephson and cyclotron frequencies.

5. Josephson frequencies are assignable to the cell membrane and would naturally correspond to the communication of sensory data to the magnetic body. This would suggest that cyclotron frequencies are assignable to the magnetic flux sheets going through DNA strands responsible for quantum control via gene expression. This picture might be too naive. Josephson radiation would induce transitions between cyclotron states should generate sensory representations at magnetic body so that both frequencies would be involved with sensory representations. Furthermore, the identification of motor action as time reversal of sensory perception allowed by zero energy ontology would mean that same mechanisms are at work for negative energies (phase conjugate radiation). Resonance is achieved if the condition $mf_J = nf_c$ is satisfied. For small values of integers m and n the condition is quite restrictive. Schumann frequencies can be assigned with the magnetic body of Earth and would correlate with the collective aspects of consciousness.

6. The model of hearing forces to assume quite a wide spectrum of Planck constants- at least the values coming as powers of two and the safest assumption is that at least integer multiples of the ordinary Planck constant are possible. Josephson radiation and cyclotron radiation have same scale if $B_{end} \propto 1/\hbar$ proportionality holds true. Note that for 5 Hz Josephson frequency and membrane potential and for $V = .-70$ mV corresponding to the resting potential of neuron one obtains $r = (0.96, 1.20, 1.34, 1.01) \times 2^{47}$ for almost vacuum extremals. For Ca^{++} ion r is very near to a power of 2.

6.1.4 Basic aspects of EEG

Consider now how one could understand basic characteristics of EEG during wake-up and sleep in this framework.

1. For small amplitudes and for the lowest harmonics this implies that alpha band to which the cyclotron frequencies most biologically important bosonic ions corresponds has as satellites theta and beta bands. Higher harmonics correspond to gamma and higher bands having also satellites.

2. For large amplitudes EEG becomes chaotic which is indeed the property of beta band during say intense concentration or anxiety. The findings of Nunez about narrow 1-2 Hz wide bands at 3,5,7 Hz and 13,15,17 Hz confirm with the prediction of satellite bands and fix the Josephson frequency to 5 Hz. This picture explains the general characteristics of EEG in wake-up state qualitatively and quantitatively.

3. In order to understand the characteristics during various stages of deep sleep one must assume that the cyclotron frequency scale of ions is scaled down by a factor of 1/2. The simplest explanation is that the value of Planck constant increases by a factor 2 in a phase transition having interpretation as a leakage of cell membrane space-time sheet between the pages of Big Book defined by the generalized imbedding space. During stage 4 sleep only only DNA cyclotron frequencies in delta band are around 1 Hz and just above the thermal threshold are predicted to be present. This stage could correspond to a value of Planck constant which is 4 times its value in wake-up state.

The generalization of the model for EEG hierarchy to the case of ZEGs is straightforward and Josephson frequency spectrum is the same. Any atom, almost always boson, has an exotically charged counterpart with same statistics so that very rich spectrum of Bose-Einstein condensates results.

6.1.5 The effects of ELF em fields on brain

The experimental data about the effects of ELF em fields at cyclotron frequencies of various ions in Earth's magnetic field on vertebrate brains were crucial for the development of the model of EEG. As a matter fact, it was the attempt to explain these effects, which eventually led to the discovery of the fractal hierarchy of EEGs and its generalizations. These effects therefore serve as a killer test for the scenario and are still only partially understood.

The reported effects occur for harmonics of cyclotron frequencies of biologically important ions in Earth's magnetic field. They occur only in amplitude windows. The first one is around 10^{-7} V/m and second corresponds to the range $1-10$ V/m: the amplitudes of EEG waves are in the range 5-10 V/m. The effects are present only in the temperature interval 36-37 C.

1. Cyclotron frqeuencies led to the vision about cyclotron condensates of biologically important ions and their Cooper pairs at the flux quanta of dark magnetic field with so large Planck constant that the energies of cyclotron photons are above thermal threshold. The model for EEG and biophotons in terms of Josephson radiation from cell membrane which is almost vacuum extremal allows to make this model more quantitative.

2. The temperature window has one interpretation in terms of a competion of almost vacuum extremal property of cell membrane possible above some critical temperature and high T_c superconductivity possible below some critical temperature.

3. The amplitude window 10^{-7} V/mfollows from a quantized form of Faraday law whose existence is supported by the fact that space-time sheets are analogs of Bohr orbits in exact sene. The quantisation condition relates the amplitude of electric field to Planck constant and frequency. For the value $r = \hbar/\hbar_0 = 2^{47}$ of Planck constant required by 5 Hz Josephson frequency the 10^{-7} V/m amplitude is predicted correctly.

4. The amplitude window around 1-10 V/m (EEG amplitudes are in the range 5-10 V/m) follows if the values of Planck constant in the range $10^7r - 10^8r$ can be justified. A possible justification is based on the observation that for $r_1 = 10^8r$ the Compton wave length of intermediate gauge bosons corresponds to $k = 163$ defining Gaussian Mersenne and wavelength nearly that corresponding to 2 eV energy, which also corresponds to bio-photon energies assignable to 50 mV subcritical membrane potential. 1-10 V/m interval corresponds roughly to the range of biophoton energies. Electron's Compton length corresponds for $r_1 = 10^8r$ to 28 cm, which defines the size scale of brain. One might hope that these findings could allow to build an internally consistent story about what happens.

6.1.6 Generalized EEG and consciousness

If the Josephson radiation for a particular primary sensory organ and corresponding sensory pathway propagates to a specific part of the magnetic body along flux quanta it for sensory qualia. Similar interpretation applies to motor action interpreted formally as sensory perception in reversed time direction. Note that the resting potential for the cell membrane is considerably higher for motor neurons than for sensory receptor neurons. The assumption that Josephson radiation induces cyclotron transitions leads to a general interpretation of the generalized EEG in terms of spectroscopy of consciousness.

1. The primary qualia are coded by quantum numbers of quark pairs (or pairs of them) assignable to the ends of the flux tubes connecting DNA nucleotide and lipids. Sensory input generates the Josephson radiation and induces the primary qualia at the level of sensory receptor. Josephson radiation can also regenerate primary qualia or mental images in one-one correspondence with the primary qualia along the entire sensory pathway. Josephson radiation can transform to either biophotons or EEG photons.

2. At the magnetic body Josephson radiation induces cyclotron transitions if resonance conditions are satisfied which implies that the communication of sensory data is optimal for special values of cell membrane resting potential for a fixed value of the magnetic field which of course can also vary. The value of resting potential critical for the generation of nerve pulse is the best candidate in this respect.

3. Also cyclotron transitions could correspond to some kind sensory qualia. "General feeling of existence" possibly accompanying all sensory qualia shared by the magnetic body is one possible identification for the quale involved. The quantum entanglement between this kind of mental image and the mental image representing the primary quale is natural candidate for the experience.

6.1.7 Vision about biological evolution and evolution of brain

The proposed model for EEG, the idea that Gaussian Mersennes (four of them are in the range 10 nm-2.5 micrometers) define p-adic length scales allowing exotic variants of color and electro-weak physics with light intermediate gauge bosons at space-time sheets near vacuum extremals, and the assumption that the preferred values of Planck constant are such that they relate these p-adic scales to each other leads to a detailed quantitative vision about evolution of life as emergence of longer scales belonging to this hierarchy and as special case also to a vision about evolution of cell, nervous system, EEG, and long term memory. The model predicts a hierarchy of preferred size scales for various sub-systems of organisms and corresponding time scales identifiable in terms of bio-rhythms and memory span.

6.2 Model for the hierarchy of Josephson junctions

As far as hierarchy of EEGs and its generalizations is considered the hierarchy of Josephson junctions assignable to cell membrane itself is relevant. Dark matter hierarchy and p-adic fractality allow to imagine a fractal hierarchy of structures analogous to cell membrane with arbitrarily large thickness. One can even imagine scaled up variants of cell membrane with different p-adic length scale and value of Planck constant but possessing same membrane potential as ordinary cell membrane. The generalization of the imbedding space helps to understand what is involved and is discussed in Appendix.

6.2.1 The most recent model for the generation of nerve pulse

For some time ago I learned [67, 71, 60, 61, 58] (thanks to Ulla Mattfolk) that nerve pulse propagation seems to be an adiabatic process and thus does not dissipate: the authors propose that 2-D acoustic soliton is in question. Adiabaticity is what one expects if the ionic currents are dark currents (large $\hbar$ and low dissipation) or even supra currents. Furthermore, Josephson currents are oscillatory so that no pumping is needed. Combining this input with the model of DNA as topological quantum computer (tqc) [28] leads to a rather precise model for the generation of nerve pulse.

1. The system would consist of two superconductors- microtubule space-time sheet and the space-time sheet in cell exterior- connected by Josephson junctions represented by magnetic flux tubes defining also braiding in the model of tqc. The phase difference between two super-conductors would obey Sine-Gordon equation allowing both standing and propagating solitonic solutions. A sequence of rotating gravitational penduli coupled to each other would be the mechanical analog for the system. Soliton sequences having as a mechanical analog penduli rotating with constant velocity but with a constant phase difference between them would generate moving kHz synchronous oscillation. Periodic boundary conditions at the ends of the axon rather than chemistry determine the propagation velocities of kHz waves and kHz synchrony is an automatic consequence since the times taken by the pulses to travel along the axon are multiples of same time unit. Also moving oscillations in EEG range can be considered and would require larger value of Planck constant in accordance with vision about evolution as gradual increase of Planck constant.

2. During nerve pulse one pendulum would be kicked so that it would start to oscillate instead of rotating and this oscillation pattern would move with the velocity of kHz soliton sequence. The velocity of kHz wave and nerve pulse is fixed by periodic boundary conditions at the ends of the axon implying that the time spent by the nerve pulse in traveling along axon is always a multiple of the same unit: this implies kHz synchrony. The model predicts the value of Planck constant for the magnetic flux tubes associated with Josephson junctions and the predicted force caused by the ionic Josephson currents is of correct order of magnitude for reasonable values of the densities of ions. The model predicts kHz em radiation as Josephson radiation generated by moving soliton sequences. EEG would also correspond to Josephson radiation: it could be generated either by moving or standing soliton sequences (latter are naturally assignable to neuronal cell bodies for which $\hbar$ should be correspondingly larger): synchrony is predicted also now.

3. The previous view about microtubules in nerve pulse conduction can be sharpened. Microtubular electric field (always in the same direction) could explain why kHz and EEG waves and nerve pulse propagate always in same direction and might also feed energy to system so that solitonic velocity could be interpreted as drift velocity. This also inspires a generalization of the model of DNA as tqc sine also microtubule-cell membrane systems are good candidates for performers of tqc. Cell replication during which DNA is out of game seems to require this and microtubule-cell membrane tqc would represent higher level tqc distinguishing between multi-cellulars and mono-cellulars.

4. New physics would enter in several manners. Ions should form Bose-Einstein cyclotron condensates. The new nuclear physics predicted by TGD [36] predicts that ordinary fermionic ions (such as K^+, Na^+, Cl^-) have bosonic chemical equivalents with slightly differing mass number obtained by replacing one or more neutral color flux tubes connecting nucleons of neutral atom with a charged one. Anomalies of nuclear physics and cold fusion provide experimental support for the predicted new nuclear physics. Electronic supra current pulse from microtubules could induce the kick of pendulum inducing nerve pulse and induce a small heating and expansion of the axon. The return flux of ionic Josephson currents would induce convective cooling of the axonal membrane. A small transfer of small positive charge into the inner lipid layer could induce electronic supra current by attractive Coulomb interaction. The exchange of exotic W bosons which are scaled up variants of ordinary $W^{\pm}$ bosons is a natural manner to achieve this if new nuclear physics is indeed present.

6.2.2 Quantum model for sensory receptor

This original model of nerve pulse and EEG was still based on the implicit assumption that the space-time sheet carrying the Josephson currents is far from vacuum. The model for sensory receptor and sensory qualia however led to a the proposal that the space-time sheet in question is near vacuum extremal [18, 26]. Near vacuum extremal property does not affect the general structure of the model in an essential manner.

1. The only change [18, 17] is the replacement of charges ± 1 of ions with effective charges given as

$$Q_{eff} = -\frac{Z-N}{2p} + 2Z + q_{em} \ . \tag{6.2.1}$$

Z and N denote nuclear charge and neutron number. $p = sin^(\theta_W)$ corresponds to Weinberg angle. 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 $p = sin^(\theta_W) = .0295$ reproducing the frequencies of peak sensitivity for photoreceptors. Rather remarkably, they are in IR or visible range.

2. The energies are in UV and visible range. Hence one can consider also Josephson junctions with considerably lower membrane potentials of order mV are possibly without losing the thermal stability. For instance, one could consider $k = 151, 157, 163, 167$ Josephson junctions with a membrane potential scaling as $1/L(k)$. For $k = 167$ the energies would be scaled down by a factor $2^{-(167-151)/2} = 2^{-8}$ giving for $V_{eff} = .09$ V a photon energy somewhat below the thermal energy at room temperature. On the other hand, the fact that Josephson junctions with a vanishing Z^0 field are at the verge of thermal instability suggests that also they might be present in living matter.

3. From Table 1 one can evaluate the value of Planck constant for a given Josephson frequency for various ions. For $f_J = 5$ Hz giving a first estimate for neuronal Josephson frequency and V=-55 mV corresponding to the critical voltage for the generation of action potential one obtains the values $r = \hbar/\hbar_0 = (1.51, 1.89, 2.11, 1.59) \times 2^{46}$ for $(Na^+, Cl^-, K^+, Ca^{++})$. For V=-70 mV corresponding to the resting potential of neuron and same Josephson frequency one obtains $r = (0.961.201.341.01) \times 2^{47}$. For Ca^{++} ion r is very near to a power of 2. A good mnemonic is that the Josephson energies of biologically inportant ions vary in an interval, which is in a reasonable approximation half octave $(E_J(K^+)/E_J(Na^+) = 1.3958 \simeq \sqrt{2} \simeq 1.4142)$.

Ion	Na^+	Cl^-	K^+	Ca^{++}
$E_J(40\ mV, p = .0295)/eV$	1.60	2.00	2.23	1.68
$E_J(50\ mV, p = .0295)/eV$	2.00	2.49	2.79	2.10
$E_J(55\ mV, p = .0295)/eV$	2.20	2.74	3.07	2.31
$E_J(65\ mV, p = .0295)/eV$	2.60	3.25	3.64	2.73
$E_J(70\ mV, p = .0295)/eV$	2.80	3.50	3.92	2.94
$E_J(75\ mV, p = .0295)/eV$	3.00	3.75	4.20	3.15
$E_J(80\ mV, p = .0295)/eV$	3.20	4.00	4.48	3.36
$E_J(90\ mV, p = .0295)/eV$	3.60	4.50	5.04	3.78
$E_J(95\ mV, p = .0295)/eV$	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 1. 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. Table 1 gives the values of Josephson frequencies of basic biological ions for typical values of the membrane potential.

1. The maximum value of the action potential during nerve pulse 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.

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.

6.2.3 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 frquencies 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

$$r(q) = \frac{Q_{eff}(q)}{Q_{em}(q)} = \frac{\epsilon(q)}{2pQ_{em}(q)} + 1 \ , \ \ \epsilon(u) = -1 \ \ , \epsilon(d) = 1 \tag{6.2.2}$$

   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 he standard option would require both d quark and electron. Gor $d$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 2. 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.

4. Besides cyclotron frequencies also the harmonics of the fundamental frequencies assignable to quark and electron CDs 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.

6.2.4 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 motor neurons at the ends of motor pathways wherefrom they would progate 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 [68]. 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 iseems 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 suggests that sensory data should be communicated from the cell membrane along the passive DNA strand. The simplest hypotesis 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 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

$$\oint (p - ZeA)dl = n\hbar \ , \tag{6.2.3}$$

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

$$N = \frac{2m}{RZ^2e^2} \tag{6.2.4}$$

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

$$N_i = \frac{2m_i v_i}{RZ_i \sum_k Z_k v_k e^2} \ . \tag{6.2.5}$$

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 possibiliy 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 assgnable 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 characteristizing 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 receival 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 wuold seem that thee 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.

6.2.5 Dark matter hierarchies of Josephson junctions

The hierarchy of Josephson junctions assignable to cell membrane and characterized by values of Planck constant provides a rather nice model for cell membrane but one can consider also more general dark hierarchies of Josephson junctions. This model conforms with the general vision that living matter processes information by locating it to various pages of the "Big Book".

Maximization of Planck constant in quantum control and communication in living matter

The sectors of the imbedding space for which CD and CP_2 are replaced with their n_a- *resp.* n_b-fold coverings define the most promising candidates concerning the understanding of living matter, at least the quantum control of living matter. The reason is that the value of the Planck constant is maximized and given by $r = \hbar/\hbar_0 = n_a n_b$. Also the number of pages with same Planck constant would be finite unlike for the more general option allowing rational values of Planck constant. In particular, infinite number of pages with the standard value of Planck constant would be possible and this might lead to mathematical difficulties.

Experimental constraints allow to consider also the possibility that only covering spaces are possible. One must be however very cautious in making hasty conclusions. If also factor spaces are allowed one can have G_a or G_b as discrete and exact symmetry groups at the level of dark matter and these symmetries would be manifested as approximate symmetries of the visible matter topologically condensed around the dark matter.

1. In M^4 degrees of freedom since the restriction to the orbifold $\hat{M}^4/G_a$ is equivalent to the exact G_a-invariance of dark matter quantum states. Molecular rotational symmetries correspond typically to small groups G_a and might relate to this symmetry. Small values of n_a would not affect dramatically the value of Planck constant if n_b is large.

2. $G_a = Z_n$, $n = 5, 6$ are favored for molecules containing aromatic cycles. Also genuinely 3-dimensional tedrahedral, octahedral, and icosahedral symmetries appear in living matter.

In the sequel only integer values of Planck constant will be considered. An especially interesting hierarchy corresponds to ruler and compass integers expressible as a product of power of two and distinct Fermat primes (see Appendix). The reason is that these integers correspond to number theoretically very simple quantum phases. This hierarchy includes as a special case powers of two and one can imagined a resonant interaction between p-adic length scale hierarchy and hierarchy of Planck constants.

Dark hierarchy of Josephson junctions with a constant thickness

The model for EEG relies on fractal hierarchy of cell membrane like structures with a fixed thickness and membrane potential. Therefore cell membrane thickness is not scaled by $\hbar$ as one might naively expect. Same applies to magnetic flux tubes: this is possible since the condition for the quantization of magnetic flux can be replaced with a more general one if one allows charged currents at the boundaries of flux quanta [18]. In this model the value of $\hbar$ becomes a measure for the evolutionary level of cell and neurons in hippocampus, associative regions of cortex and their motor counterparts, and frontal lobes are expected to correspond to the largest values of $\hbar$ measuring also the time scale of long term memory and planned action. Note that cell membrane corresponds to twin primes $k = 149$ and $k = 151$ with $k = 151$ defining a Gaussian Mersenne so that it is indeed very special.

Page of a book is rather precise metaphor for the magnetic flux sheet going through a linear array of strings of nuclei and also for a collection flux tubes parallel to axons. This raises several questions. Do the lines of the text of this book correspond to axons in neural circuits? Do the pages correspond to larger structures formed by the axons?

The quantum model for qualia [18] implies that Josephson radiation travels through flux tubes parallel to sensory pathways and there could be also a horizontal organization of the neurons- at least at the level of sensory receptors in the sense that magnetic flux tubes connecting DNA nucleotides to lipids of cell membrane fuse to form longer flux tubes between DNA nucleodites of different cells when sensory receptor is active. Axons could thus be seen as the analogs of text lines which however can interact with each other. Similar organization would appear at the level of flux sheets traversing through DNA strands.

Books are made for reading and one can thus ask whether the book metaphor extends. Could the observed moving brain waves scanning cortex relate to the "reading" of the information associated with these sheets of book by the magnetic body and does our internal speech correspond to this "reading"? One is also forced to ask whether these brain waves are induced by waves propagating along magnetic flux quanta of the magnetic body of Earth or personal magnetic body in the case that it has components other than magnetic flux sheets serving as Josephson junctions.

An objection against a fractal hierarchy of Josephson junctions with thickness scaling as $\hbar$

One can consider also a hierarchy of Josephson junctions with a scaled up thickness proportional to $\hbar$ instead of constant thickness. If these junctions have same voltage at all levels of the hierarchy a resonant interaction between various levels of the hierarchy would become possible.

One can represent common sense objections against this idea. The electric field involved with the higher levels of Josephson junction hierarchy is very weak: something like 10^{-7} V/m for lito-ionospheric Josephson junctions (of thickness about 176 km from the scaling of the cell membrane thickness by $\lambda^4 = 2^{44}$) which might be responsible for EEG. The electric field of the Earth at space-time sheets corresponding to ordinary matter is much stronger: about $10^2 - 10^4$ V/m at the surface of Earth but decreasing rapidly as ionosphere is approached being about .3 V/m at 30 km height. The estimate for the voltage between ionosphere and Earth surface is about 200 kV [42].

The many-sheeted variant of Faraday law implies that on order to have a voltage of order .08 V over lito-ionospheric Josephson junction at dark matter space-time sheet, the voltage over ionospheric cavity must be almost completely compensated by an opposite voltage over litosphere so that lito-ionospheric double layer could be seen as a pair of capacitor plates in a radial electric field of order 10^{-7} V/m generated by the charge density in sub-litospheric part of Earth. This condition requires fine-tuning and therefore looks unrealistic.

A natural distance scale in which the electric field is reduced would correspond to 10-20 km thick layer in which whether phenomena are present. The mirror image of this layer would be Earth's crust. The cell membrane counterpart would be a dipole layer like charge density between the lipid layers of the cell membrane. Note that the electric field at dark matter space-time can be constant. However, as far as Josephson junction is considered, it is only the net voltage what matters.

6.2.6 p-Adic fractal hierarchy of Josephson junctions

p-Adic length scale hypothesis allows to imagine a hierarchy of Josephson junctions at least in length scales regarded usually as biologically relevant. The voltage through the junction need not however be same as for the ordinary cell membrane anymore. Twin primes are especially interesting since they would naturally correspond to pairs of structures analogous to a pair of lipid layers defining cell membrane.

In particular, twin primes abundant in the p-adic length scale range assignable to living matter could define double layered structures acting as Josephson junctions.

$(k, k+2)$	$(137, 139)$	$(149, 151)$	$(167, 169 = 13^2)$	$(179, 181)$
$L(k)$	$.78\ A$	$5\ nm$	$2.5\mu m$	$.32\ mm$
$(k, k+2)$	$(191, 193)$,	$(197, 199)$		
$L(k)$	$1\ cm$	$8\ cm$		

Table 3. Twin primes define especially interesting candidates for double membrane like structures defining Josephson junctions. Also included the pair $(137, 13^2 = 169)$ although $k = 169$ is not prime. The two largest scales could relate to structures appearing in brain.

Also Gaussian Mersennes define highly interesting p-adic length scales and the length scale range between cell membrane thickness and the size of cell contains as many as four Gaussian Mersennes corresponding to $k = 151, 157, 163, 167$. Only the smallest one is associated with a twin prime but p-adic length scale hypothesis allows also non-prime values of k.

The possibility of a p-adic hierarchy of membrane like structures accompanied by Josephson junctions

One can imagine the existence of fractally scaled up variants of cell membrane defining hierarchy of Josephson junctions possibly realized as magnetic flux tubes. The possible existence of this hierarchy is however not relevant for the model of EEG in its recent form.

The first hierarchy correspond to the p-adic length scales varying in the range of biologically relevant p-adic length scales $L(k)$ involving membrane like structures. Twin primes $(k, k+2)$ are good candidates here (Table 3). Second hierarchy corresponds to dark matter hierarchy for which length scales come as $\sqrt{r}L(k))$, $r = \hbar/\hbar_0$. Later the question which values of r are favored will be discussed.

The size of cell nucleus varies in the range $(L(169) = 5\ \mu m, 2L(169) = 10\ \mu m)$. This is consistent with the assumption that cell nucleus provides the fundamental representation for this block. This would mean that at least the multiply coiled magnetic flux quantum structures associated with DNA appear as fractally scaled up copies.

Each dark matter level corresponds to a block of p-adic length scales $L(k)$, $k = 151, ..., 169$. Also new length scales emerge at given level and correspond to $L(k)$, $k > 169$. The dark copies of all these length scales are also present. Hence something genuinely new would emerge at each level.

Fractal hierarchy of magnetic bodies assignable to cell

Second hierarchy corresponds to a dark matter hierarchy involving values of Planck constant. The original hypothesis was that the values of Planck constant comes as $r \equiv \hbar/\hbar_0 = 2^{11k}$ of given p-adic length scale assignable to biological membrane like structure. A possible justification for the hypothesis is that the ratio of electron and proton masses is rather near to 2^{11} and that this number appears in quantum TGD in the role of fundamental constant. This hypothesis is however un-necessarily restrictive and it is better to consider at least the values of r given as products of two ruler and compass integers n_F expressible as a product of distinct Fermat primes and some power of two. The justification comes from the number theoretic vision about evolution and number theoretical simplicity of the phases $q = exp(i2\pi/n_F)$ (Appendix).

The emergence of a genuinely new structure or function in evolution would correspond to the emergence of new level in this fractal hierarchy. Quantum criticality would be essential: phases corresponding different values of Planck constant would compete at quantum criticality.

The flux sheet or tubes through cell membranes should integrate to larger structures at the higher levels of dark matter hierarchy implying the integration of sensory inputs from a large number of cells to single coherent input at higher levels of dark matter hierarchy. One can think two options: the sensory inputs from cell membranes are communicated directly to the magnetic body or via the DNA. The second option would require that the flux sheets or tubes starting from cell membrane traverse also the DNA.

6.3 What is EEG made of?

The usual classification of EEG frequencies by EEG bands is more or less a convention and the definitions of various bands vary in frustratingly wide ranges. In a more ambitious approach bands should be replaced with some substructures identified on basis of their physical origin and function. In the proposed framework this is possible. This identification of substructures of course applies only to that part of EEG from which noise is subtracted. The contribution of neural activity is one such source of noise, often regarded as the only contribution.

6.3.1 Dark hierarchy of EEGs

The dark hierarchy of Josephson junctions with fixed size characterized by a p-adic length scale most naturally assignable to a member of twin prime pair defining a fractal hierarchy of EEGs is the basic element of the model of generalized EEG.

Josephson current

Each junction has a background voltage over it. The basic hierarchy involves the p-adic length scales $L(k)$, $k = 151, 157, 163, 167$ corresponding to Gaussian Mersennes. One could consider the possibility that not only $k = 151$ but all these length scales and also twin primes define their own Josephson junctions with their own values of Josephson potential.

Josephson current can be written as

$$J \propto sin[Q_{eff}eVt + Q_{eff}e\int V_1 dt)/\hbar] \ , \tag{6.3.1}$$

where Q_{eff} is the effective charge of the ion. If the membrane structure corresponds to an almost vacuum extremal as assumed in the model of sensory receptor discussed in the chapter about hearing [18], one must replace the ionic charge Z effective ionic charge Q_{eff} taking into account the classical Z^0 force. This point will be discussed explicitly later. V corresponds to the background voltage analogous to resting potential of cell membrane and varies in rather narrow limits. $V_1(t)$ represents external perturbation- the evoked potentials reflecting nerve pulse patterns.

The model for nerve pulse [17] supports strongly the view that V corresponds to a propagating soliton sequence associated with Sine-Gordon equation. As described in the section about EEG, the situation is mathematically equivalent to a linear array of gravitational penduli coupling with each other and soliton sequence corresponds to a rotation of penduli with constant phase difference between neighbors so that a propagating wave would result. The analog of EEG would be associated also with ordinary cell membranes but the smaller value of $\hbar$ would imply that the frequencies involved are higher. Non-propagating EEG would accompany neuronal soma and possible propagating EEG waves with axons.

The frequency of V_1 is represented as a period of periodic multiplicative modulation of the V_0. J itself is not periodic. There is however a periodicity with a period $T = n/f$, where f is frequency of V_1 for $f_J = mf/n$. There are two interesting limits. For $f_J^1 = 2eV_1/2\pi\hbar \gg f_J$ amplitude V_1 is represented as frequency since in reasonable approximation frequencies $f_\pm = f_J \pm f_J^1$ dominate. Second limit corresponds to $f_J^1 \ll f_J$. In this case the dominating frequencies are $f_\pm = f_J \pm f$.

Josephson frequency would define a kind of drum beat whereas the frequencies associated with V_1 would represent the rest of the music. Josephson frequency $f_J = Q_{eff}eV/2\pi\hbar$ indeed turns out to belong to the scaled up variant of delta band of EEG and thus defines the analog of drum beat and corresponds to a resonance frequency in delta band for the scaled up variants of EEG. Josephson frequency defines a candidate for the time unit in which the time scale of memories and intentional action of the living system are measured.

The coherent photon state generated by J defines representation of evoked potentials V_1 as a generalized EEG and biological representations result when the photons interact with the living matter. At the level of magnetic body the Josephson photons induce cyclotron transitions and in this manner communicate generalized sensory input to the magnetic body.

Thermodynamical considerations

Josephson energy does not depend on the level of dark matter hierarchy and is thus above thermal energy. If the membrane is almost vacuum extremal, Josephson energy corresponds to that for a visible or UV photon so that the Josephson photons are well above the thermal energy. The identification of EEG and biophotons as decay products of large $\hbar$ Josephson photons is possible.

One must consider the possibility that the cell membrane can be also in far from vacuum extremal phase with very small Z^0 field. From the resting potential whose nominal value is often taken to be for .08 V, f_J corresponds roughly to the energy .16 eV roughly twice the energy allowed by thermal stability. Thermal stability of drum beat would allow 140 °C temperature. The growth temperatures of thermophilic bacteria can be even higher than 100 °C.

Nerve pulse is generated when the potential drops to .055 eV: the corresponding Josephson energy for far from vacuum extremal Josephson junction is .01 eV, which is above thermal threshold for $T \leq 70$ C. For organisms possessing no nervous systems, in particular bacteria, this constraint is not relevant. The energy $E = .1$ eV is twice the energy $E = .05$ eV, which is a universal transition energy of Cooper pairs of high T_c electronic super conductor [29]. The generation of nerve pulse might involve these transitions. They might also accompany the transition of the cell from a resting state to active state, which involves folding of the parts of straight unfolded parts of proteins and partial melting of globular proteins due to the melting of ordered water surrounding them.

6.3.2 Basic contributions to EEG

The following general overview about quantum communication and control emerges in this framework.

There are three contributions to EEG besides the contributions due to the neural noise and evoked potentials. These contributions correspond to Schumann frequencies, cyclotron frequencies f_c of biologically important ions and Josephson frequences f_J.

1. Schumann resonances do not depend on magnetic field strengths assignable with the magnetic flux sheets and would characterize Earth's magnetic field and collective aspects of consciousness. According to the model for sensory receptor and magnetic body [26, 18] the inner rotating part of the Earth's magnetosphere could correspond to the third person aspect of sensory perception whereas the personal magnetic body would be anchored to body and move with it. Both inner and outer magnetosphere (which does not rotate with Earth) could receive sensory input from biosphere.

2. Cyclotron frequencies correspond to magnetic field $B_{end} = .2$ Gauss for the ordinary value of Planck constant and its $1/\hbar$ scaled down counterparts. For cyclotron frequencies the extremals are assumed to be far from vacuum extremals carrying very small classical Z^0 fields but nonvanishing classical W fields and color fields (with $U(1)$ holonomy). The corresponding flux quanta would naturally correspond to flux sheets traversing through DNA strands while

3. Josephson frequencies f_J associated with Josephson junctions assigned with cell membranes. Almost vacuum extremals are assumed. If Josephson radiation modulates cyclotron radiation, also the frequencies $mf_J \pm nf_c$ appear in the spectrum.

   (a) Bio-photons and EEG can be seen as manifestations of one and same thing: Josephson radiation with a large value of Planck constant with energies of biophotons and frequencies of EEG. Ordinary EEG photons result when dark visible photon decays into a bunch of ordinary ELF photons and biophotons result when dark photon transforms to ordinary visible photon. Josephson radiation would propagate along flux tubes parallel to the cell membrane.

(b) Josephson frequencies can be said to code for qualia if the Josephson radiation is guided along magnetic flux tubes to a part of magnetic body specific to a given sensory receptor (or even neuron or cell in the case of cell level qualia). According to the model of sensory receptor [18, 26] they do not however directly induce the sensory quale, which would be characterized by the net quantum numbers of quark pair (or two of them depending on the model). Josephson radiation can also regenerate the sensory quale along neural pathway. Therefore the original vision about spectroscopy of consciousness is realized in a limited sense. This implies that the precise value of the membrane resting potential could characterize both the parts of the organism and state of consciousness in the case of cortical neurons (say alertness) since depending on the value of membrane potential the neuron is in wake-up state or "sleeps". The value of the membrane potential would also directly correlate with the analog of EEG assignable to the body part. The fact that neuron types correspond to different membrane potentials conforms with this picture and suggest that they also correspond to different magnetic bodies with different field strengths.

4. Far from biological body one expects both kinds of flux quanta to fuse to form larger quanta so that one has parallel space-time sheets carrying cyclotron *resp.* Josephson radiation. Wormhole contacts between Josephson and cyclotron flux sheets would induce a non-linear interaction giving rise to a superposition of harmonics of Josephson and cyclotron frequencies. One cannot exclude the possibility that cell membrane space-time sheets can be far from vacuum extremals and the fact that membrane potential defines Josephson energy slightly above thermal energy at room temperature might relate to this.

How these two kinds of radiations relate to the communication between magnetic and biological body and to the control of biological body by magnetic body is not quite clear.

1. One of the basic functions of the cell membrane is to monitor 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. Receptor proteins would communicate cell level sensory input to the magnetic body via MEs parallel to magnetic flux tubes connecting them to the magnetic body. Josephson frequencies would code various fundamental qualia assignable to DNA nucleotide-lipid pairs so that a sensory map defined by the cell membrane would be communicated to the magnetic body.

2. A good guess is that cyclotron frequencies are assignable to the magnetic flux sheets going through DNA strands responsible for quantum control via gene expression. This guess might be too naive. Josephson radiation would induce transitions between cyclotron states and generate in this manner sensory representations at magnetic body so that both frequencies would be involved with sensory representations. Furthermore, the identification of motor action as a time reversal of sensory perception allwed by zero energy ontology would mean that the mechanisms of sensory perception are at work for negative energies (phase conjugate radiation). Resonance is achieved if the condition $mf_J = nf_c$ is satisfied. For small values of integers m and n the condition is quite restrictive. Schumann frequencies can be assigned with the magnetic body of Earth and would correlate with the collective aspects of consciousness.

3. The model of hearing forces to assume quite a wide spectrum of Planck constants- at least the values coming as powers of two and the safest assumption is that at least integer multiples of the ordinary Planck constant are possible. Josephson radiation and cyclotron radiation have same scale if $B_{end} \propto 1/\hbar$ proportionality holds true. Note that for 5 Hz Josephson frequency the estimate for $\hbar$ in the case of 2 eV Josephson photon is $r \simeq 3 \times 2^{47}$.

This picture could explain why the temperature of brain must be in the narrow range 36-37 C to guarantee optimal functionality of the organism- one of the fundamental mysteries related to living matter.

1. Near vacuum extremal property might be possible only above some critical temperature -say 36 C- and the cyclotron condensates could exist only below some critical temperature -say 37 C. This would leave only a narrow temperature range in which both frequencies could be present.

2. There are two interpretations depending on whether one believes that Josephson and cyclotron frequencies can be assigned to sensory communication and motor control respectively or not. The believer would say that below this temperature range the value of f_J is reduced dramatically and magnetic body becomes blind whereas above this temperature range cyclotron condensates disappear and magnetic body becomes lame. This is excellent rhetoric but is not a correct statement if one believes that both cyclotron and Josephson frequencies are needed for sensory communications. If motor action corresponds to the time reversal of the sensory perception (as Libet's findings suggest) magnetic body magnetic body cannot anymore receive sensory information nor perform motor control since both frequencies are needed for this purpose.

Far from critical vacuum extremals allow also classical W fields and gluon fields and they might be relevant for the quantum control via DNA flux sheets.

1. In the length scales below the weak length scale L_w also charged dark weak bosons behave as massless particles and the exchange of virtual W bosons makes possible a nonlocal charge transfer. For instance, for $\hbar \sim 2^{89}$ W bosons behave like massless particles below the length scale 10^{-4} m and classical W fields and the exchange of W bosons might make possible charge entanglement. The hypothesis that Mersenne primes and Gaussian Mersennes correspond to a hierarchy of exotic weak physics leads to a highly unique vision for how life has evolved. In this model weak interactions play a key role in even macroscopic length scales.

2. Dark quark-antiquark pairs associated with the color bonds of the atomic nuclei could become charged via the emission of dark W boson and thus produce and exotic ion. The same can happen at the higher levels of dark matter hierarchy. This provides a nonlocal quantal mechanism inducing or changing electromagnetic polarization in turn inducing ordinary charge flows and thus making possible quantum control. Long range charge entanglement could be understood also in terms of classical W fields. Same applies to color entanglement which could be crucial element of topological quantum computation.

3. Massless extremals (MEs, topological light rays)- or actually pairs of them- serve as classical correlates for bosons which are identified as wormhole contacts connecting MEs. The interpretation of the charged MEs has remained open hitherto. Charged W MEs (hierarchy of WEGs!) could induce long length scale charge entanglement of Bose-Einstein condensates by inducing exotic ionization of ionic nuclei. State function reduction could lead to a state containing a Bose-Einstein condensate in exotically ionized state.

   In this manner the dark charge inside neuron and thus by Faraday's law also membrane potential could be affected by magnetic body. The generation of nerve pulse could rely on the reduction of the resting potential below the critical value by this kind of mechanism inducing charge transfer between cell interior and exterior. The mechanism might apply even in the scale of magnetic body and make possible the control of central nervous system. Also remote mental interactions, in particular telekinesis, might rely on this mechanism.

To sum up, 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.

6.3.3 Classification of cyclotron frequencies

Consider now the classification of cyclotron frequencies ($B_{end} = .2$ Gauss will be assumed).

1. Cyclotron frequencies can be classified those associated with atomic and molecular ions. For biologically important atomic ions most frequencies are above 7.5 Hz. For molecular ions frequencies are lower and for DNA sequences the frequencies are in delta band. Thermal stability condition suggest a lower bound of ~ 1 Hz for significant frequencies of this kind. Thus it would seem that delta band dominating during deep sleep corresponds to DNA and possibly other bio-molecules and EEG during wake-up state corresponds to atomic ions.

2. Atomic ions can be classified into bosonic and fermionic ions. Practically all biologically important bosonic ions have $Z = 2$ and in alpha band: $f(^6Li^+) = 50$ Hz and $f(Mg^{2+}) = 25$ Hz are the only frequencies above alpha band. Situation is essentially the same for biologically interesting ions too. $^7Li^+$ is exception and corresponds to 42.9 Hz: as a fermionic ion it does not possess satellites and does not contribute to Josephson part of EEG. Thus the frequency range $7.5 - 15$ Hz is very strongly represented and expected to be fundamental.

3. The integer n characterizing the harmonics of the cyclotron frequency is an additional classificational criterion and n could correlate with the character of neural processing. The harmonics of Josephson frequency are present in Josephson radiation and and induce resonant cyclotron transitions with arbitrary high values of n if the ratio of Josephson frequency and cyclotron frequency is rational number. Note that the sensory representations at magnetic body are generated only at at critical values of the membrane potential. In case of hearing the values of n would characterize the harmonics of the fundamental and determine the character of the pitch.

4. Also the position in the periodic table of elements provides a classificational criterion (see Appendix) but this criterion does not seem to be so useful as thought originally.

6.3.4 Wake-up EEG

The question is whether this classification is consistent with the conventional decomposition into various bands and whether it allows to gain some real insights EEG. Consider first wake-up EEG [46].

1. The first implication is that each cyclotron frequency f_c is accompanied by by two satellites $f_c \pm f_J$ (of course, all harmonics $mf_c \pm nf_J$ are present but one expects that the lowest harmonics are the most important ones). For alpha band these satellites correspond to theta band and beta band identifiable as responses to control signals from magnetic body in alpha band. One can ask whether these bands as a whole correspond to the satellites of alpha band. This identification implies that both bands are present and makes sense for wake-up EEG but not as such for the EEG during first and second stage of sleep during which theta band is present but higher bands are absent.

2. Sensorimotor rhythm in range (12-16) Hz is associated with physical stillness and body presence. The interpretation is as a low amplitude satellite of alpha rhythm with low amplitude control signals from the magnetic body so that rhythmicity is not lost and frequencies are clearly $f_c + f_J$.

3. Beta band is above 12 Hz and associated with active, busy or anxious thinking and active concentration and is chaotic and highly asynchronous. The natural interpretation is as large amplitude satellite of alpha band involving the activation of communications to the magnetic body and large control signals with $f_J^1 \gg f_c$. Hence the spectra would for a considerable part of period $1/f_c$ effectively consist of frequencies $f_\pm = f_J \pm f_J^1$, where f_J^1 varies in frequency range characterized by the amplitude of perturbation. There is no definite resonance frequency since ω_1^J can vary continuously. Globally the situation is different since the spectrum can in principle be decomposed to frequencies $f_J \pm nf_c$. These two descriptions correspond to time domain and genuine frequency domain.

   For sufficiently high harmonics of f_c the chaoticity disappears and frequencies $f_J \pm nf_c$ become more manifest. The Josephson amplitudes of higher harmonics decrease as $1/nf_c$.

   Beta band is predicted to have a mirror image in theta band during cognitive activity. The frequencies in theta band are assigned with cognitive activities and memory recall. Note that also alpha band due to cyclotron frequencies should be present as well as the basic "drum beat" defined by f_J for $f_J^1 \gg fc$.

4. Odd higher harmonics of cyclotron frequency are expected to be the most important ones and would have interpretation as control signals from magnetic body. Satellites would correspond to responses to magnetic body involving entire 160 km thick Josephson junction but certainly correlating strongly with what happens in brain (recall the analog of biological body with a receptor at cell membrane).

For alpha band the third harmonics of most bosonic ions are in the range 28.2-34.2 Hz and roughly in gamma band above 30 Hz assignable with the control of cognitive activities from a flux quantum of Earth's magnetic field.

Fifth harmonics would bein the range 37.5-57 Hz. The fermionic ion Na^+ would correspond to 65 Hz. During REM sleep EEG very similar to awake but 65 Hz resonance is present. One can ask whether fifth harmonics are present during REM sleep and serve as correlates for conscious visual imagery.

5. 40 Hz thalamocortical resonance band is very important EEG band. The upper satellite of the third harmonic of Mn^{2+} is 37.9 Hz. The third harmonics of fermionic ions $^7Li^+$ and Na^+ correspond to 42.9 Hz and 39 Hz (Schumann resonance) and have no satellites as fermionic ions.

6.3.5 Satellites exist as mirror pairs

The existence of the mirror satellites might be regarded as a killer prediction. Amazingly, narrow EEG bands which are mirror images of each other with respect to alpha band have been reported [44]. Besides alpha band at 11 Hz, Nunez mentions also narrow sub-bands at 3, 5 and 7 Hz at delta and theta range, as well as the bands at 13, 15 and 17 Hz in beta band [44]. All these frequencies are expressible in the form $f_c \pm f_J$, $f_J = 5$ Hz, which is one half of the frequency 10 Hz of the memetic code.

The cyclotron frequencies associated with the bands are 8, 10, and 12 Hz. The cyclotron frequencies of bosonic ions $^{80}Se^{2-}$, $^{64}Zn^{2+}$, and $^{55}Mn^{2+}$ for a magnetic field strength $B_{end} = .2$ Gauss are 8.00, 9.90, and 12.00 Hz. The cyclotron frequencies of bosonic ions $^{59}Co^{2+}$ and $^{56}Fe^{2+}$ would be 10.52 Hz and 11.36 Hz and the satellites are at frequencies 5.52 Hz and 6.36 Hz and 15.52 and 16.36 Hz. All these frequencies belong to the bands reported by Nunez since their widths are 1-2 Hz. Thus the frequencies of all bosonic ions in alpha band and in their satellites belong to the bands reported by Nunez for values of f_J and B_{end} very near to their nominal values used in calculations!

With these assumptions the frequencies $3f_c(Mn^{2+}) \pm f_J$ are 40.97 Hz and 30.97 Hz corresponding to 40 Hz band and the threshold of gamma band. That $f_c(O^{2-}) = 39.6$ Hz is also in this band suggests additional reason for why oxygen is so important for consciousness. $f_c(Mg^{2+}) = 26.3$ Hz is very near to Schumann resonance 26 Hz and its upper satellite corresponds to the threshold of gamma band.

What is also very remarkable that the 10 Hz magic frequency of the memetic code corresponding to the secondary p-adic length scale $L(2,127)$ associated with Mersenne prime M_{127} characterizing electron and emerging as the basic prediction of the zero energy ontology appears. It should be also noticed that $f_J = 5$ Hz frequency corresponds to cognitive theta appearing during tasks requiring mathematical skills. Note that the scaling of ordinary value of $\hbar$ by a factor of 2 scales 10 Hz frqeuency to 5 Hz.

6.3.6 Alpha band dominance during relaxed state

In a relaxed state beta band disappears and the spectral power in alpha band increases. This seems to be in conflict with the idea that beta band is a mere satellite. It might be that the cyclotron frequencies in alpha band are not actually present and only Schumann frequency 7.8 Hz and 10 Hz resonance frequency associated with the excitations of electric field in ionospheric cavity behaving like 2-dimensional waves on sphere. Also the 10 Hz frequency assignable to electron's CD could be involved.

This kind of situation would result if the transition to the relaxed state corresponds to a phase transition $\hbar \rightarrow 2\hbar$ reducing Josephson frequencies by factor 1/2.

1. If the phase transition takes place also for magnetic flux quanta implying the reduction of the magnetic field strength by factor 1/2. This would be allowed by the generalized flux quantization conditions: the intensities of the em currents at the boundaries of flux quanta would be scaled down by factor 1/2. The phase transitions changing the value of $\hbar$ indeed play a key role in TGD inspired model of bio-catalysis. For instance, a phase transition reducing the value of $\hbar$ for a flux tube connecting biomolecules can force them near to each other so that two biomolecules can find each other in the dense soup of biomolecules. One might argue that the conservation of magnetic flux for flux quanta does not allow this transition to take place.

2. If the transition does not occur for magnetic flux quanta responsible for cyclotron frequencies only even harmonics of Josephson frequency can induce cyclotron transitions resonantly. This would be reflected as a reduced contribution of the sensory input and motor action to conscious experience.

6.3.7 EEG during sleep

The EEG during sleep [64, 68] provides a testing ground for the proposed anatomy of EEG. Sleep consists of 90 + 90 minute periods of NREM and REM sleep. This period is also the period of brain hemisphere dominances during wake up and day dreaming occurs with the same period as REM sleep. During REM sleep the EEG is essentially similar to that during wake-up. These observations inspire the hunch that brain hemisphere dominance dictates whether REM or NREM is in question.

The scalings of $\hbar$ to $2\hbar$ and $4\hbar$ seem to explain basic characteristics of these states but it is not completely clear whether the phase transitions occur for both cell membrane space-time sheets and flux quanta or only for the first ones.

EEG during stage 1

During stage 1 of deep sleep [64] theta waves in frequency range 4-8 Hz dominate and amplitudes increase when frequency is reduced. The control signals from magnetic body are expected to be weak so that $f_J^1 < f_J$ approximation should hold true implying that frequencies $f_J \pm f_c$ should dominate and EEG would look rhythmic rather than chaotic as indeed observed. The amplitudes behave as $1/f_c$ and thus increase with decreasing f_c. The fact that the amplitudes increase with decreasing EEG frequency suggests that the frequencies they correspond to different cyclotron frequencies.

These facts do not conform with the general picture as such. If theta and beta bands are mere satellites of alpha band, both of them should be present during stage 1 sleep but this is not the case. The idea that cyclotron frequencies of heavier ions in $B_{end} = .2$ Gauss could replace those appearing during wake-up does not work. Theta band simply does not contain the cyclotron frequencies of biologically important ions for $B_{end} = .2$ Gauss.

The simplest way out of difficulty is that the value of Planck constant associated with the flux sheets and Josephson junctions increases by factor 2 so that the situation could be basically the same as in the case of relaxed state. The only difference would be that the transition is more complete during stage 1 sleep. For instance, during relaxed state only parts of hemispheres or might perform the transition. If the value of Planck constant is permanently 2 times larger for the right hemisphere or parts of it, the interpretation would be in terms of right hemisphere dominance.

The most important range 7.5-15 Hz of cyclotron frequencies would be scaled down to 3.75-7.5 Hz which indeed corresponds to the theta band. If one excludes Ca^{2+}, the range for bosonic ion reduces from $7.5 - 11.4$ to $3.75 - 5.7$ Hz. The satellites correspond to the range $.05 - 8.7$ Hz and $7.45 - 9.4$ Hz plus Ca^{2+} satellites at 3.8 Hz and 11.2 Hz. With Ca^{2+} forming a possible exception, the resulting frequency ranges are consistent with empirical facts. Of course, it is quite possible that magnetic body does not generate cyclotron transitions at Ca^{++} cyclotron frequency.

One must consider two options.

1. If both magnetic cyclotron and Josephson frequencies are scaled down, the communication-control loop between magnetic and biological body remains intact. This might be necessary for the survival. This raises the question whether sleep actually means a loss of consciousness. Could it be that only the character of consciousness is changed? Since the magnetic body moves to a different page of the Big Book, one could argue that consciousness is not lost but that it is difficult to remember anything about this period during wake-up period since the negative energy signals responsible for memory recall should leak to another page of Big Book and this process could take place with a low rate. The mental images appearing just at the border of falling asleep could give a glimpse about the character of conscious experience in this.

2. The phase transition changing Planck constant could take place for shell membrane space-time sheets only so that only Josephson frequencies would be scaled down. For flux sheets traversing through DNA the value of Planck constant would not be changed. In this case resonance conditions satisfied in wake-up state would be satisfied for the even harmonics of Josephson

frequencies during stage 1 of sleep. Therefore one expect that the sensory-motor loop involving magnetic body would not be so active in the relaxed state and in the first stage of sleep.

EEG during stage 2

Sleep spindles appearing in the state 2 of deep sleep are sudden increases in EEG amplitude and frequency from theta band to 12-16 Hz [66]. The spindles .5-.1.5 seconds and appear with a period of about minute. In some sources frequency range 7-16 Hz is given as sleeping spindle range. The so called K-complexes are sudden increases in EEG amplitude but no change in frequency.

One interpretation is that sleep spindles correspond to the occasional wake-ups of the left hemisphere or part of it via the phase transition $\hbar \rightarrow \hbar/2$. Sleep spindles would thus correspond to the satellites of alpha band identifiable as responses of the corresponding Josephson junctions to occasional strong control signals at cyclotron frequencies in alpha band. K complexes could be interpreted as signals from magnetic body to left hemisphere but inducing no response. It might be that these sudden responses reflect the fact that the left brain is not fully asleep yet.

EEG during stages 3 and 4

Most of EEG power during deep sleep stages 3 and 4 is in the range .75-4.5 Hz [64]. The most straightforward interpretation is in terms of the scaling $\hbar \rightarrow 4\hbar$ so that alpha band would correspond to 2.5 Hz and beta frequency 15 Hz to 3.75 Hz.

Again one has two options corresponding to the scaling of $\hbar$ for all flux quanta and only for the cell membrane space-time sheets.

1. For the first option consciousness need not be lost during these phases of sleep if the above argument makes sense. The experiences just at the border of wake-up could give an idea about what this kind of consciousness is.

2. For the second option DNA cyclotron transitions could be important during deep sleep and it might be even possible to speak about DNA consciousness. For phosphorylated DNA sequences with charge of 2 units per single base-pair one would have $A \geq 300$. More precisely, the atomic weights for base pairs plus phosphate group and deoxyribose sugar are $327, 321, 291, 344$ corresponding to A, T, C, G. From the fact that proton's cyclotron frequency for $B_{end} = .2$ Gauss is 300 Hz one obtains that DNA cyclotron frequency is 1 Hz in good approximation. This would suggest that during deep sleep DNA cyclotron transitions are induced by Josephson frequencies and that DNA defines the sensory perceiver.

6.4 The effects of ELF fields on brain and high T_c ionic super conductivity

The article 'Spin the tale on the dragon' by David Jarron [79] gives excellent popular review about the history of the bio-electromagnetic research and about the frequencies for which electromagnetic fields have special effects on living matter and brain. The material from this article led to the realization of how brain manages to be a macroscopic quantum system in TGD Universe. A more technical view about the effects can be found from review articles of Adey and Blackman [87, 80]. The online review article of Cherry [84] provides a good technical representation about various effects of weak ELF em fields and ELF modulated radiofrequency em fields on brain and an extensive list of references.

6.4.1 Summary about effects of ELF em fields on brain

The work by pioneers of bio-electromagnetism (Wertheimer, Milham, Marino, Becker, Adey, Blackman and many others) which began already at sixties led to amazing discoveries about ELF fields on brain. The article of Blackman [80] provides a detailed summary of these developments. The results of the work of Bawin, Adey, Blackman and others can be summarized by saying that radio frequency em fields amplitude modulated by ELF frequencies affect in certain frequency and amplitude windows brain tissue [90, 81, 83]. The function of the radio frequency carrier wave is to facilitate the penetration of em field into tissue and its frequency is not essential for the occurrence of the effect. Presumably nonlinear effects give rise to a secondary wave with modulation frequency which is the primary source of effects.

Basic effects

The effects of ELF em fields on brain include chemical, physiological and behavioral changes within windows in frequency and field intensity. It is essential that the effects have been observed only in vertebrates which thus possess EEG. A good summary is the online review article of Cherry [84].

The well documented and established non-thermal biological effects of EMR include significant alteration of cellular calcium ion homeostasis, reduction of melatonin, and the detection of Schumann Resonances by human and avian brains. A key effect is change in Ca^{2+} homeostasis: Ca^{2+} it is involved with both pre- and postsynaptic steps of nerve pulse transmission and also with intracellular communication. For instance, Ca^{2+} is involved with gene expression, the development and plasticity of nervous system, modulation of synaptic strengths, and with $Ca^{2+} - c$AMP signal transduction process.

Change in Ca^{2+} homeostasis has harmful effects in central nervous system, endocrine system and immune system. At the level of CNS this means changes of reaction time and behavioral alternations. At the level of neuro-endocrine system a good example is the reduction of the melatonin production in pineal gland having wide variety of harmful effects since melatonin serves as effective scavenger of free radicals: among the effects are DNA strand breakage, chromosome aberrations and problems with gap junction communications. Melatonin is also crucial for healthy sleep and for the reduction of cholesterol and blood pressure. In case of immune system an example is provided by the change of functioning of lymphosytes in turn reducing the competence of immune system making the subject more vulnerable to allergens, toxins and viruses.

Amplitude windows

There are several amplitude windows but here only the main amplitude windows will be discussed. For the first window ELF em fields have values of electric field in tissue around 10^{-7} V/m. The effects are high level effects and associated with navigation and prey detection in marine vertebrates and with the control of human biological rhythms. For ELF modulated radio frequency fields (RF) and microwaves (MW) the intensities are around $1-10$ V/m. In this case the effects are neurophysiological effects are lower level effects at the level of the brain tissue. In case of brain tissue maximal sensitivity to electromagnetic fields occurs between 6 and 20 Hz.

In order to get grasp about orders of magnitude, it is good to notice that on some experiments cell membrane electric field has a strength about 10^7 V/m whereas EEG electric fields in the range $5-10$ V/m. The fact that the second intensity window corresponds to $1-10$ V/m suggests that the em field simulates the em field associated with EEG: a valuable guideline in attempts to understand what is involved. For Schumann resonances electric field is of order .6 mV/m. For sferics (em perturbations associated with lightnings) magnetic field strength is not above nTesla: this corresponds to electric field strength 10 V/m associated also with EEG waves [39]. Field strength of V/m corresponds roughly to energy flux $\mu W/m^2$.

The presence of windows and weak intensities implies that the effects cannot be thermal. A good metaphor is the effect of radio noise on radio receiver: it occurs at definite frequency and destroys the information content of the original transmission.

The effects occur at harmonics of cyclotron resonance frequencies

Blackman also discovered that odd multiples 15, 45, 75, 105... of 15 Hz had much stronger effect on tissue than even multiples 30, 60, 90... Hz and realized a possible role of Earth's magnetic field [82]: it must be however emphasized that the value of magnetic field in question is $B_{end} = .2$ Gauss and smaller than $B_E = .5$ Gauss. A possible interpretation is that harmonics of cyclotron frequencies might be the information carrying frequencies in EEG.

In response to the results and speculations of Blackman, Liboff formulated ionic cyclotron resonance (ICR) model [85] based on the realization that the frequencies in question correspond to multiples of the cyclotron frequencies of Ca^{2+} ion in a magnetic field $B_{end} = .2$ Gauss. This model was classical. Later Blanchard and Blackman proposed so called ionic parametric resonance model (IPR) [88]. This phenomenological model combines ICR model with ideas about atomic physics.

There are several objections against ICR model; classical orbits of ions in Earth's magnetic field have radius of order meters; dissipative effects and Brownian forces do not allow cyclotron orbits; charge-to mass ratios appearing in cyclotron frequencies correspond to vacuum rather than water environment characterized by a large value of dielectric constant; it is difficult to understand why odd multiples of cyclotron frequencies give rise to stronger effects [80]. Some of these objections apply also to IPR model.

The pattern of data seems to suggest that the interaction occurs at quantum level. This is in dramatic conflict with the predictions of the standard quantum theory and with the standard view about space-time.

Are quantal effects in question?

The conclusion that the effect of ELF fields on brain represents quantum effects associated with the transitions of ions confined in magnetic field having same strength as Earth's magnetic field, is supported by the following observations.

1. The frequencies $15, 30, 45, 60, 75$ Hz having effect on primates are multiples of the same basic frequency $f = 15$ Hz, which turns out to be the cyclotron frequency of Ca^{2+} ion in magnetic field $B_{end} = .2$ Gauss. That these frequencies come in multiples is a direct signature of quantum: in classical world only basic frequency $f = 15$ Hz should have effects (forcing ions to rotational motion around field lines with this frequency.

2. Even multiples of 15 Hz have a weak but non-vanishing effect. Transitions are not possible at all in the lowest order of perturbation theory since the interaction Hamiltonian describing the transitions in question has non-vanishing matrix elements only between states of opposite parities in the dipole approximation applying when the wavelength of the radiation is much larger than the size of the radiating system [39]. Odd and even values of n for cyclotron states have opposite parities so that Δn odd rule results. In higher orders of perturbation theory also transitions for which transition frequency is even multiple of the cyclotron frequency are possible. This observation provides additional strong support for the hypothesis that quantum transitions are involved.

There are however also objections.

1. The cyclotron energy scale is about 10^{-14} eV and ridiculously small as compared to the energy scale .086 eV defined by room temperature so that quantal effects should be masked completely by thermal noise.

2. Also ELF em fields at spin flip frequencies (Larmor frequencies) should induce transitions. To my best knowledge these have not been reported.

3. The wave functions of ions in magnetic field are confined in a region of size of order

   $$r_n \sim \sqrt{2n/eB} \ ,$$

   which is of the order of cell size: macroscopic quantum state is in question. In fact, the value $.5 \times 10^{-4}$ Tesla for Earth's magnetic fields corresponds to the p-adic length scale $L(169) = 5$ μm rather precisely for minimal value of the magnetic flux quantized as $ZeBS = n2\pi$ obtained for $n = 1$ (S denotes the area of the flux tube) and $Z = 2$. If one requires quantum classical correspondence, very large values of n are required and cyclotron radii would be much larger than flux tube radius.

A common resolution of all these objections is provided by large $\hbar$ phases and hierarchy of magnetic flux sheets with B scaling like $1/\hbar$ meaning that cyclotron frequencies scale down similarly and cyclotron energies remain invariant. Same applies to spin flip energies scaling in the same manner as cyclotron energies (for some time I thought that the scaling behaviors are different). By the quantization of the magnetic flux, predicted by TGD also classically, the minimal radius of the magnetic flux tube for the magnetic field of Earth of cell size for ordinary value of $\hbar$ but scales like $\hbar$ if magnetic field remains invariant and flux quantization $BS = n2\pi\hbar$ implying $S \propto \hbar$ holds true. This implies consistency with classical theory for large values of $\hbar$.

6.4.2 A brief summary of the model explaining cyclotron frequencies

Some work is required to end up with the following interpretation based on a model for how the different levels of dark matter hierarchy communicate and control. This model already discussed at the general level relies on resonant cyclotron transitions induced by Josephson radiation from cell membrane Josephson junctions, which are almost vacuum extremals.

1. Ions with charge Z, mass m and spin S in the external magnetic field behave quantum mechanically like harmonic oscillator with energies quantized as

$$E = E_c + E_L \ , \quad E_c = (n+\frac{1}{2})\hbar\omega_c \ , \quad E_L = S_z\frac{g\omega_c}{2} \ , \quad \omega_c = \frac{ZeB}{m} \ \ (c=1) \ . \tag{6.4.1}$$

   The first contribution corresponds to cyclotron contribution. For a given value of n the component of angular momentum in the direction of B has $n+1$ values $n, n-2, ..., -n$. E_L denotes spin (Larmor) contribution. g is so called Lande factor which for free elementary fermions equals to $g = 2$. Since S_z is invariant under the scalings of $\hbar$, Larmor contribution is negligible as compared to cyclotron contribution for large values of $\hbar$. The contribution to energy coming from the free motion in the direction of magnetic field has not been written.

2. Experimental findings suggests strongly that external em field induces resonant transitions between cyclotron states: these transitions are identified as transitions inside the cell/nucleus or its fractally scaled up variant. Cyclotron radiation can drive charged particles to smaller space-time sheets and this is essential for the metabolism and this process is expected to be part of the interaction of ELF em fields with cell nucleus. This in turn induces a response of magnetic body affecting the state of brain.

3. Dark matter hierarchy leads to the hypothesis that there is entire hierarchy of EEGs generated as coherent photon states by Josephson currents associated with the Josephson junctions whose thickness scales as $\hbar$ and frequency scales as $1/\hbar$ so that cyclotron energy remains invariant and is above the thermal threshold. For each value of $\hbar$ there is also p-adic hierarchy corresponding to $k = 151, ..., 169$ with same Josephson frequency: these levels combine to form single block for dark matter hierarchy formed from the scaled up variants of this block. At least the magnetic flux tube structure of DNA and membrane structure appear as scaled up copies. The lowest level corresponds to cellular or nuclear membrane and ordinary value of $\hbar$.

6.4.3 Interpretation of the temperature window

The effects of ELF em fields on matter have been observed only in a temperature window 36-37 C around body temperature. I have already proposed that this interval is due to competition of two effects.

1. High T_c super-conductivity and cyclotron condensates are possible below 37 C whereas near vacuum extremal property is possible above 36 C so that only a narrow temperature range remains making possible communications and control of the biological body by magnetic body.

2. Also the model of high T_c super-conductivity as a quantum critical phenomenon predicts that there is a narrow interval around T_c around which two competing phases corresponding to ordinary value and scaled up value of $\hbar$ compete.

More generally, dark matter hierarchy should correspond to a hierarchy of quantum criticalities. A fractal hierarchy of cusp catastrophes such that the next cusp is inside the critical line of the previous cusp would be a convenient manner to visualize the situation. Each big leap in the evolution corresponds to the emergence of a new level in the dark matter hierarchy made possible by the external conditions allowing co-presence and competition of phases corresponding to different Planck constants.

Quantum critical high T_c super-conductivity for electrons and protons (at least) is the essential prerequisite for the existence of Josephson currents through the cell membrane and its scaled up variants, and thus the hierarchy of generalized EEGs. Electronic super-conductivity is expected to be possible in a very limited temperature range usually idealized with single critical temperature.

Quantum critical phase is analogous spin glass phase possible in a finite interval around critical temperature, and one can indeed speak of quantum spin glass phase for which the analogs of regions with fixed direction of magnetization are 4-dimensional rather than 3-dimensional and static. This relates to the breaking of the strict classical determinism of the basic variational principle of TGD having interpretation in terms of space-time correlate for quantum non-determinism in long time and length scales. Quantum coherence and quantum nondeterminism in long scales is obviously what makes system living. An educated guess is that the critical range of temperatures allowing quantum criticality and high T_c super-conductivity is just 36-37 C: this in turn implies that the effects of ELF em fields occur only in this temperature range.

6.4.4 How could one understand the amplitude windows?

The following arguments relate to an attemp to understand the mysterious looking amplitude windows for electric field in terms of the new physics provided by zero energy ontology and causal diamonds, hierarchy of Planck constants, and cyclotron frequencies of electron and quarks and Z^0 cyclotron frequency of neutrino. I have considered the problem already earlier but these specilations do not survive in the new framework.

Can one take into account the complications due to modulation?

Before representing any arguments it must be emphasized that the actual signal is either ELF signal or ELF modulated signal -say microwave signal (frequency in the range is .3 GHz-300 GHz) modulated by cyclotron frequence. The effects are very similar in the two cases. The assumption is therefore that the eventual interaction of the tissue is with ELF frequency signal. This requires demodulation in the tissue. In the case of modulated signal one has to be careful with the experimental definitions of field amplitudes. It will be assumed that the reported amplitude windows correspond in the case of ELF modulated signals to the ELF amplitudes measured in the tissue after de-modulation.

Demodulation requires a highly non-linear mechanism leaving from the rapidly oscillating amplitude only the envelope. In TGD framework it is not difficult to imagine non-linear mechanisms since the dynamics of Kähler action is extremely non-linear. Massless extremals represent the most promising classical description for the radiation fields. In this case the time profile of the induced gauge field at given point is essentially arbitrary and one can easily imagine a process leading from ELF modulated field to a pure ELF field at given point. Energy conservation and effective 2-dimensionality of the signal (polarization direction and direction of 4-D wave vector) certainly puts bounds on the change of the amplitude and the simplest guess is that the amplitude squared for pure ELF corresponds to the average of the amplitude squared over the cycle of the carrier wave for the modulated radiation so that amplitude is reduced by $1/\sqrt{2}$ factor.

Amplitude windows from quantized form of Faraday law

In order to explain amplitude windows one must have a quantization condition for the amplitude of the electric field and one can indeed deduce this kind of condition as a kind of semiclassical quantization condition. The preferred extremal property and quantum holography due to General Coordinate Invariance indeed imply that space-time sheets are analogous to Bohr orbits.

What this means in the case of the amplitude windows is that the electric field satisfying the quantization condition is able to leak to a space-time sheet with a particular value of Planck constant so that the amplitude would serve as a kind of password allowing the radiation to access a particular page of the Big Book and resonantly interact with the cyclotron condensate at it and in this manner interfere the brain function or more general biological function. This mechanism is totally different from the mechanisms based on standard biochemistry. The following is a proposal for how to achieve this kind of quantization.

1. The idea is two use Maxwell's equations

$$\nabla \times E - \partial_t B = 0$$

in integral form

$$\oint_{\delta S} E \cdot dl = \partial_t \int_S B \cdot dS \ .$$

By integrating this with respect to time and using quantization of the magnetic flux one obtains

$$\int eE \cdot dldt = \Delta \int_S eB \cdot dS = n\hbar \ .$$

E is periodic radiation field with period defined by say Ca^{++} cyclotron frequency.

2. One must choose the integration contour suitably to get a non-trivial condition on field strength. Let the radiation describe plane wave in direction of z-axis. Choose the surface S a rectanble in the plane defined by the polarization ϵ and wave vector k. The loop integral for E gives only contributions from the ends of the rectangle corresponding to $z = 0$ and $z = h$. Select $h = \lambda/2$ so that the value of electric field is opposite at the ends. Select the width of the rectangle to be λ. This gives

$$\oint_{\delta S} E \cdot dl = Esin(\omega t)2\lambda \ .$$

3. By integrating from $t = 0$ to $t = \pi/\omega = 1/2f$ one obtains

$$\frac{2eE\lambda}{\omega} = n\hbar \ . \tag{6.4.2}$$

4. One can of course criticize the argument as ad hoc since the choice of the integration contour involves guesswork. First of all the amplitude has maximum value at $t = 0, z = 0$ and secondly the length of the contour at the ends is taken to be λ. These choices could be interpreted as physical constraints on the process in which the magnetic flux can change by a multiple of $\hbar$. The outcome is semiclassical quantization rule for the amplitude of the electric field. Second reason for criticism is that cyclotron frequency apears as a modulation frequency.

The amplitude window at $E = 10^{-7}$ V/m

Consider first the challenge of understanding the origin of the critical electric field $E = 10^{-7}$ V/m.

1. The above condition gives

$$\frac{eE\lambda}{\hbar\pi f(Ca^{++})} = n \ . \tag{6.4.3}$$

If one is able to fix the value of E to $E = 10^{-7}$ V/m for a given Ca^{++} cyclotron frequency and Planck constant then its value for other values of Planck constant follows by scaling: $E \rightarrow rE$ for $\hbar \rightarrow r\hbar$. The values $E = 1 - 10$ V/m could be justified if a further scaling of r by a factorin the range $10^7 - 10^8$ can be justified physically.

2. Assuming that $\hbar$ corresponds to 5 Hz Josephson frequency, the above condition gives the magnitude of the electric field as $eE = rnf^2(Ca^{++})/\pi c$. For $r = r_0 = 2^{47}$ corresponding to $V = 70$ mV membrane potential for almost vacuum extremal and 5 Hz Josephson frequency one obtains $eE = n \times 1.12 \times 10^{-7}$ eV/m. The result is encouraging. $V = 62.5$ mV would give $eE = n \times 10^{-7}$ eV/m. Even admitting the somewhat ad hoc character and details of the quantization argument, the result is highly non-trivial. Note that for r_0 electron Compton length corresponds to the p-adic length scale $k = 2 \times 87 = 174$ and to length scale 28 μm, a typical cell length scale.

The amplitude window at 1-10 V/m

One should understand also the amplitude window 1-10 V/m. The first point to notice is that the electric field strengths for EEG waves are in the range 5-10 V/m. This is probably not accident and could mean that the mechanism involved is different and that the above argument does not generalize to the recent situation. What comes in mind is that if phase conjugate waves are involved then a process which is reversal to sensory perception and communication of information to the magnetic body as Josephson radiation occurs. This process would lead to a generation of an oscillation of membrane voltage with cyclotron frequency. Amplitude window would correspond to an amplitude window for the oscillations of the membranepotential. Two weak amplitudes would have no effect and too strong amplitude would be eliminated since they would induce nerve pulse. Therefore amplitude window would eliminate undesired signals affecting the CNS and leave only those coming from the magnetic body.

As a first trial one can of course try to find whether the amplitude window could reduce to a range of preferred values of Planck constant obtained by scaling $r \simeq 2^{47}$ by a factor in the range $10^7 - 10^8$.

1. The Josephson currents associated with near vacuum extremals generate also Z^0 Josephson radiation within the Z^0 Compton length scaling as $\hbar$. For $r = 2^{47}$ the scaled up Compton length of Z^0 boson, which scales as $\sqrt{r}$, corresponds to $k = 89+47 = 136$, which is slightly below atomic length scale. The scaling of r by $10^8 \simeq 2^{27}$ gives $r_1 = 2^{47+27} = 2^{74}$ the p-adic length corresponds to $k = 89 + 47 + 27 = 163$, which corresponds to one of the Gaussian Mersennes expected to be important for living matter. The corresponding p-adic length scale is 640 nm, and as a wavelength in a good approximation corresponds to the 2 eV metabolic energy quantum. Recall that also the Josephson frequencies of biological ions are in the range [2,3] eV for the membrane potential of 50 mV corresponding to $r = 2^{47}$. The entire range $10^7 - 10^8$ would correspond to energy range 2-6.3 eV which could relate to the energy range assignable to bio-photons which for the entire range of membrane resting potentials corresponds to 1.6-5.3 eV. Note that $k = 164$ corresponds to the energy 1.4 eV. Maybe there is a story behind these co-incidences.

   Therefore the question is whether the preferred range of the values of the Planck constant in the range $10^{21} - 10^{22}$ relates to the fact that weak boson Compton lengths correspond to one of the four Gaussian Mersennes defining a biologically important length scale in this case? The reader can decide whether to take these co-incidences seriously. The vision about biological evolution and evolution of EEG lends strong support for the importance of Gaussian Mersennes.

2. One can also consider the cyclotron frequency of neutrino, which is for $m(\nu) = .1$ eV is about 3×10^{12} Hz. For $r = 10^7 - 10^8$ this frequency is reduced to $3 \times 10^4 - 3 \times 10^5$ Hz. This range contains the cyclotron frequencies of quarks. This would suggest that for the scaling of r is such that the cyclotron frequency for neutrinos becomes same as its value for electrons and classical Josephson frequencies can affect them simultaneously. More generally, the preferred scalings of Planck constants would be such that they would make possible resonant interaction between cyclotron condensates.

3. One can can also consider ordinary cyclotron frequences to see the scaling of r by a factor in the range $10^7 - 10^8$ could pop up naturally. The quantization condition for the electric flux in this caes requires that the value of $r = 2^{47}$ is scaled up by a factor $x = 10^7 - 10^8$ so that the Josephson period would be scaled to $x/f_J(r_0)$ giving time scale in the range 23.15-231.5 days. One should understand why this time cale is fundamental in living matter. In the case of electron the cyclotron period would be reduced to $16.7 - 167$ second range. For u quark the time scale would be between 66.7 -667 seconds. These time scales should have some clear identification as biologically important time scales before one can take them seriously.

4. Note that for $r = 2^{47} \times 10^8$ electron's Compton length becomes 28 cm, which corresponds to the size scale of brain (note that the effects of ELF radiation are found for vertebrates) and to the sound wave length corresponding to the magic kHz frequency in turn assignable to quark CD. One might hope that these observation might be completed to a logical story in which various length and time scales interact.

These amplitude windows are certainly not the only ones and the hierarchy of Planck constants indeed allows many of them. If one has identified preferred values of Planck constants it is possible to predict the amplitude windows for a given cyclotron frequency. For instance, the assumption that the dark p-adic length scales of some particles- say intermediate gauge bosons- correspond to the ordinary p-adic length scales assignable to Mersenne primes-both ordinary and Gaussian- leads to predictions for the values of Planck constant and amplitude windows, and also predicts other biologically interesting scales assignable as dark p-adic length scales and time scales of CDs of other particles for particular value of $\hbar$. Also scaled up Josephson and cyclotron frequencies are predicted.

6.5 How does generalized EEG relate to conscious experience?

In this section possible interpretation of cyclotron phase transitions and EEG from the point of view of conscious experience are discussed.

6.5.1 Sensory canvas hypothesis

Sensory canvas hypothesis assumes that magnetic transition frequencies code for the temporal and possibly also spatial positions of the objects of the 4-D perceptive field at the personal magnetic body characterized by field strength B_{end}.2 Gauss at the surface of Earth. Magnetic transition frequencies are associated with MEs serving as sensory projectors to which various sub-selves representing features are entangled.

The view about evolution of consciousness as a gradual emergence of increasingly lower EEG frequency scales suggests a general paradigm concerning the assignment of the frequency bands with various cyclotron frequencies and possibly spin flip frequencies. 40 Hz band could naturally correspond to MEs projecting symbolic representations associated with the sensory input to the magnetic sensory canvas. The range 20-40 Hz could be associated with some simple cognitive features or emotions (say associated with odor discrimination) whereas 13-20 Hz interval could correspond to more refined cognitive features. Alpha and theta bands could relate to the features representing memories. The possibility of communications at theta, delta and alpha frequencies to higher level many-brained magnetic selves representing collective levels of consciousness must be considered seriously in TGD framework.

The processing of the sensory input involves where-what division. The fact that 'where' aspect has developed earlier encourages to think that it is more primitive aspect of perception so that the EEG frequencies associated with the simplest 'where' aspects might be higher. This is supported also by the fact that the EEG rhythms associated with brain stem and cerebellum correspond to 80 Hz and 200 Hz respectively.

The narrow highly coherent frequency bands with width of order 1-2 Hz reported by Nunez at 3, 5 and 7 Hz, the alpha band at 11 Hz, and the narrow bands at 13, 15 and 17 Hz [44] plus the 8 Hz width band around 40 Hz provide empirical support for the basic assumptions and a good starting point for possible more detailed identifications.

6.5.2 Magnetic quantum phase transitions and EEG

The original attempt to assign our qualia to magnetic and Z^0 magnetic transitions need not be correct. The following scenario looks a more realistic working hypothesis.

1. The EEG MEs associated with magnetic transitions serve as quantum entanglers of the bodily mental images to the personal magnetic body. If sensory representations are realized at the personal magnetic body, the magnetic quantum phase transitions at the personal magnetic body contribute to our conscious experience by the fusion of "simple feeling of existence" mental images with much more complex bodily mental images.

2. The field patterns associated with negative energy EEG MEs code for declarative long term memories perhaps using the hierarchy of p-adic cognitive codes discussed above. The model of long term declarative memories suggests that bodily magnetic qualia need not be conscious-to-us. The magnetic quantum phase transitions would represent a step in the transformation of the field patterns of EEG MEs representing declarative memories to conscious experiences.

The overall conclusion would be that, as far as primary sensory qualia are considered, magnetic transitions are not very interesting. On the other hand, the hypothesis that magnetic fields are such that magnetic transition frequencies tend to coincide with various universal frequencies (say those assignable toCDs) , makes them very interesting concerning the practical models for what might be happening at the magnetic flux tubes of body and brain.

Sensory maps by magnetic frequency scale coding

There is a large temptation to assume that the great variety magnetic magnetic transitions in EEG frequency range make possible hierarchy of living maps. A varying magneti frequency scale would code for a position of neuron or some larger unit of brain and to which input from a point of perceptive field is mapped by entanglement (sharing of mental images) and/or by classical communications. Personal magnetic body would essentially remember what happens at material body by sending entanglement inducing negative energy ME to brain along magnetic flux tube and receiving positive energy MEs inducing self-organization and generation of mental images. The classical communication would be like communicating selectively by broadcasting radio waves to receivers each having their own narrow radio wave band.

The working hypothesis is that various mental images in the cortex are projected outside the cortex and CNS at the canvases formed by the magnetic flux quanta associated with various body parts. There are good reasons to believe that these maps are realized in the length scales of EEG wavelengths. The resulting 3-dimensionality of the map is a strong argument in favor of these maps as also the complete decoupling between representation and information processing yielding the representation.

Quantum maps could be realized by place coding using cyclotron frequencies associated with ELF MEs emerging radially from various parts of CNS, also from sensory organs even. If the time mirror mechanism is the general mechanism of sensory perception, motor action, and memory applied by the magnetic body, the length along the magnetic flux tube codes for the temporal distance to the geometric past. This coding would rely on resonance mechanism involving also resonant interaction of MEs with Alfven waves associated with magnetic flux tubes (much like oscillations of string). The very slow dependence of these frequencies on distance would be determined by the strengths of the classical magnetic fields for which these flux tubes provide a representation as topological field quanta.

Positive energy magnetic transitions could be used for the temporal coding of the sensory representations whereas negative energy magnetic transitions could be used for the temporal coding of generalized motor actions. This would obviously help to avoid overlap between signalling associated with sensory representations and motor actions.

Magnetic quantum phase transitions could give rise to chemical maps of parts of organ. By using an appropriate value of frequency, magnetic quantum phase transitions can be induced and the intensities of these transitions would provide conscious measure for the densities of Bose-Einstein condensates of ions (and perhaps even their Cooper pairs if they manage to be thermally stable) whose densities in turn relate to those at atomic space-time sheets by many-sheeted ionic equilibrium conditions. If the thickness of the magnetic flux tube varies different quantum phase transitions occur at different points of the flux tube and kind of conscious spectrogram results. This kind of generalization of NMR spectroscopy need not be conscious to us although chemical senses could relate to it.

Place coding for the geometric parameters characterizing simple geometric features

Place coding for various geometric parameters characterizing simple geometric 'features' could be realized using the variation of the cyclotron frequency along a magnetic flux tube of varying thickness. The hierarchy of the sensory canvases allows a modular structure in which a geometric feature such as triangle, line, or ellipse represented at a lower level sensory canvas is projected to a *single* point of 'our' sensory canvas. If one accepts that only negative energy MEs can serve as entanglers, the conclusion would be that place coding must utilize negative energy MEs to entangle brainy mental images with the "simple feelings of existence" at the magnetic body.

Becker tells in his book "Cross Currents" [89] about a technique discovered by Dr. Elizabeth Rauscher, a physicist, and William Van Bise, an engineer. The technique uses magnetic fields generated by two coils of wire, each oscillating at a slightly different frequency and directed so as to intersect at the the head of the subject person. When two energy beams with different frequencies intersect at some point in space, a third frequency, so called beat frequency is formed as the difference of the frequencies. What Bise and Rauscher found that this ELF frequency (unfortunately, I do not know what the precise frequency range was) generates simple visual percepts like circles, ellipses and triangles and that the variation of the second frequency induces the variation of the shape of the percept.

The simplest interpretation is that the beat frequency is extracted by non-linear effects in brain and induces a magnetic quantum phase transition at magnetic tubes whose thickness varies and codes for a parameter (say scaling in some direction) characterizing the geometry of the primitive percept (or 'feature'). The proposed general mechanism for how EEG MEs give rise to declarative memories should apply also now and would mean that EEG MEs induce cyclotron transitions giving in turn rise to neural activity. If primary sensory organs are seats of sensory qualia, back-projection to the eyes is involved with the process as also in the case of electric stimulus of cortex inducing visual sensations. The intersection of ELF waves would wake-up symbolic mental images representing triangle and back-projection would make this concept visual. The geometric parameters characterizing the triangle would be coded to frequency differences. An analogous phenomenon occurs also for auditory inputs with slightly different frequencies feeded into ears and makes it possible to 'hear' sounds below the audible range. The mechanism could be the same.

Flag-manifold qualia and magnetic fields

Recall that the flag-manifold representing various choices of quantization axes is a coset space associated with the zero modes. The association of the six-dimensional flag-manifold of color group $SU(3)$ to honeybee dance and geometric aspects of honeybee's sensory experience (described in the chapter [26] inspired the hypothesis that the values of the flag manifold coordinates might be quite generally mapped to magnetic or Z^0 magnetic frequencies by mapping these coordinates to the parameters characterizing magnetic flux tubes. Thus there are two frequencies involved and the mappings projects everything to 2-dimensional space.

The flag-manifold defined by the choices of the quantization axes for the super-symplectic algebra of the configuration space is infinite-dimensional. One can however consider finite-dimensional flag-manifolds as lowest order approximation. In the case of MEs of type $E^2 \times CP_2$, the minimal flag-manifold would be the one defined by the Cartan group of $SO(2) \times SU(3)$, which is just the flag-manifold $F_3 = SU(3)/U(1) \times U(1)$ of color group introduced by Barbara Shipman. For MEs of type $S^2 \times CP_2$ which correspond to spherical light fronts the flag manifold is $S^2 \times F_3$. A very natural identification of S^2 is as labelling orientations of a vector in 3-space. Thus one might consider the possibility that the increments S^2 coordinates could represent changes of orientation at the level of conscious experience. On the other hand, linear sequence of sub-selves inside self would represent experienced orientations very concretely.

One could try to generalize, and consider the possibility that the proper flag manifold is defined by $SO(3,1) \times SU(3)$ by the division by Cartan subgroup. Lorentz group would give 4-dimensional flag-manifold $SO(3,1)/R \times SO(2)$. Lorentz rotations can be decomposed to boosts followed by rotations in rest frame of the resulting system. This suggests that $SO(3,1)$ flag-manifold has a bundle structure with the sphere S^2 defined by boost directions serving as the base and the sphere S^2 defined by the possible directions for the axis of rotation in the rest frame serving as the fiber. Again sub-self moving inside self could represent the direction of boost naturally.

There must be some correlation between the values of zero modes (in particular, flag manifold coordinates) and classical em Z^0 magnetic fields. For instance, color rotation affects the em and classical Z^0 fields. In this sense flag-manifold coordinates can be coded to em and Z^0 magnetic frequencies but the image is 2-dimensional. The work of Barbara Shipman with the dance of honeybee indeed implied that flag-manifold coordinates are mapped to spatial positions in *2-dimensional* plane representing the dance stage. This suggests that $F_3 = SU(3)/U(1) \times U(1)$ coordinates have representational role: they represent concrete geometric information about spatial positions. This representational role could derive from more general assumptions. The positions of plane are represented as frequencies by the place coding by magnetic and Z^0 magnetic frequencies and $SU(3)$ rotations affect em and Z^0 magnetic frequencies so that plane points can be mapped to equivalence classes of $SU(3)$ rotations so that a 2-dimensional space associated with the flag-manifold F_3 emerges naturally.

Could magnetic phase transitions define sensory qualia?

If universality principle holds truemagnetic qualia can be divided to universal kinesthetic qualia and to generalized chemical qualia corresponding to the change of a number of particles in a state with given quantum numbers (say the integer n characterizing cyclotron state). The interpretation of these qualia is far from obvious.

1. Magnetic qualia could be "universal feelings of existence" associated with the place coding of the motor actions from the sensory canvas and also inside brain. This would mean a neat separation of sensory and motor representations from each other. Universal feeling of existence might also be the basic aspect of tactile senses and in fact, all sensations.

2. If the harmonic of the cyclotron frequency does not affect the character of the quale, the number of cyclotron qualia is finite. Alpha band is expected to be the most interesting frequency range as far as qualia are considered. The five bosonic ions $Mn^{2+}, Fe^{2+}, Co^{2+}, Zn^{2+}$, and Se^{2-} have cyclotron frequencies 7.6, 9.4, 10.0, 10.8 and 11.4 Hz. The number of basic tastes is thought to be five, which could mean that magnetic cyclotron phase transitions code for the basic tastes. The number of odors is definitely larger than basic tastes as is also the number of exotic Z^0 ions, which are almost always bosons. Thus the identification of Z^0 magnetic cyclotron transitions as correlates for odors can be considered.

This proposal can be criticized. Any bosonic molecule with $A/Z \leq 223$ (thermal stability of the BE condensate at room temperature) could as such directly define a cyclotron quale so that tastes and odors would correspond to cyclotron transitions of molecules themselves rather than those of bosonic ions in alpha band. One could also argue that the odors and tastes should have a natural ordering according to the value of cyclotron frequency and be continuously transformable to each other by changing the strength of the magnetic field. This doesn't seem to be the case.

What about Larmor frequencies?

Larmor frequency characterizes the nuclear contribution of this interaction to energy and is related to the cyclotron frequency of a singly ionized atom by

$$\omega_L = g\frac{S}{2}\omega_c \ , \quad \omega_c = \frac{eB}{m} \ .$$

where S denotes the maximal projection of spin in the direction of the magnetic field and g is Lande factor, which equals to $g = 1$ in the ideal classical case for which spin corresponds to angular momentum whereas $g = 2$ holds true for elementary fermions. Nuclear contribution is the dominant contribution for ions Na_+, K_+, Cl_- since electron shell is full for the ions in question. The magnetic moments of ions Cl_-, K_+, Na_+ reduce to their nuclear magnetic moments and are rather large:

$$\mu = x\frac{e}{2m_p}S \ , \quad g \simeq 2xA \ ,$$

where m_p denotes proton mass and x is a parameter of order one so that Lande factor is proportional to the mass number A of nucleus. The reason for large value of μ is that magnetic interaction energy of the nucleus is essentially the sum over the interaction energies of nucleons.

If anomalous magnetic moment vanishes Larmor frequency differs by a factor 1/2 from cyclotron frequency: $f_L = f_c/2$ so that spin flip frequency is same as cyclotron frequency. For atomic nuclei the Larmor frequency tends to be larger than cyclotron frequency as the table of Appendix demonstrates. The effects of em fields in living matter at Larmor frequencies have not been however reported.

The interaction of the nuclear spin with magnetic field dominates over the cyclotron interaction energy by a factor of order A and that the natural frequency scale for the ionic Larmor frequencies is hundreds of cycles per second. The values of the parameter x are $x(Na) = 2.214$, $x(Cl) = .82181$ and $x(K) = .3915$. For instance, for Na_+ spin flip transition frequency with $\Delta S = 1$ is $f \sim 222$ Hz. For Ca_{++} spin and magnetic moment vanishes. Note that for $J = 3/2$ ions there are in principle three kinds of transitions corresponding to $\Delta S = \pm 1, \pm 2, \pm 3$. If transition reduces to single nucleon level, $\Delta S = \pm 1$ is the only possibility. The conclusion is that Larmor frequencies probably correspond to different components of sensory modalities than cyclotron frequencies.

The transitions changing the direction of spin of the Cooper pair are induced by the frequencies

$$\omega = (2n+1)\omega_c + 2\Delta m\omega_L = (2n+1+g\frac{\Delta m}{2})\omega_c \ .$$

Odd multiples of the cyclotron frequency are possible in the first order perturbation theory whereas even multiples are possible only in the second order.

The natural question is whether also spin flips to which Larmor frequencies are associated could be also important from the point of view of conscious experience. The natural expectation is that Larmor frequency behaves in the same manner as cyclotron frequency in the scaling of Planck constant and this is indeed the case since spin scales as $\hbar_{eff}$. This allows to consider the possibility that also spin flip transitions are of interest and perhaps define correlates for sensory qualia.

Consider now some examples.

1. For proton and neutron the Lande factors are $g(p) = 3.58$ and $g(n) = -3.82$ so that the spin flip transition frequencies in Earth's magnetic field would be $2\omega_L = 542$ cycles/second for proton and 570 cycles/second for neuron. The frequencies $2f_L$ and $2f_L + f_c = 842$ cycles/second could have something to do with the time scale of nerve pulse in case of proton. Note that $2f_L - f_c = 242$ cycles/second is of same order as f_c for proton so that corresponding qualia might resemble each other.

2. For electron $g = 2$ in excellent approximation and the Larmor frequency is very nearly identical with one half of cyclotron frequency. The deviation is

$$\frac{\Delta g}{g} = \frac{\alpha}{2\pi}$$

in the lowest order of perturbation theory ($\alpha \simeq 1/137$) and thus the frequency for the transition $(n+1, up) \leftrightarrow (n, down)$ changing the spin direction of the second electron of the Cooper pair is $\omega \simeq 902$ Hz. This time scale corresponds to the duration of memetic codon fixed by the fact that memetic code corresponds to Mersenne prime M_{127}, which happens to be the p-adic prime characterizing also electron.

3. Spin flip frequencies for atomic nuclei are in general of order few hundred Hz for $B = .2$ Gauss. For instance, the spin flip frequencies of Mn, Co, Cu, and Na are for $B = .2$ Gauss 228 Hz, 199 Hz, 223 Hz, and 222 Hz. What makes this interesting is that cerebellar resonance frequency is around 200 Hz.

The eight ions listed in the table below have however exceptionally low Larmor frequencies and, very importantly, the singly ionized states have vanishing electronic spin for all ions except Rh and Ir for which electronic configuration corresponds to $J - e = 2/2$ (non-vanishing electronic spin implies that the Larmor frequency of ion is of order $f_L = f_c(e)/2 \simeq 3 \times 10^5$ Hz). This suggests that electromagnetic spin flip transitions for these ions at least could be related to our consciousness. Note that K, Ag and Au have spin flip frequencies near to the harmonics of the fundamental frequencies of exotic super-symplectic representations important in EEG frequency range. Note that the spin flip frequency of K is 39.1 Hz which is in 40 Hz thalamocortical resonance band. The spin flip frequency 82.2 Hz for Cl might relate to the resonance frequency 80 Hz associated with retina.

Ion	(Z,A,S)	f_1/Hz	f_{flip}/Hz	J
Cl	(17,35,F)	8.5	82.2	3/2
K	(19,39,F)	7.5	39.1	3/2
Rb	(37,85,F)	3.5	81.0	5/2
Y	(39,89,F)	3.4	41.2	1/2
Rh	(45,103,F)	2.9	26.6	1/2
Ag	(47,107,F)	2.8	34.2 (39.2)	1/2
Ir	(77,193,F)	1.6	17.0	3/2
Au	(79,197,F)	1.5	14.0	3/2

Table 4. The ions for which electronic spin vanishes in ground state and minimum spin flip frequency f_{flip} is below 90 Hz. f_{flip} is defined as $f_{min} = 2f_L/J$m, where J is nuclear spin. Ag allows two stable isotopes with almost same abundances and the values of f_{flip} are given for both.

Magnetic states have momentum in the direction of the magnetic field and a priori the transition frequency spectrum is continuous rather than discrete. Energy and momentum conservation however imply that the increment of longitudinal momentum is fixed in transition and in excellent approximation transition energies are equal to those obtained by neglecting longitudinal momenta altogether.

To get an idea about energy and momentum transfers involved with the transitions between magnetic states with longitudinal momenta k_1 and k_2, one one apply energy and momentum conservation by assuming that the classical field associated with ME, and thus propagating with light velocity, induces the transition. Let k_1 and k_2 denote the wave vectors of initial and final magnetic states in the direction magnetic field: the corresponding contributions to the energies of the magnetic states are $k_i^2/2m$, $i = 1,2$. Let $k_{||} = kcos(\theta)$ denote the projection of the wave vector k of the ME em wave to the direction of the magnetic field satisfying $k = E$: momentum conservation gives $k_1 - k_2 = k_{||}$. Energy conservation in turn gives

$$\Delta E = \Delta E_B + \frac{k_1^2 - k_2^2}{2m} = E \ ,$$

where

$$\Delta E_B = n\omega_c + \omega_{flip}$$

denotes to the contribution of the cyclotron and spin flip components to the transition frequency. The condition

$$(k_1 + k_2)/m << 1$$

is certainly satisfied and this allows the approximations

$$k = \Delta E \simeq \Delta E_B$$

$$k_1 - k_2 \simeq \Delta E_B cos(\theta)$$

The result means that transition frequencies are not essentially affected by the energy transfer in longitudinal degrees of freedom and it is an excellent approximation to assume that the frequencies inducing magnetic transitions correspond to the transition frequencies associated with the transitions in cyclotron and spin-flip degrees of freedom.

6.5.3 Altered states of consciousness and EEG

The magnetic flux tubes in the length scale range determined by theta and delta band could quite well connect magnetic body to several different organisms and make possible sharing of experiences. Also magnetosphere and even larger magnetic structures could give rise to sensory and other representations receiving input from several organisms and sharing of mental images would allow to share these experiences.

If magnetic body is the experiencer applying time mirror mechanism and if positive energy EEG boundary MEs in delta and theta bands correspond to classical communications of declarative memories usually not conscious-to-us, the dominance of theta and delta waves during sleep suggests two alternatives.

1. During the sleep our attention is directed to transpersonal levels of consciousness but that we do not remember anything about this. The reason might be that no declarative memories are generated during this period.

2. We are entangled with transpersonal levels of consciousness and have lost our personal consciousness. A conscious contact with transpersonal levels requires sharing of mental images with these levels and this might occur during meditation. Theta and delta bands are also known to dominate during deep meditation.

One can consider two alternative interpretations corresponding to interior MEs (phase velocity equal to light velocity) and positive energy boundary MEs (phase velocity equal to EEG phase velocity) associated by scaling law with the negative energy MEs.

1. For positive energy interior MEs the frequencies would correspond to magnetic flux tube lengths up to about 10 Earth circumferences and contained within Earth's magnetotail at the night side. Time scale would be $T = 1/f$. These MEs could feed data using appropriate cognitive codes at p-adic resonances frequencies to the magnetospheric multi-brainy collective selves responsible for the transpersonal levels of consciousness.

2. The scaling law, assuming the alpha wave phase velocity to be the effective phase velocity v of boundary ME, would predict that the time $T_1 = \lambda/v$ needed by the boundary MEs to travel the distance $L = c/f$ defining the distance to the point of the magnetic body wherefrom the negative energy EEG ME was sent to the brain, is measured using decade as a natural unit. If magnetic body is the experiencer applying time mirror mechanism this would mean that delta band would correspond to memories with time span of about ten years. One might think that the magnetic body triggers boundary MEs using negative energy MEs in ULF range which automatically give rise to memories experienced after time T_1.

Transcendental states of consciousness and EEG

Transcendental states of consciousness are characterized by the presence of alpha and theta bands [86] (note that theta band is present also during childhood, youth and even early adolescence but usually disappears at older age). It is found that that theta and alpha bands are preserved also during deep sleep [69]. A possible interpretation is that the presence of alpha band signifies that left brain remains awake in a state of relaxed alertness involving weak signals from magnetic body. One could also argue that even deep sleep is a conscious state but that the presence of alpha band activity in left brain is necessary in order to have memories about this state.

Transpersonal levels of consciousness

Individual organisms or even larger structures could define the 'pixel size' for higher level multi-brained selves realized as sensory, symbolic and cognitive representations at various magnetic structures like the magnetosphere of Earth. These levels could correspond to any p-adic length scale above brain size. These levels would obviously represent the consciousness of various kinds of groups and collectives.

1. Sleep and transpersonal states of consciousness

The simplest assumption is that one loses consciousness during sleep by entanglement with some higher level self, say magnetospheric multi-brained self. This would give rise to a fusion of mental images at this higher level and to a stereo consciousness representing "human condition".

One should not be however too hasty to make this kind of conclusion. If it is indeed biological body which sleeps, our field body could be full awake with attention directed to transpersonal levels of existence. If this is indeed the case, the basic question would be about how to have these experiences and simultaneously form long term declarative memories about them: some part of brain, probably including hippocampus, should be kept awake during these experiences. Perhaps meditative states, often characterized as transpersonal ego-free consciousness, are this kind of states.

2. Who am I?

These arguments raise the question 'Who am I really?'. What precise length scale my ME does corresponds size of Earth, of solar system, of galaxy? Or can my self size be literally infinite and correspond to some infinite p-adic prime and is only the localization for the contents of my conscious experience to this particular corner of this particular galaxy which creates the illusion that I am this biological body? During episodal memories and also ordinary memory recall parts of magnetic body and MEs having size $L = cT$, T the time span of the episodal memory are actively involved so that one can say that the size of "me" is measured in light years. But it is difficult to say whether the contents of my consciousness contains only personal memories even in ordinary states of consciousness. For instance, it is difficult to locate mathematical ideas in any particular portion of space-time and p-adic space-time sheets which are infinitesimally small p-adically are infinitely large in real sense.

Whatever the detailed answer to these questions is, this view allows to interpret physical death as a re-directed attention and giving rise to what might be called re-incarnation. What would differentiate between my and my dog's soul that our attentions are differently directed.

3. Examples of transpersonal experiences

Near-death experiences and out-of-body experiences could be examples of of almost transpersonal, 'ego-free' consciousness. That these experiences often involve the experience of seeing one's own body from outside, is consistent with the transpersonal nature of the experience. As already noticed, delta band is peak frequency in the EEG of infant, which would suggest that children either direct their attention mostly to the transpersonal levels or that children are strongly entangled and almost unconscious as also we are when theta and delta bands of EEG dominate. That this would be the case would conform with the ideas about bicamerality. Otherwise our personal development would be gradual spiritual degeneration.

The experiences of what I call whole-body consciousness could also be example of consciousness involving transpersonal component. These states appear often at night time as dream like experiences and involve illusion of being in ordinary wake-up consciousness. The usual 'noise' present everywhere in body, possibly due to the averaging over proprioceptive experiences of sub-selves, disappears totally and peculiar silence falls down. Whole-body consciousness starts as a stir in spine (same as generated by good music sometimes) extending gradually to the entire body. Experiences of weightlessness and of 'wavy' nature of physical body, flying into roof and falling down smoothly back into bed are typical aspects of these experiences. During this kind of experience it is sometimes also possible to leave the room. During my 'great experience' I experienced of leaving the hospital and walking along street knowing that I was invisible. This experience ended to experience of being brought back to hospital by hospital personnel.

Short lasting form of whole-body consciousness is also possible after waking-up immediately after falling asleep in daytime: perhaps theta consciousness prevails for a short time after wake-up. My personal 'great experience' involved besides whole body consciousness enhanced cognition: entire flux of ideas many of which have later developed to basic principles of quantum TGD.

Meditative states of consciousness and EEG

.

The proposed general picture allows to build a rough model for the mechanism leading to meditative states. One can also understand how so called ORMUS elements [44] might help to achieve these states.

The harmonics of cyclotron frequencies in delta band should represent even more deeper transpersonal qualia with time scale of about $t_1 = (c/V) \times T$, $T = 1/f$ light years for $f = 1.5$ Hz and $V = 3$ m/s. One could of course argue that the concentrations of heavy ions in brain are so low so that corresponding cyclotron transitions do not give rise to any experiences even if scaling law would not forbid them. This objection is not necessarily very convincing since the needed densities of ions in cellular space-time sheet might be by a fraction of order $[L(137)/L(167)]^3 \sim 10^{-13}$ smaller than density of water and because heavier ions are in gas form and presumably tend to be mostly in non-atomic space-time sheets. TGD predicts also new electro-weak physics would could dramatically change the isotope ratios at cellular space-time sheets.

Delta waves might relate to the interaction of brain with sferics which are atmospheric em perturbations [39]. The spectrum of sferics at delta frequencies resembles EEG spectrum at same frequencies [39]. The electric fields associated with sferics are of same order of magnitude as waves in delta band so that they are not amplified as much as alpha waves. This could explain why delta and theta consciousness is so weak.

One could also consider enhancing delta consciousness artificially: perhaps this could make enlightment experience, if not more probable, at least more intense. This could perhaps be achieved by feeding in brain some heavy singly ionized ions with cyclotron frequencies in delta band and stimulating brain using ELF em field at corresponding cyclotron frequency in $B_{end} = 0.2$ Gauss. Some candidate ions are $Ag^+ : f_c = 2.8$ Hz; $I^+ : f_c = 2.4$ Hz and $Au^+ : f_c = 1.5$ Hz. Also heavy ions like Hg and Pb are in the same frequency range as Gold. For $Z = 1$ flux quantization these frequencies are halved since magnetic field strength is halved.

There are claims for so called ORMUS atoms which somehow differ from ordinary atoms [44]. The persons involved take doses of what they call ORMUS elements, in particular so called White Gold, to induce spiritual experiences. In fact, Barry Carter who wanted to understand what is involved, contacted me about five years ago and told about these effects and I ended up the notion of wormhole Bose-Einstein condensate as a possible explanation of the claimed properties of White Gold. It might be that Gold ions and other heavy element ions enhance transpersonal sensory consciousness in delta band and lead therefore to spiritual experiences.

There is also a patented process developed by Robert Monroe and called Hemi-Synch [57] which might induce delta and theta consciousness. Feeding audible sounds to ears with carrier frequencies below kHz and frequency difference of say 10 Hz, which is as such not audible, generates binaural beat involving appearance of an EEG wave at difference frequency [77]. The difference frequency is not only 'heard' but binaural beats in delta and theta range tend to induce relaxed, meditative and creative states [57]. This method might provide a test for the hypothesis that linear combinations or p-adic frequencies are crucial for consciousness by choosing beat frequencies equal to these frequencies. In a similar manner one could test the alternative hypothesis that cyclotron frequencies are fundamental for consciousness. One should know the precise value of local magnetic field and also take into account the possibility that brain could be able to regulate the value of the local magnetic field to some extend. It could be also possible to apply EEG biofeedback and delta and theta frequencies.

Empirical evidence for transpersonal levels of consciousness

Recall that hyper-genes would correspond to flux sheets traversing through cell nuclei belonging to several organisms. Obviously this level would correspond to a transpersonal level of consciousness: kind of multi-brained conscious entities receiving sensory input from several organisms and performing intentional control over their behavior would be in question. Strong correlations between EEGs of individuals, in particular those having a close personal relationship, would be the obvious implication.

The experiments of Mark Germine [91] provide evidence for the notion of transpersonal conscious entities and associated collective memory perhaps realized in terms of flux sheets traversing the neuronal nuclei of several persons. What was studied was the evoked EEG response to a series of random quantum stimuli which consisted of series of identical sound stimuli with randomly located deviant stimulus. Two subject persons, A and B, were involved. In the case that A observed the differing stimulus 1 second before B, the evoked EEG response of B became incoherent. Since evoked stimulus was oscillation at EEG frequency of about 11 Hz in the case that A had not observed the stimulus, one could understand the mechanism as a direct evidence for transpersonal conscious entity interacting with brains of both A and B. When transpersonal conscious entity had hear the stimulus once, it did not react to it in similar manner.

6.5.4 EEG and Golden Mean

Dan Winter has reported [45] that in certain altered states of consciousness (described as experiences of bliss) the ratio of beta and alpha peaks approaches Golden Mean $\Phi \simeq 1.618...$ It is interesting to look what TGD based model for EEG could say about this finding.

1. For $f_J = 5$ Hz and $f_c = 10$ Hz (the p-adic frequency corresponding to the secondary p-adic time scale $T_2(127)$ associated with Mersenne prime M_{127}, and identifiable as a fundamental biorhythm) one has $\beta/\alpha = 3/2$ which is the lowest approximation to Golden Mean in terms of ratios of Fibonacci numbers. The higher approximations approach to Φ. The approximation sequence would be consistent with the 1 Hz width for the narrow beta bands.

2. This would suggest that beta/alpha ratio is maximal in this state and approaches to Φ in a discrete manner. The question is whether the resting potential is quantized in terms of ratios of Fibonacci numbers $F_{2n}/F_{2n-1} \in \{3/2, 8/5, 21/13, ..\}$. At the limit theta peak would approach to 3.92 Hz: note that shamanic drumming rhythm corresponds to 4 Hz frequency. This hypothesis is testable by comparing possible changes in the measured resting potentials with subjective reports of meditators.

3. The sequence of ratios of F_{n+1}/F_n approaches Golden Mean in an oscillatory manner, which suggests that states of hyperpolarization following generation of nerve pulse correspond to ratios $F_3/F_2 = 5/3$, $F_8/F_5 = 13/8$,... above Golden Mean. In the sate of "full bliss" there would be no hyperpolarization after the generation of nerve pulse. A possible interpretation is that there is no "dead" time after nerve pulse and system is immediately in a state of maximal possible alertness. On the other hand, the state of pure bliss should be ideally a state of pure alertness without mental images. In the state in which cell membrane in resting state is maximally hyperpolarized,

nerve pulse generation does not occur too easily and thus sensory or other mental are not easily generated.

4. The sequence of Fibonacci numbers could relate to a hierarchy of finite-dimensional approximations for Jones inclusions for quantum phase $q = exp(i\pi/5)$ represented in terms of braids. $n = 5$ is also the minimal value of n allowing universal topological quantum computation [33]. The state of full bliss would correspond to the limit at which the number of strands of braid is infinite so that topological quantum computations resources are maximal.

5. Dan Winter has also emphasized the importance of tedrahedral and icosahedral symmetries for DNA. These symmetries correspond to the only genuinely 3-dimension finite subgroups of rotation groups and are symmetries of water molecule clusters. Icosahedral group has $n = 5$ and would allow universal topological quantum computation.

6.5.5 Pineal gland and EEG

Pineal gland is an unpaired structure and strictly speaking not part of brain being located outside the brain in primitive vertebrates. Pineal gland is known to play a role in the control of both central nervous system, endocrine system and immune system [76]. There is also strong evidence that pineal gland forms part of the magnetic navigation system in birds, and possibly also in humans who also have this system. Pineal gland is biological timekeeper and responsible for 24-hour circadian rhythms via a secretion of hormones, in particular melatonin. What pineal gland does is to inhibit secretion whereas pituitary gland facilitates it. Pineal melatonin level controls the hormone secretion and sleep wave cycle and magnetic exposure changes pineal melotonin secretion [76].

What makes pineal gland interesting is that it is accompanied by 10 Hz rhythms. This rhythm corresponds to the strongest resonance frequency in the alpha band for both EEG and ZEG.

Pineal gland as timekeeper

10 Hz corresponds to the p-adic frequency $f(2, 127)$ associated with the 126-bit memetic code, which is an especially important code in the hierarchy of the cognitive codes. The fact that tiny electric field at average alpha frequency of 10 Hz restores biorhythms in absence of local magnetic field [79], suggests that pineal gland has a coupling to some cavity resonances or some magnetic transition frequency equal to 10 Hz.

1. The lowest Schumann frequency 7.8 Hz is too low. On the other hand, the resonance frequency associated with effectively two-dimensional excitations of em fields inside Schumann cavity is exactly 10 Hz and could be involved with the realization of the memetic code.

2. Fe^{++} ion appears naturally and has cyclotron frequency of 10.74 Hz and provides a natural candidate for a biological clock, not necessarily associated with the pineal gland. A 3 per cent reduction of the Earth's magnetic field from the nominal value of .5 Gauss would reduce the cyclotron frequency to 10 Hz.

3. Co^{++} cyclotron frequency would be 10 Hz for $B = .5$ Gauss. Co^{++} has very high nuclear spin and is therefore a natural magnet: Yarrow has indeed suggested that vitamin B_{12} containing Co makes pineal gland magnetic hormone and fundamental biological clock at 10 Hz frequency [79]. Thus at least ELF ME with Co^{++} cyclotron frequency should go through pineal gland. In the case that they are singly ionized $n = 2$ multiples of corresponding cyclotron frequencies would be involved with the biological clocks in question: these transitions are possible in the second order of perturbation theory.

In darkness 24-hour circadian rhythm changes to 25-hour rhythm perhaps defined by the rotation of Moon and Earths's own rotation. The ratio of 24-hour period to 25-hour period is .96. The ratio of the average of Co^{++} and Fe^{++} frequencies to Fe^{++} frequency is .964 giving period of 24 hours 53 minutes if the average period is 24 hours. This observation suggests that circadian period is measured during daylight in time unit given by the period of Fe^{++} rhythm possibly associated with some visual pathway, perhaps even with eyes, and in darkness by the slightly slower Co^{++} rhythm associated with the pineal gland. Under this assumption the ordinary circadian rhythm f is weighted average of Fe^{++} and Co^{++} rhythms:

$$f = xf(C0^{++}) + (1-x)f(Fe^{++}) \ ,$$

In ideal circumstances circadian rhythm is 24 hours: this gives $x = .44$ with roughly 13.5 day hours and 10.5 dark hours. In continual darkness the rhythm would transform to the slower Co^{++} rhythm of 25 hours with $f = f(Co^{++})$. These two rhythms would presumably distinguish between sleep and awake since pineal gland closely related to the regulation of sleep-wake cycle.

The deviation of x from ideal value $x = .44$ could be an important factor in some disorders. It is known that human melatonin levels do not depend very strongly on season except in arctic latitudes (seasonal affective disorder) but that melatonin levels affect sleep-wake cycle. Abnormally high activity of pineal gland is associated with the hallucinatory periods of schizophrenia: perhaps visual hallucinations of schizophrenic are partially mediated by pineal gland. The manic (depressive) phase of bipolar disorder correlates also with over- (under-) activity of the pineal gland [76]. Keeping x by artificial lighting near its ideal value could be of help. The artificial modification of the strength of the local magnetic field should modify the unit of biological time: perhaps this could provide a manner to cure not only jet lag but even much more serious mental disorders.

Pineal gland as "third eye"

The question is whether the 25-hour rhythm equals to the rhythm defined by moon's rotation or is it a mere coincidence. If not, then the MEs going through through pineal gland might mediate unconscious-to-us information about the rotation of Moon. Could higher level self 'see' moon in its orbit? Perhaps in some sense! The ability to restore circadian rhythms is based on the photosensitivity of the pineal gland. Pineal gland has been indeed regarded as "third eye" by mystics. As a matter fact, in some lower vertebrates pineal gland serves as a genuine eye [75]. For long it has been thought that in mammals pineal gland is not (or perhaps cannot be!) directly photosensitive. Indeed, there is a pathway from the retinas to the hypothalamus called the retinohypothalamic tract [75]. It brings information about light and dark cycles to a region of the hypothalamus called the suprachiasmatic nucleus (SCN). From the SCN, nerve impulses travel via the pineal nerve (sympathetic nervous system) to the pineal gland. These impulses inhibit the production of melatonin. When these impulses stop (at night, when light no longer stimulates the hypothalamus), pineal inhibition ceases and melatonin is released. The pineal gland is therefore a photosensitive organ and an important timekeeper for the human body.

The belief that pineal gland receives information about changes in the lighting from retinas only, has turned to be wrong: mammals lacking ordinary rods and cones genetically, can preserve they circadian rhythms [75]! Thus pineal gland must perceive changes in lighting somehow. TGD based explanation for pineal vision is based on the many-sheeted space-time concept and ELF selves: light reaches pineal gland via MEs associated with EEG frequencies. Why we do not then see with our third eye? Or do do we actually see?: perhaps visual dreaming involves also seeing with the third eye providing 'spiritual input'! This hypothesis can be tested by checking whether the dreams of people with pineal gland injury somehow change. This explanation also suggests that also eyes are foci of converging MEs so that eyes would be rather concretely mirror of the soul!

Perhaps Descartes was not so wrong after all!

Descartes has been ridiculed for his belief that pineal gland is the seat of soul. Perhaps this sentence has been precipitate as suggested by a clinical case in which over-activity of 5-year old child had led to premature adolescence. Here is a fragment from Frederic Tilney's book 'The Pineal Gland':

Until a few decades ago scant attention was paid to the pineal gland. Then came the case, noted by Dr. Berman, in which a child was brought to a German clinic suffering from eye trouble and headaches. He was five years old and very mature, and apparently had reached the age of adolescence. He was abnormally bright mentally, discussing metaphysical and spiritual subjects. He was strongly group-conscious and only happy when sharing what he had with others. After his arrival at the clinic, he rapidly grew worse and died in a month. An autopsy showed a tumor of the pineal gland.

Pineal gland is one of so called chakras in mystic teachings and it is known that pineal gland is involved with altered states of consciousness [76]. Meditation practices assign to third-eye meditation development of "light in the original cavity or center of spirit" located in the center of the brain and "waking of Kundalini" is associated to pineal gland [76].

The fractal hierarchy of the magnetic flux tubes corresponds to a hierarchy of selves and pineal gland is known to contain magnetic crystals. These crystals create magnetic fields which are much weaker than Earth's magnetic field. Their flux tubes, with thickness measured in centimeters, could thus be carriers of super-conducting BE condensates with cyclotron time scale measured in the range year–thousand years. These higher level magnetic selves together with corresponding MEs could be responsible for the higher levels of the self hierarchy. One could perhaps understand also the various characteristics of near death experiences in terms of higher level magnetic consciousness [34]. Thus Descartes could have been right after all!

6.6 Great vision about biological evolution and evolution of brain

The following great vision about evolution and is not perhaps strictly about hierarchy of EEGs. The hierarchy of dark matter and EEGs however leads to this vision naturally. The first part of vision relates to biological evolution. Second part is about the evolution of brain. Here the key thread is evolution of two kinds of intelligences, the ordinary fast intelligence evolving via the emergence of fast computation type activities and emotional slow intelligence developing via the emergence of higher levels of dark matter hierarchy. The latter intelligence is what distinguishes us from animals.

6.6.1 Basic assumptions

The great vision about evolution and brain relies on two several new notions and ideas.

1. Life as something in the intersection of real and p-adic worlds making possible negentropic entanglement- both space-like and time-like. This makes possible to understand what conscious intelligence is and NMP reduces evolution to a generation of negentropic entanglement. DNA as topological quantum computer hypothesis [28] finds also a justification.

2. The notion of many-sheeted space-time implying a universal hierarchy of metabolic energy quanta, and the notion of magnetic body.

3. Communication and control based on Josephson radiation and cyclotron transitions crucial for understanding biophotons and EEG and its fractal generalization as a key element of bio-communications.

4. Zero energy ontology and the closely related notion of causal diamond (CD) assigning a hierarchy of macroscopic time scales to elementary particles coming as octaves of the basic time scale and justifying p-adic length scale hypothesis. Zero energy energy ontology also justifies the vision about memory and intentional action and the idea that motor action can be seen as time reversal of sensory perception.

5. The hierarchy of Planck constants and the identification of the fundamental evolutionary step as an increase of Planck constant. Evolutionary steps mean migration to the pages of the Big Book labeled by larger values of Planck constant and living system can be regarded as a collection of pages of the Big Book such that a transfer of matter and energy between the pages is taking place all the time. The change of the Planck constant implies either reduction or increase of the quantum scales-this leads to a model for biocatalysis and a model of cognitive representations as scaled down or scaled up "stories" mimicking the real time evolution.

6. A resonant like interaction between hierarchy of Planck constants and p-adic length scale hierarchy favoring the values of Planck constant proportional to powers of two, and idea that weak and color interactions are especially important in the length scales which correspond to Mersenne primes and Gaussian Mersennes. The simplest option is that weak bosons have their standard masses but appear as massless below their Compton length which scales up like $\hbar$ and preferred p-adic length scales correspond to Mersenne primes. Also copies of weak bosons and gluons with ordinary value of Planck constant and reduced mass scale can (and will) be considered.

How to identify the preferred values of Planck constant?

The basic problem is to identify the preferred values of Planck constant and here one can only make theoretical experimentation and all what follows must be taken in this spirit. One can consider assumptions which become increasingly stronger.

1. If only singular coverings of CD and CP_2 are possible Planck constant is a product of integers. Algebraic simplicity of algebraic extensions of rationals favors ruler and compass integers (Appendix).

2. A resonant interaction between the dark length scales and p-adic length scales with ordinary value of Planck constant favors Planck constants coming as powers of two.

3. An even stronger assumption would be that p-adic length scales coming as Mersennes and Gaussian Mersennes are especially interesting.

   (a) If weak bosons can appear with the ordinary value of Planck constant only in the p-adic length scale $k = 89$, one obtains the condition

   $$k_d = k - 89 \quad , \quad k \in \{89, 107, 113, 127, 151, 157, 163, 167\} \tag{6.6.1}$$

   for the values of of $r = 2^{k_d}$ allowing dark weak bosons in p-adic length scales assignable to Mersennes. These values of k_d assign to electrons and quarks dark p-adic length scales $L(k_{eff}) = \sqrt{r}L(k)$, $r \equiv \hbar/\hbar_0 = 2^{k_d}$. The scales could correspond to size scales of basic units of living systems.

   (b) If weak bosons and possibily also gluons with ordinary value of Planck constant are possible in all p-adic length scales $L(k)$, $k \in \{89, 107, 113, 127, 151, 157, 163, 167\}$, one obtains much richer structure. This hierarchy defines defines secondary dark matter hierarchies from the condition that the scaling the p-adic length scale $L(k_1)$ in this set by $\sqrt{r}$, $r \equiv \hbar/\hbar_0 = 2^{k_d}$, gives a p-adic length scale equal to another p-adic length scale $L(k_2)$ in this set. This requires $k_d + k_1 = k_2$ so that the values

   $$k_d = k_2 - k_1 \tag{6.6.2}$$

   are favored for the scaling of $\hbar$. In this case the hierarchy of dark scales assignable to quarks and leptons is much richer. The tables below demonstrate that electron appears as its dark variant for all Mersennes and also in atomic length scales $k = 137, 139$ so that this option puts electron in a completely unique position.

4. Also other scales are possible. For instance, $r = 2^{47}$ required by 5 Hz Josephson frequency gives dark weak scale which corresponds $k = 136$ as a p-adic scale. The stages of sleep can be understood in terms of scaling of $\hbar$ by factor 2 and 4 so that also the atomic length scale $k = 137$ and the scale $k = 138$ are involved.

Since the experimental input is rather meager, one is forced to do theoretical experimentation with various hypothesis. The quantitative experimental tests are rather primitive but basically quantal.

1. The time scales assignable to CDs of leptons and quarks and their scaled up counterparts for the preferred values of Planck constant should define biologically important time scales. One might even speak about evolutionary level of electron. These time scales could define fundamental biorhythms and also time scales of long term memory and planned action.

2. Josephson frequencies and cyclotron frequencies scaling like $1/\hbar$ (if magnetic field scales down like $1/\hbar$) charactering biologically important ions and elementary particles. In accordance with the quantum criticality of living matter it is assumed that cell membrane corresponds to almost vacuum extremal so that classical Z^0 force is an essential element of the model. Also these frequencies should define fundamental bio-rhythms and characterize the evolutionary level of cell. Experimentally of special importance are the cyclotron frequencies assignable to Ca^{++} ions.

3. The amplitude windows for electric field scaling like $\hbar$ for a particular cyclotron frequency define a basic prediction.

Tables about predicted time and length scales

The following tables summarize various predictions for time scales and length scales. They correspond to the most general assumption that exotic bosons with the ordinary value of Planck constant are possible in all length scales associated with Mersennes and Gaussian Mersennes.

k_d	p_1	p_2		k_d	p_1	p_2
4	163	167		38	**89**	127
6	107	113		38	113	151
6	151	157		40	127	167
6	157	163		44	107	151
10	157	167		44	113	157
12	151	163		50	107	157
14	113	127		50	113	163
16	151	167		54	113	167
18	**89**	107		56	107	163
20	107	127		60	107	167
24	**89**	113		62	**89**	151
24	127	151		68	**89**	157
30	127	157		74	**89**	163
36	127	163		78	**89**	167

Table 5. The integers k_d characterizing the preferred values of $r = \hbar/\hbar_0 = 2^{k_d}$ identified from the condition that the dark variant of p-adic length scale $L(p_1)$ corresponding to some ordinary p-adic length scale defined by Mersenne prime M_p or Gaussian Mersenne $M_{G,p}$, $p \in \{89, 107, 113, 127, 151, 157, 163, 167\}$ corresponds to similar p-adic length scale $L(p_2)$. If one assumes that weak bosons can appear with ordinary value of Planck constant only in the p-adic length scale $k = 89$, only the rows with $p_1 = 89$ of the table are possible: in these cases p_1 is in boldface and the row has double underline. The corresponding values of k_d are in the set $\{18, 24, 38, 62, 68, 74, 78\}$.

Note that the table above include only the dark length scales associated with $k = 89$ gauge bosons.

Z,W	d	u	e	k_d
89	120	124	127	**0**
93	124	127	131	4
95	126	129	133	6
99	130	133	137	10
101	132	135	139	12
103	134	137	141	14
105	136	139	143	16
107	138	141	145	**18**
109	140	143	147	20
113	144	147	151	**24**
119	150	153	157	30
125	156	159	163	36
127	158	161	165	**38**
129	160	163	167	40
133	164	167	171	44
139	170	173	177	50
143	174	177	181	54
145	176	179	183	56
149	180	183	187	60
151	182	185	189	**62**
157	188	191	195	**68**
163	194	197	201	**74**
167	198	201	205	**78**

Table 6. The dark p-adic length scales $\sqrt{r}L(k) = L(k_{eff})$, $k_{eff} = k + k_d$, of intermediate gauge bosons Z, W, d and u quarks, and electron for the values $r = 2^{k_d}$ of Planck constant defined in Table 5. The uppermost row gives the integers characterizing the p-adic length scales of the particles for the standard value of Planck constant. k_{eff} characterizes also the CD times scale through the formula $T(CD, k_{eff}) = 2^{k_{eff}-127} \times .1$ seconds. The rows which correspond to the less general option for which only M_{89} corresponds to weak bosons with ordinary value of Planck constants have double underline and the corresponding values of k_d are in boldface.

k_1	k_M		k_1	k_M		k_1	k_M		k_1	k_M
113	89		113	107		163	127		163	157
127	89		119	107		167	127		169	157
151	89		123	107		133	127		173	157
157	89		113	107		139	127		163	157
163	89		117	107		143	127		167	157
167	89		111	107		133	127		161	157
95	89		175	113		137	127		169	163
109	89		181	113		131	127		183	163
133	89		187	113		225	151		207	163
139	89		191	113		229	151		213	163
145	89		119	113		157	151		219	163
149	89		133	113		171	151		223	163
103	89		157	113		195	151		177	163
127	89		163	113		201	151		201	163
133	89		169	113		207	151		207	163
139	89		173	113		211	151		213	163
143	89		127	113		165	151		217	163
113	89		151	113		189	151		187	163
119	89		157	113		195	151		193	163
125	89		163	113		201	151		199	163
129	89		167	113		205	151		203	163
95	89		137	113		175	151		169	163
101	89		143	113		181	151		175	163
105	89		149	113		187	151		179	163
95	89		153	113		191	151		169	163
99	89		119	113		157	151		173	163
93	89		125	113		163	151		167	163
145	107		129	113		167	151		187	167
169	107		119	113		157	151		211	167
175	107		123	113		161	151		217	167
181	107		117	113		155	151		223	167
185	107		195	127		235	157		227	167
113	107		201	127		163	157		181	167
127	107		205	127		177	157		205	167
151	107		133	127		201	157		211	167
157	107		147	127		207	157		217	167
163	107		171	127		213	157		221	167
167	107		177	127		217	157		191	167
121	107		183	127		171	157		197	167
145	107		187	127		195	157		203	167
151	107		141	127		201	157		207	167
157	107		165	127		207	157		173	167
161	107		171	127		211	157		179	167
131	107		177	127		181	157		183	167
137	107		181	127		187	157		173	167
143	107		151	127		193	157		177	167
147	107		157	127		197	157		171	167

Ǐ

Table 9. The table gives all weak boson length scales -both non-dark and dark implied by the assumption that all Mersennes primes and their Gaussian counterparts and their dark counterparts defined $k_d = k_i - k_j$ them are possible.

particle	Z,W	d	u	e
k	89	120	123	127
f(CD)/Hz	2.7488×10^{12}	1280	160	10

Table 8. The fundamental frequencies associated with the CDs of intermediate gauge bosons Z,W, d and u quarks, and electron. Note that for intermediate gauge bosons the frequency of CDs corresponds to energy $E = 1.13 \times 10^{-2}$ eV and wavelength $\lambda = 1.01 \times 10^{-4}$ m (size of a large neuron).

Z,W	d	u	e	k_d
3.64e-13	7.81e-04	6.25e-03	1.00e-01	**0**
5.821e-12	1.25e-02	1.00e-01	1.60e+00	4
2.31e-11	5.00e-02	4.00e-01	6.40e+00	6
3.73e-10	8.00e-01	6.40e+00	1.02e+02	10
1.49e-09	3.20e+00	2.56e+01	4.10e+02	12
5.97e-09	1.28e+01	1.02e+02	1.65e+03	14
2.38e-08	5.12e+01	4.10e+02	6.55e+03	16
9.54e-08	2.05e+02	1.64e+03	2.62e+04	**18**
3.81e-07	8.19e+02	6.55e+03	1.05e+05	20
6.10e-06	1.31e+04	1.05e+05	1.68e+06	**24**
3.91e-04	8.39e+05	6.71e+06	1.07e+08	30
2.50e-02	5.37e+07	4.30e+08	6.87e+09	36
1.00e-01	2.15e+08	1.72e+09	2.75e+10	**38**
4.00e-01	8.59e+08	6.87e+09	1.10e+11	40
6.40e+00	1.37e+10	1.10e+11	1.76e+12	44
4.10e+02	8.80e+11	7.04e+12	1.12e+14	50
6.55e+03	1.41e+13	1.13e+14	1.80e+15	54
2.62e+04	5.63e+13	4.50e+14	7.21e+15	56
4.19e+05	9.01e+14	7.21e+15	1.15e+17	60
1.68e+06	3.60e+15	2.88e+16	4.61e+17	**62**
1.07e+08	2.31e+17	1.84e+18	2.95e+19	**64**
6.87e+09	1.48e+19	1.18e+20	1.89e+21	**74**
1.10e+11	2.36e+20	1.89e+21	3.02e+22	**78**

Table 9. The $\hbar$-scaled fundamental time scales $T(CD, k_{eff}) = 2^{k_{eff}-127} \times .1$ seconds associated with the CDs of intermediate gauge bosons Z,W, d and u quarks, and electron for the values $\hbar/\hbar_0 = 2^{k_d}$ of Planck constant defined in Table 5. The scales are expressed in seconds. The uppermost row gives the time scales of CDs for the standard value of Planck constant. The rows which correspond to the less general option for which only M_{89} corresponds to weak bosons with ordinary value of Planck constants have double underline and the corresponding values of k_d are in boldface.

Electron and u quark are different

Before continuing an important observation is in order. Electron is exceptional when compared to quarks. It appears as a dark particle in all p-adic length scales defined by biologically important Gaussian Mersennes and also in atomic length scales $k = 137$ and $k = 139$. The reason is trivial: by the basic assumptions electron must appear at same length scales as weak bosons above $k = 127$ since it corresponds to Mersenne prime. Also for the less general option (exotic intermediate gauge bosons are possible only as the dark variants of the standard ones) it appears at cell membrane length scale $k = 151$, which is due to the fact that one has $113 - 89 = 151 - 127 = 24$. Also u quark can appear with $k_{eff} = 137, 139, 163, 167$ and also this is an accident. The light invariants of intermediate gauge bosons appearing in long p-adic length scales would naturally correspond to almost vacuum extremals making possible the criticality as the basic aspect of life. One must of course be very cautious about the masses of exotic counterparts of u and d quark: one can also consider the possibility that masses are identical.

6.6.2 Dark matter hierarchy and big leaps in evolution

Dark matter hierarchy leads to an amazingly concrete picture about evolutionary hierarchy allowing to identify the counterparts for concepts like mineral, plant, and animal kingdom that we learned during schooldays and ceased to take seriously as students of theoretical physics as we learned that other sciences are just taxonomy. Even more, a view about what distinguishes between prokaryotes, eukaryotes, animal cells, neurons, EEG, and even about what makes cultural evolution, becomes possible. This view is also very useful when one tries to understand the role of microtubules.

The appearance of CDs scaled up in size by $r = \hbar/\hbar_0$ and space-time sheets scaled up in size by $\sqrt{r}$ means the emergence of new levels of structure and it is natural to identify big leaps in evolution in terms of emergence of new larger matter carrying space-time sheet magnetic flux sheets and corresponding magnetic bodies. If magnetic flux quanta are scaled by r magnetic flux quantization conditions remain unaffected if magnetic field strengths scale down by $1/r$ so that the energies of cyclotron photons are not affected. The thickness of flux tubes can remain unchanged if the currents running at the boundaries of the flux quantum cancel the magnetic flux. As already found, this mechanism must be at work inside living organisms wheras in far away region flux quanta are scaled up in size.

The attractive hypothesis is that the leaps in evolution correspond to the emergence of dark variants of weak and possibly also color interactions in dark p-adic length scales which correspond to ordinary p-adic length scales characterized by Mersenne primes. These leaps would be quantum leaps but in different sense as thought usually. The emergence of higher dark matter levels would basically mean the integration of existing structures to larger structures. A good metaphor are text lines at the pages of book formed by magnetic flux sheets whose width is scaled up by r as the new level of dark matter hierarchy emerges. The big leaps can occur both at the level of organism and population and organisms with rather low individual dark matter level can form societies with high dark matter levels and high collective intelligence (honeybees and ants are good example in this respect).

Certainly also other scalings of Planck constant than those summarized in tables are possible but these scalings are of primary interest. This intuition is supported by the observation that electron is completely exceptional in this framework. Electron's dark p-adic length scales corresponds to p-adic length scales $L(k)$, $k = 167, 169$, assignable to atomic and molecular physics and to the Gaussian Mersennes $M_{G,k} = (1+i)^k - 1$, $k \in \{151, 157, 163, 167\}$, assignable to the length scale range between cell membrane thickness 10 nm and nucleus size 2.58 μm. The corresponding p-adic length scales, the number of which is 23, are excellent candidates for the scales of basic building brickes of living matter and vary from electron's p-adic length scale up to 1.25 m ($k = 167$ defining the largest Gaussian Mersenne in cell length scale range) and defining the size scale of human body. The corresponding p-adic time scales are also highly interesting and vary from .1 seconds for electron defining the fundamental biorhythm to 9.6×10^{14} years which is by 4-5 orders longer than the age of the observed Universe. For $k = 167$ the time scale is 1.1×10^{11} years and is by one order of magnitude longer than the age of the observed Universe estimated to be 1.37×10^{10} years [41].

This conceptual framework gives rather strong guidelines for the identification of the levels of evolutionary hierarchy in terms of dark matter hierarchy. The outcome is a more detailed vision about big evolutionary leaps. Note that in the sequel only the general option is considered: the justification for this is that for this option electron appears as a dark particle for all length scales defined by Gaussian Mersennes as well as in atomic length scales. The basic vision in nutshell is that evolution means the emergence of dark weak and gluonic physics in both dark and ordinary length scales and that the size scales of the basic biostructures correspond to Mersenne primes and their Gaussian variants.

A sketch about basic steps in evolution

The vision about evolution depends on what one assumes about the initial state.

1. If one assumes that weak bosons with ordinary value of Planck constant were present in the begining, evolution would mean a steady growth of k_d. The problem is that small values of

$k_d = k_1 - k_2$ correspond to the Gaussian Mersennes defining cellular length scales. If these exotic weak physics were present from the beginning, large parity breaking in cellular length scales would have been present all the time.

2. An alternative and perhaps more realistic view is that the evolution means the emergence of exotic weak physics corresponding almost vacuum extremals in increasingly longer length scales. A possible mechanism could have been the induction of exotic $\hbar_0$ variant of weak physics at the nearest Mersenne length scale k_{next} by the dark variant of weak physics at level k so that one would have $k_d = k_{next} - k$. The simplest induction sequence would have been $89 \rightarrow 107 \rightarrow 113 \rightarrow 127 \rightarrow 151 \rightarrow 157 \rightarrow 163 \rightarrow 167$ corresponding to $k_d \in \{18, 6, 14, 24, 6, 6, 4\}$. A possible interpretation of exotic $\hbar_0$ physics is in terms of almost vacuum extremals and non-standard value of Weinberg angle: also weak bosons of this physics would be light. This sequence defines the minimal values for k_d but also larger values of k_d are possible and would correspond to steps between neighbours which are not nearest ones.

The following sketch about the basic steps of evolution relies on the latter option.

1. Elementary particle level

Magnetic bodies with size scale defined by the sizes of CDs assignable to quarks and leptons and possibly also weak bosons (already now the size of big neuron emerges) corresponds to the lowest level of hierarchy with the sizes of the basic material structures corresponding to the Compton lengths of elementary particles. The fundamental bio-rhythms corresponding to frequencies 10, 160, and 1280 Hz appear already at this level in zero energy ontology which suggests that elementary particles play a central and hitherto unkown role in the functioning of living matter.

2. $89 \rightarrow 107$ *step with* $k_d = 18$

The first step would have been the emergence of $k_{eff} = 107$ weak bosons inducing $\hbar_0$ weak physics in $k = 107$ length scale characterizing also ordinary hadrons. This in turn would have led to the emergence of exotic nucleons possibly corresponding to almost vacuum extremals. The reduction of the model for the vertebrate genetic code to dark hadron physics [23] is one of the most unexpected predictions of quantum TGD and assumes the existence of exotic- possibly dark- nucleons whose states with a given charge correspond to DNA, RNA, mRNA, and tRNA. The $\hbar_0$ variants of these nucleons would interact via weak bosons with hadronic mass scale. The exotic variants of the ordinary $k = 113$ nuclei would correspond to the nuclear strings consisting of exotic nucleons [22, 23] and define nuclear counterparts for DNA sequences. Their dark counterparts could define counterparts of DNA sequences in atomic physics length scales. Therefore a justification for the previous observation that genetic code could be realized at the level of hadron physics and that chemical realization would be higher level realization finds justification. The anomalous properties of water could be also partly due to the presence of dark nucleons and the proposal was that the presence of exotic nuclei is involved with water memory [16]. The possible existence of the the analog of DNA-RNA transcription between ordinary DNA and its nuclear counterpart would have dramatic implications. For instance, one can imagine a mechanism of homeopathy based on this kind of transription process which would also allow a modification of genome by using dark nuclei to communicate the DNA sequences through the cell membrane to the target nuclei.

3. $107 \rightarrow 113$ *step with* $k_d = 6$

The next step would have been the emergence of $k_{eff} = 113$ weak bosons inducing $\hbar_0$ weak physics in $k = 113$ length scale characterizing also ordinary hadrons. Exotic variants of the ordinary nuclei possibly corresponding to almost vacuum extremals could have emerged interacting weakly (or actually relatively strongly!) via the exchange of weak bosons with mass scale of order 100 MeV. Also dark variants of the exotic $k = 107$ nucleons could have have emerged and formed exotic nuclei of size scale $k = 119$.

4. $113 \rightarrow 127$ *step with* $k_d = 14$

At this step weak bosons in electron mass scale would have emerged. Whether these weak bosons could have induced large parity breakings in atomic and molecular length scales is not clear. Viruses, which do not yet possess cell membrane could correspond to this level of hierarchy.

5. $127 \rightarrow 151$ *step with* $k_d = 24$

This step would have been fundamental since weak bosons in cell membrane length scale would have appeared. Note that by $113 - 89 = 24$ this step also leads from $k = 89$ weak bosons to $k = 113$ weak bosons. The weak bosons assignal to $k = 151$ could correspond to the weak interactions associated with almost vacuum extremals and $sin^2(\theta_W) = .0295$ could correspond to the weak physics in question.

$k_d = 24$ step for $k = 113$ $\hbar_0$ weak bosons would have produced them in $k_{eff} = 137$ atomic length scale with $L(137) \simeq .78$ Angstrom This could have naturally led to large parity breaking effects and chiral selection.

Dark $k_{eff} = 151$ electrons appearing in the TGD inspired model of high T_c super-conductivity would have been a by-product of this step. Whether dark electrons could have transformed to light $\hbar_0$ electrons (of mass .25 keV) with a common mass scale of order 10^2 eV with exotic weak bosons is an interesting question. The model of high T_c super-conductivity predicts the presence of structures analogous to cell membrane. This would suggest that cell membranes emerged and chiral selection emerged at this step so that one could not distinguish the emergence of molecular life as a predecessor for the emergence of cell membrane like structures. This would conform with the fact that DNA molecules are stable only inside cell nucleus. Note that for $k_{eff} = 151$ electron's CD has time scale $2^{24} \times .1$ seconds -that is 19.419 days (day=24 hours).

The smallest nanobes [48] appearing in rocks have size 20 nm and could have emerged at this step. The size of the viruses [53] is between 10-300 nm covers the entire reange of length scales assignable to Gaussian Mersennes, which suggests that smallest viruses could have emerged at this step. Also the smallest nannobacteria [50], which by definition have size smaller than 300 nm could have appeared at this stage.

6. The remaining steps

The remaining steps $k = 151 \rightarrow 157 \rightarrow 163 \rightarrow 167$ could relate to the emergence of coiling structure DNA and other structures inside cell nucleus. $k = 167$ would correspond to $k_d = 167 - 89 = 68$ to be compared with the value $k_d = 47$ required by 5 Hz Josephson frequency for the neuronal membrane for -70 mV resting potential. Note that $k_d = 48$ (state 1-2 of deep sleep) corresponds to $k = 163$.

By their smallness also double and triple steps defined by $k_d = k_{i+n} - k_i$, $n > 1$, are expected to be probable. As a consequence, electrons can appear as dark electrons at all the Gaussian Mersenne levels. At these steps the dark electrons corresponding to primes $k_{eff} = 137, 139$ would appear. For $k = 137$ dark electron appears with CD time scale equal to 128 seconds- rather precisely two minutes. The model for EEG suggests that the exotic weak bosons appear in the scales $k_{eff} = 136, 137, 138$.

Further multisteps from the lower levels of hierarchy would give structures with size scales above the size of cell nucleus possibly assignable to organs and structural units of brain. The dark levels assignable to electron are expected to be of special interest. It is encouraging that the longest scale assignable to electron in this manner corresponds to $k = 205$ and length scale of 1.28 m defining body size. As a consequence dark electrons are predicted at levels $k = 137, 139, 141, 143, 145, 147$ coming as octaves.

Prokaryotic cells (bacteria, archea) without cell nucleus for which cell membrane is responsible for metabolic functions and genome is scattered around the cell could have emerged at this step. This would mean that the emergence of the cell membrane thickness as a fundamental scale is not enough: also the size scale of membrane must appear as p-adic length scale. The sizes of most prokaryotes vary between 1 μm and 10 μm: the lower bound would require $k = 163$. There also prokaryotes with sizes between .2 μm ($k = 157$ corresponds to .08 μm) and 750 μm. Cell nuclei, mitochondria, and other membrane bounded cell nuclei would have evolved from prokaryotes in this framework. The sizes of eukaryote cells are above 10 μm and the fact that multicellular organisms are in question strongly suggests that the higher multisteps giving rise to weak bosons and dark electrons in length scales above $L(167)$ are responsible for multi-cellular structures.

This scenario leaves a lot of questions unanswered. In particular, one should understand in more detail the weak physics at various length scales as well as various exotic nuclear physics defined by dark nucleons and dark variants of nuclei.

Division of the evolution to that of biological body and magnetic body

Electron's Mersenne prime M_{127} is the highest Mersenne prime, which does not correspond to a completely super-astrophysical p-adic length scale. In the case of Gaussian Mersennes $M_{G,k}$ one has besides those defined by k in $\{113, 151, 157, 163, 167, \}$ also the ones defined by k in $\{239, 241, 283, 353, 367, 379, 457, 997\}$ [38]. The appropriately extended model for evolution allows to distinguish between three kinds of values of k_{eff}.

1. The values of k_{eff} for which electron can appear as dark particle and thus satisfying $k_{eff} \leq 205$ (Table 5). These levels would correspond to structures with size below 1.25 m defined roughly by human body size and it is natural to assign the evolution of super-nuclear structures to the levels $167 < k_{eff} \leq 205$.

2. The values of of k_{eff} for which dark gauge bosons are possible in the model. This gives the condition $k_{eff} \leq 235$. These levels correspond to structures in the range 1.25 m-40 km. The identification as parts of the magnetic body can be considered.

3. The values of k_{eff} obtained by adding to the system also the Gaussian Mersenne pair $k \in \{239, 241\}$ allowing also the dark electrons. The lower size scale for these structures is 640 km.

4. The higher levels corresponding to k_{eff} in $\{283, 353, 367, ...\}$. The lower size scale for these structures is 3 AU (AU is the distance from Earth to Sun).

$k_{eff} > 205$ levels would correspond to the emergence of structures having typically size larger than that of the biological body and not directly visible as biological evolution. This evolution could be hidden neuronal evolution meaning the emergence of extremely low Josephson frequencies of the neurons modulating higher frequency patterns and being also responsible for the communication of long term memories.

Biological evolution

In principle the proposed model allowing multisteps between hierarchy levels defined by Mersenne primes and their Gaussian counterparts could explain the size scales of the basic structures below the size scale 1.25 m identified in terms of the $k_{eff} \leq 205$ levels of the hierarchy.

1. The emergence of cells having organelles

The appearance of the structures with $k_{eff} > 167$ (possibly idetifiable as magnetic body parts) should correlate with the emergence of simple eukaryotic cells and organisms, in particular plant cells for which size is larger than 10 μm, which could correspond to $k_{eff} = 171$ for electron and dark variants of weak gauge bosons. $k_{eff} = 177$ is the next dark electron level and corresponds to 80 μm scale. It seems natural to assume that these dark weak bosons do not transform to their $\hbar_0$ counterparts at these space-time sheets.

Cell nucleus would be the brain of the cell, mitochondria would be the energy plant, and centrioles generating microtubules would define the logistic system. Also other organelles such as Golgi apparatus, ribosomes, lysosomes, endoplasmic reticulum, and vacuoles would be present. These organelles would live in symbiosis by topologically condensing to $k_{eff} \geq 171$ magnetic body controlling their collective behavior. Centrosomes associated with animal cells would not be present yet but microtubule organizing centers would already be there.

The recent observations show that centrioles are not always in the characteristic T shaped conformation. Daughter centrioles resulting during the replication of mother centriole use first ours of their lifetime to roam around the cell before becoming mature to replicate. A possible interpretation is that they are also life forms and that magnetic body utilizes daughter centrioles to perform some control functions crucial for the future development of the cell. For instance, centrioles visit the place where axonal growth in neurons starts.

Cytoskeleton would act as a counterpart of a central nervous system besides being responsible for various logistic functions such as transfer of proteins along microtobuli. Centrioles give also rise to basal bodies and corresponding cilia/flagella used by simple cells to move or control movement of air or liquid past them. Centriole pair would be also used by the magnetic body to control cell division.

The logistic functions are the most obvious functions of microtubules. Magnetic body would control cell membrane via signals sent through the cell nucleus and communicated to the cell membrane along microtubuli. Basal bodies below the cell membrane and corresponding cilia/flagella would serve as motor organs making possible cell motion. Tubulin conformations representing bits would allow microtubule surface to represent the instructions of the magnetic body communicated via via cell nucleus to various proteins moving along the microtubular surface so that they could perform their functions.

TGD based view about long memory recall as communication with geometric past allows also the realization of cellular declarative memories in terms of the conformational patterns. Memory recall corresponds to a communication with geometric past using phase conjugate bosons with negative energies reflected back as positive energy bosons and thus representing an "image" of microtubular conformation just like ordinary reflected light represents ordinary physical object. There would be no need for a static memory storage which in TGD framework would mean taking again and again a new copy of the same file.

Receptor proteins would communicate cell level sensory input to the magnetic body via MEs parallel to magnetic flux tubes connecting them to the magnetic body. We ourselves would be in an abstract sense fractally scaled up counterparts of receptor proteins and associated with dark matter iono-lito Josephson junction connecting the parts of magnetosphere below litosphere and above magnetosphere. The communication would be based on Josephson radiation consisting of photons, weak bosons, and gluons defining the counterpart of EEG associated with the level of the dark matter hierarchy in question.

3. The emergence of organs and animals

The emergence of magnetic bodies with k_{eff} in the range $(177, 181, 183, 187,\ 189, 195, 201, 205)$ allowing both dark electron and weak bosons could accompany the emergence of multicellular animals. Magnetic body at this level could give rise to super-genome making possible genetic coding of organs not yet possessed by plant cells separated by walls from each other. The super structures formed from centrosomes and corresponding microtubuli make possible complex patterns of motion requiring quantum coherence in the scale of organs as well as memories about them at the level of organs.

4. The emergence of nervous system

k_{eff} in the range $(187, 189, 195, 201, 205)$ allowing dark electrons and weak bosons gives size scales $(.25, .5, 4, 32, 128)$ cm, which could correspond to the scales of basic units of central nervous system. What would be of special interest would be the possibility of charged entanglement based on classical W fields in macroscopic length scales. The emergence of the new level means also the integration of axonal microtobuli to "text lines" at the magnetic flux sheets making possible logistic control at the multineuronal level. The conformational patterns of the microtubular surface would code nerve pulse patterns to bit patterns representing declarative long term memories. An interesting question is whether the reverse coding occurs during memory recall.

The evolution of magnetic body

For mammals with body size below 1.25 m the levels $k_{eff} > 205$ cannot correspond to biological body and the identification in terms of magnetic body is suggestive. The identification of EEG in terms of Josephson frequencies suggests the assignment of EEG with these levels.

1. The emergence of EEG

EEG in the standard sense of the word is possessed only by vertebrates and one should understand why this is the case. The value of Josephson frequency equal to 5 Hz requires only $k_d = 47$ so that something else must be involved. A possible explanation in the framework of the proposed model comes from the following observations.

1. Besides the maximal p-adic scale $k = 205$ for which electron and weak bosons appears as dark variants the model allows also levels at which only gauge bosons appear as dark particles. From Table 9 one finds that levels $k \in \{207, 211, 213, 217, 219, 221, 223, 225, 229, 235\}$ are allowed. Could it be that these levels and possibly some highest levels containing both electrons and gauge bosons as dark particles are a prerequisite for EEG as we define it. Its variants at higher

frequency scales would be present also for invertebrates. The lowest Josephson frequency coded by the largest value of $\hbar$ in the cell membrane system determins the Josephson frequency.

2. The membrane potentials -55 mV (criticality against firing) correspond to ionic Josephson energies somewhat above 2 eV energy ((2.20,2.74,3.07,2.31) eV, see Table 1). For 2 eV the wavelength 620 nm is near to $L(163) = 640$ nm. Therefore the Josephson energies of ions can correspond to the p-adic length scale $k = 163$ if one assumes that a given p-adic mass scale corresponds to masses half octave above the p-adic mass scale so that the opposite would hold true at space-time level by Uncertainty Principle. Josephson frequencies $f_J \in \{5, 10, 20, 40, 80, 160\}$ Hz correspond to $k_d \in \{47, 46, 45, 44, 43, 42\}$ giving $k_{eff} \in \{210, 209, 208, 207, 206, 205\}$.

   (a) Cerebellar resonance frequency 160 Hz would correspond to $k = 205$ -the highest level for for which model allows dark electrons (also 200 Hz resonance frequency can be understood since several ions are involved and membrane potential can vary).

   (b) The 80 Hz resonance frequency of retina would correspond to $k_{eff} = 206$ -for this level dark electrons would not be present anymore.

   (c) 40 Hz thalamocortical frequency would correspond to $k_{eff} = 207$.

   (d) For EKG frequencies are EEG frequencies below 20 Hz 12.5 and heart beat corresponds to .6-1.2 second cycle (the average .8 s corresponds to $k_{eff} = 212$).

3. Even values of k_{eff} are not predicted by the model based on Mersenne primes allowing only odd values of k_{eff} so that the model does not seem to be the the whole truth. The conclusion which however suggests itself strongly is that EEG and its variants identified as something in the range 1-100 Hz, are associated with the levels in at which only dark weak bosons are possible in the proposed model. Note that the size scales involved with EEG would be above the size scale of human body so that we would have some kind of continuation of the biological body to be distinguished from the magnetic body. The time scales assignable to the dark CDs would be huge: for instance, $k = 205$ would correspond to $T = 2^{42} \times .1$s making about 1395 years for electron.

2. Does magnetic body correspond to the space-time sheets carrying dark weak bosons?

The layers of the magnetic body relevant for EEG have have size of order Earth size. Natural time scale for the moment of sensory consciousness is measured as a fraction of second and the basic building blocks of our sensory experience corresponds to a fundamental period of .1 seconds. This scale appears already at $\hbar_0$ level for electron CD. The natural question concerns the relationship of the magnetic body to the $k > 205$ space-time sheets carrying only gauge bosons in the model and having size scale larger than that of biological body. Do they correspond to an extension of biological body or should they be regarded as parts of the magnetic body? The following observations suggest that they could correspond to layers of the magnetic body responsible for the fractal variant of EEG.

1. The primary p-adic time scales (Compton times) $T(239)$ and $T(241)$ correspond to frequencies, which are $2^{\pm 1/2}$ kHz. The geometric average $k = 240$ corresponds to kHz frequency. Is the appearance of kHz scale a mere accident or do the frequencies assignable to the quark CDs correspond to Compton times $\propto \sqrt{2^{k_{eff}/2}}$?

2. One can apply scalings by 2^{k_d} to the triplet $(239, 240, 241)$ to get a triplet $(239 + k_d, 240 + k_d, 241 + k_d)$. The results are summarized in Table 10. Clearly the frequencies in question cover also the EEG range. Note that these frequencies scale as $\sqrt{1/r}$ whereas Josephson frequencies scale as $1/r$.

k_d	f_1/Hz	f_2/Hz	f_3/Hz
0	707	1000	1412
4	177	250	354
6	89	1250	177
10	22.1	31.3	44.2
12	11.1	15.6	22.1
14	5.5	7.8	11.1
16	2.8	3.9	5.5
18	1.4	2.0	2.8
20	0.7	1.0	1.4
24	0.2	0.2	0.3

Table 10. The Compton frequencies obtained by scaling $2^{k_d/2}$ from the basic triplet $k_{eff} = (239, 240, 241)$. The values of k_d correspond to those predicted by the model based on Mersenne primes.

Also ZEG and WEG would appear but in much shorter scales dictated by k_{eff} and might accompany EEG. Somehow it seems that the effective masslessness of weak bosons below given scale is highly relevant for life. One can of course ask whether some larger Gaussian Mersenne could change the situation. There is a large gap in the distribution of Gaussian Mersennes after $k = 167$ and the next ones correspond to $M_{G,k}$, with k in $(239, 241, 283, 353, 367, 379, 457, 997)$ [38]. The twin pair $k = (239, 241)$ corresponds to a length scales $(1.6, 3.2) \times 10^2$ km and the minimum value for k_d are (72,74) ($167 \rightarrow (239, 241)$ transition).

3. Long term memory and ultralow Josephson frequencies

What determines the time scale associated with long term memory is a crucial question if one really wants to understand the basic aspects of consciousness.

1. Does the time scale correspond to the size scale of CD assignable to electron scaled by $r = \hbar/\hbar_0$? In this case relatively small values of r would be enough and $r = 2^{47}$ would give time scale of 10^{13} s for for electron's CD, which is about 3×10^5 years. This does not make sense.

2. Does Josephson frequency define the relevant time scale? In this case the long term memory would require the analog of EEG in the time scale of memory span. $k_{eff} = 205$ would give 6 ms time scale for memory from the assigment of $k_{eff} = 163$ to the Josephson photons at V=-50 mV implying $k_d = 42$. Minute scale would require $k_{eff} = 217$. The highest level $k_{eff} = 235$ allowed by the model involving only Gaussian Mersennes with $k \leq 167$ would correspond to a time scale of 77.67 days (day is 24 hours). For Gaussian Mersennes defined by $k_{eff} = (239, 241)$ the time scales become about (41.4,82.8) months (3.4 and 6.8 years). These scales should also define important biorhythms. The claimed 7 years rhythm of human life could relate to the latter rhythm: note that the precise value of the period depends on the membrane potential and thus varies. The presence of the scaled up variants of the by $k_d \leq 78$ allows longer time spans of long term memory and the scaling defined by $k_d = 167 - 163 = 4$ scales up the span of long term memories to (54.4,108.8) years.

4. Cultural evolution

Higher levels in the hierarchy would correspond mostly to the evolution of hyper-genome coding for culture and social structures. Introns are good candidate for the nucleodes involved. The development of speech faculty is certainly a necessary prerequisite for this breakthrough. Already EEG seems to correspond to dark layers of biological body larger than biological body so that one can cask whether the weak bosons and dark electrons in the length scales $k = 239, 241, 283, 353, 367, ...$ could be relevant for the collective aspect of consciousness and cultural evolution. Maybe the size scales $(175, 330)$ km and their scaled up variants by $k_d \leq 78$ might have something to do with the spatial scale of some typical social structure (not city: the area of New York is only 790 km^2).

6.6.3 Could insect colonies have "EEG"?

Only vertebrates can have EEG in 1-100 Hz range. According to the proposed model this means the presence of the $k > 205$ levels which can be regardd as a continuation of the biological body carrying dark weak bosons and having size scales larger than 1.25 m. That only vertebrates have EEG conforms with the empirical findings about the effects of ELF em fields on vertebrate brain.

This does not however imply that one could not assign EEG to the collective levels of consciousness. For instance, in the case of social insects forming colonies some kind of collective EEG might exist and explain the ability of the colony to behave like single organism. Indeed, ELF magnetic field and magnetic fields affect the behavior of honeybees just as ELF em fields affect the behavior of vertebrates [46]: the model for this findings led to a model for the fractal hierarchy of EEGs.

One could argue that insect brain is so simple (in the case of honeybee the number of neurons 1/1000 of number of neurons in human retina) that it is not possible to assign "personal" EEG to honeybee. The fact that a honeybee isolated from colony dies just as does the cell separated from organism, suggests that the relationship of insect to colony is like that of a cell to organism. Hence one could test whether colonies of social insects or their sub-colonies might possess an analog of ordinary EEG. What this would mean that ant colonies have sufficiently complex hyper-genome making possible collective variants of memory, sensory input, and intelligence, as well as the ability to realize collective motor actions. Even bacterium colonies have intricate social structures [47] so that one must remain open minded.

An objection against this line of thinking is that even in the case of collective EEG the proposed model assigns the Josephson frequencies with neurons. One might imagine Josephson frequencies at EEG range even in case of insects- say the queen of the nest. Since dark photons are in question the fields are very weak. I do not know whether any-one has got the crazy idea about checking whether beehive has EEG -certainly not any routine measurement! One an also imagine a fractal counterpart of EEG at the level of some individuals- say queen of the nest- at very low frequencies making possible long term memory.

Do honeybees have long term memory?

The realization that insect colonies rather than insects might correspond to higher $k_{eff} > 205$ levels of the dark matter hierarchy came via an indirect route. The article "Why honeybees never forget a face?" of New Scientist [52] described evidence supporting the view that that honeybees might possess long term memory in the time scale of days.

Adrian Dyer of the University of Cambridge and colleagues trained honeybees to associate a sucrose drink with a photograph of a particular face. The insects were then tested on their memory and recognition skills by being presented with the picture of this face and the pictures of three other faces not associated with any reward. Of the seven bees tested, two lost interest in the trial and flew away. But the five remaining bees correctly identified the target face in more than 80 per cent of trials, even though the reward had been removed. Moreover, some bees remembered the face two days later, indicating that they had formed a long-term memory of it.

1. The conservative explanation is that the achievement is due to keeping the face-honey association intact in the absence of the stimulus which created it in a time scale of days. For this option the ability of honeybee to express the distance and orientation to the food source could be hardwired involving no conscious memory about the flight. Also the interpretation of the honeybee dance telling the distance and orientation of food source to advices where to fly would be completely "instinctive"- whatever this means.

2. A more radical option is that honeybee hive rather than honeybee has long term memories in the sense as long term memories are interpreted in TGD framework: that is as communications with the geometric past. In this case the span of long term memories is determined by the level of dark matter hierarchy as time scale defined by Josephson frequency assignable to level of dark matter hierarchy in question and a span of few days for long term memories forces the conclusion $k_d \geq 63$: the upper bound is $k_d = 78$ (see Table 5), when one allows only $k \leq 167$ Mersennes and this corresponds to 87.6 years.

One can ask whether the ability of honey bee queen to found a new honeybee colony could involve long term memory in the time scale of year. If this were the case, the queen would not face her formidable challenge alone: the former colony in the geometric past still exists as a conscious entity and could communicate advices to the queen. The magnetic body of the former colony could exist also in the geometric now, being physically associated with the queen. This magnetic body could serve as the conscious entity communicating to the queen the advices and commands making possible to construct the beehive. A more conservative explanation is that these activities are genetically hardwired and instinctive (leaving open what 'instinctive' really means if it actually means anything).

The distinguished social position and anatomy of queen are consistent with the hypothesis that queen has more massive connections than other bees with the magnetic body of beehive. For instance, it is known that the new hive is oriented in exactly the similar manner as the old. Either long term memory or passive magnetic coding of the orientation of the hive with respect to Earth's magnetic field made possible by the magnetite in the abdomen of queen could explain this. The neurons of queen could correspond to a very large value of $\hbar$ giving rise to the required low Josephson frequencies.

The colony would have sensory resolution in a time scale of a fraction of second and short term memory in minute time scale. The counterpart of EEG at the level of hive is highly suggestive and conforms with the finding that ELF magnetic fields with strengths in the range .1-1 mT ($2B_E - 20B_E$ affect honeybee dance [46] as does also the absence of Earth's magnetic field. Interestingly, 1-2 mT DC field causes epileptiform activity in the case of humans [56] (the change of the DC field used seems to be more important that the period it is applied). Could the beehive suffer a kind of epileptic seizure!

The intentional actions of the honeybee colony would be realized via magnetic flux sheets traversing the super-genes of the insects participating to the action in question. Workers, soldiers, etc.. would act to some extent as organs of the colony being connected by hyper-genes of hyper-genome to larger units. Queen could act as the analog of a complex Grand Mother neuron in brain or a leader in human society.

This view can be criticized. Honeybee dance [49] is performed by forager bees and the dance represents among other things the angle between the lines connecting hive to the food source and sun as the angle between movement of bee and vertical direction (also other options are possible). The intricate pattern of the dance in turn codes for the distance to the food source. If beehive is a conscious entity using bees as its cells, why is honeybee dance needed at all? TGD based vision about the evolution of modern human society from a bicameral society in which individuals received advice and commands from "God" [28, 21], suggests an answer to this criticism. The society able to survive must be maximally flexible and allow maximal individual intelligence and maximal freedom of individual actions consistent with the overall goals. This requires delegation of simple tasks to lower levels meaning also that communications between individuals become necessary (the development of language and other communications parallels the transition from bicamerality to modern society in the case of humans). The communication itself might however involve also the beehive. Foreagers could be like the prophets of the bicameral society communicating in semitrance the advices of God to the colony.

It should be noticed in passing that honeybees have already earlier made a visit to TGD inspired theory of consciousness [26]. As discovered by topologist Barbara Shipman [37], honeybee dance has a mathematical description in terms of a construct assignable to color group SU(3) of gauge interactions between quarks and gluons. This led her to propose that color interactions might have some deep role in living matter. This is in a sharp contrast to the fact that color interactions as establishment knows them are completely invisible above the length scale of 10^{-15} meters. The TGD based prediction that there exists an entire hierarchy of scaled up copies of QCD, in particular QCDs with confinement length scale of order cell size, changes completely the situation.

Honeybees as magneto-receptors of the beehive or magnetic cells as magneto-receptors of bee?

Earth's magnetic field has a crucial status in the model of living systems even at the lowest levels of dark matter hierarchy so that Earth's magnetic field is expected to play a role in the functioning of all cells, also bees and ants. This is indeed the case.

It is known that that bees have two navigation systems. The first system is based on the direction of sun and polarization of solar light but does not work on cloudy days. The second navigation system uses Earth's magnetic field and is used in cloudy days. Bees have in their abdomen magnetite (Fe_3O_4) particles of size about 30 nm and iron storage protein ferritin which correspond 10 to nm sized super-paramagnetic particles [51]. Magnetite particles and ferritin in principle make possible magneto-reception instead of a mere passive compass behavior.

The minimum option is that honeybee itself does not receive any neural information about the magnetic field but acts as a passive magneto-receptor of the bee colony or sub-colony (such as workers flying to the food source) and that the information contained by the receptor grid allows the sub-colony to deduce its position in the varying magnetic field. "BEEG" would mediate this information to the magnetic body of the (sub-)colony and the general mechanism based on Josephson currents does not require nerve pulse patterns to achieve this.

Since foreagers seem to act as individuals able to navigate in the magnetic field of Earth, it would seem that some cells of the honeybee could act as magneto-receptors so that the reaction of the magnetic particles would be coded to a neural signal. It has been proposed that the changes in the shape of the configurations formed by magnetite particles in a varying magnetic field induce changes in the shape of neuron and in this manner can induce neural signal. This mechanism could also induce the voltage perturbations coding the information to the Josephson current giving rise to the sensory part of EEG as a state of coherent ELF photons. Perhaps the genes expressing these neurons are activated only in foragers and ferritin makes possible the magneto-reception in this sense.

Social bacteria and magneto-tactic bacteria

Magneto-tactic behavior of bacteria [54] was discovered for 30 years ago by microbiologist Richard P. Blakemore and means that certain motile, aquatic bacteria orient and migrate along magnetic field lines. This ability could be purely passive compass mechanism made possible by the magnetite detected in the bacteria.

During last years we have learned that bacteria are not simple creatures having only single goal: to multiply and fill the Earth. Bacteria are able to communicate and act co-operatively [47]. This raises the question whether hyper-genes could appear already at this level and whether bacteria acting as a colony they individual bacteria could act as magneto-receptors of colony allowing it to detect even variations of the magnetic field much like individual cells in the brain of vertebrates or perhaps even in the abdomen of honeybee are believed to serve as magneto-receptors.

Great leaps in evolution as emergence of higher levels of dark matter hierarchy at level of individuals

The vision about great leaps in evolution led to the view that the emergence of EEG corresponds to the emergence of $k_{eff} > 205$ levels of dark matter hierarchy. On the other hand, the time scale of gene translation corresponds to that associated with the ordinary EEG, which forces to ask whether these levels are present already in the lowest life forms. Perhaps a more plausible option is that the .1 second time scale of electronic CD defines the time scale of gene translation and corresponds therefore to the standard value of $\hbar_0$. The findings about honeybees however support the view that $k_{eff} > 205$ levels are present but are associated with the honeybee colony rather than individuals. This however requires that the these levels have neuronal realization in terms of Josephson frequencies.

Therefore a more precise formulation of the hypothesis about great leaps in evolution would be that great leaps in evolution correspond to the emergence of a new dark matter level at the level of individual organism. If this view is correct then $k_{eff} > 205$ levels would correspond to a collective level of consciousness in the case of invertebrates down to bacteria, which are indeed found to form societies [47]. This conforms also with the fact that the genome of invertebrates is too small to allow realization of $k_{eff} > 205$ flux sheets as genes or even super-genes. The somewhat unexpected conclusion would be that all activities of invertebrates involving gene expression would be controlled by collective levels of consciousness: invertebrates would not be individuals in this sense. Viruses do not possess DNA translation machinery which is consistent with the absence of also collective $k_{eff} > 205$ levels. One can of course ask whether the queen of honeybee could be an exception to this rule.

If one believes that the time scale of gene expression corresponds to Josephson frequency then the explanation for the universality of the genetic code could be that $k_{eff} > 205$ levels controls gene expression: for $k_{eff} > 205$ wave length scale indeed corresponds to the length scale assignable to the magnetosphere of Earth. One could of course counter argue that it is more reasonable form magnetic Mother Gaia to delegate this kind of duties to the lower levels and that the CDs of electron and quarks are ideal for this purpose.

6.6.4 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 as 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 crebella 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 [63]. 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 [74]. 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 [74] 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 [70] 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 [70] 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 [73], 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 [59] 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 corresponds 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.

6.7 Appendix

6.7.1 Hierarchy of Planck constants and the generalization of the notion of imbedding space

In the following the recent view about structure of imbedding space forced by the quantization of Planck constant is summarized. The question is whether it might be possible in some sense to replace H or its Cartesian factors by their necessarily singular multiple coverings and factor spaces. One can consider two options: either M^4 or the causal diamond CD. The latter one is the more plausible option from the point of view of WCW geometry.

The evolution of physical ideas about hierarchy of Planck constants

The evolution of the physical ideas related to the hierarchy of Planck constants and dark matter as a hierarchy of phases of matter with non-standard value of Planck constants was much faster than the evolution of mathematical ideas and quite a number of applications have been developed during last five years [20, 18, 19].

1. The starting point was the proposal of Nottale [40] that the orbits of inner planets correspond to Bohr orbits with Planck constant $\hbar_{gr} = GMm/v_0$ and outer planets with Planck constant $\hbar_{gr} = 5GMm/v_0$, $v_0/c \simeq 2^{-11}$. The basic proposal [18, 19] was that ordinary matter condenses around dark matter which is a phase of matter characterized by a non-standard value of Planck constant whose value is gigantic for the space-time sheets mediating gravitational interaction. The interpretation of these space-time sheets could be as magnetic flux quanta or as massless extremals assignable to gravitons.

2. Ordinary particles possibly residing at these space-time sheet have enormous value of Compton length meaning that the density of matter at these space-time sheets must be very slowly varying. The string tension of string like objects implies effective negative pressure characterizing dark energy so that the interpretation in terms of dark energy might make sense [21]. TGD predicted a one-parameter family of Robertson-Walker cosmologies with critical or over-critical mass density and the "pressure" associated with these cosmologies is negative.

3. The quantization of Planck constant does not make sense unless one modifies the view about standard space-time is. Particles with different Planck constant must belong to different worlds in the sense local interactions of particles with different values of $\hbar$ are not possible. This inspires the idea about the book like structure of the imbedding space obtained by gluing almost copies of H together along common "back" and partially labeled by different values of Planck constant.

4. Darkness is a relative notion in this framework and due to the fact that particles at different pages of the book like structure cannot appear in the same vertex of the generalized Feynman diagram. The phase transitions in which partonic 2-surface X^2 during its travel along X^3_l leaks to another page of book are however possible and change Planck constant. Particle (say photon -) exchanges of this kind allow particles at different pages to interact. The interactions are strongly constrained by charge fractionization and are essentially phase transitions involving many particles. Classical interactions are also possible. It might be that we are actually observing dark matter via classical fields all the time and perhaps have even photographed it [24].

5. The realization that non-standard values of Planck constant give rise to charge and spin fractionization and anyonization led to the precise identification of the prerequisites of anyonic phase. If the partonic 2-surface, which can have even astrophysical size, surrounds the tip of CD, the matter at the surface is anyonic and particles are confined at this surface. Dark matter could be confined inside this kind of light-like 3-surfaces around which ordinary matter condenses. If the radii of the basic pieces of these nearly spherical anyonic surfaces - glued to a connected structure by flux tubes mediating gravitational interaction - are given by Bohr rules, the findings of Nottale [40] can be understood. Dark matter would resemble to a high degree matter in black holes replaced in TGD framework by light-like partonic 2-surfaces with a minimum size of order Schwartschild radius r_S of order scaled up Planck length $l_{Pl} = \sqrt{\hbar_{gr}G} = GM$. Black hole entropy is inversely proportional to $\hbar$ and predicted to be of order unity so that dramatic modification of the picture about black holes is implied.

6. Perhaps the most fascinating applications are in biology. The anomalous behavior ionic currents through cell membrane (low dissipation, quantal character, no change when the membrane is replaced with artificial one) has a natural explanation in terms of dark supra currents. This leads to a vision about how dark matter and phase transitions changing the value of Planck constant could relate to the basic functions of cell, functioning of DNA and aminoacids, and to the mysteries of bio-catalysis. This leads also a model for EEG interpreted as a communication and control tool of magnetic body containing dark matter and using biological body as motor instrument and sensory receptor. One especially amazing outcome is the emergence of genetic code of vertebrates from the model of dark nuclei as nuclear strings [36, 24].

The most general option for the generalized imbedding space

Simple physical arguments pose constraints on the choice of the most general form of the imbedding space.

1. The fundamental group of the space for which one constructs a non-singular covering space or factor space should be non-trivial. This is certainly not possible for M^4, CD, CP_2, or H. One can however construct singular covering spaces. The fixing of the quantization axes implies a selection of the sub-space $H_4 = M^2 \times S^2 \subset M^4 \times CP_2$, where S^2 is geodesic sphere of CP_2. $\hat{M}^4 = M^4 \backslash M^2$ and $\hat{CP}_2 = CP_2 \backslash S^2$ have fundamental group Z since the codimension of the excluded sub-manifold is equal to two and homotopically the situation is like that for a punctured plane. The exclusion of these sub-manifolds defined by the choice of quantization axes could naturally give rise to the desired situation.

2. CP_2 allows two geodesic spheres which left invariant by $U(2$ *resp.* $SO(3)$. The first one is homologically non-trivial. For homologically non-trivial geodesic sphere $H_4 = M^2 \times S^2$ represents a straight cosmic string which is non-vacuum extremal of Kähler action (not necessarily preferred extremal). One can argue that the many-valuedness of $\hbar$ is un-acceptable for non-vacuum extremals so that only homologically trivial geodesic sphere S^2 would be acceptable. One could go even further. If the extremals in $M^2 \times CP_2$ can be preferred non-vacuum extremals, the singular coverings of M^4 are not possible. Therefore only the singular coverings and factor spaces of CP_2 over the homologically trivial geodesic sphere S^2 would be possible. This however looks a non-physical outcome.

   (a) The situation changes if the extremals of type $M^2 \times Y^2$, Y^2 a holomorphic surface of CP_3, fail to be hyperquaternionic. The tangent space M^2 represents hypercomplex sub-space and the product of the modified gamma matrices associated with the tangent spaces of Y^2 should belong to M^2 algebra. This need not be the case in general.

   (b) The situation changes also if one reinterprets the gluing procedure by introducing scaled up coordinates for M^4 so that metric is continuous at $M^2 \times CP_2$ but CDs with different size have different sizes differing by the ratio of Planck constants and would thus have only piece of lower or upper boundary in common.

3. For the more general option one would have four different options corresponding to the Cartesian products of singular coverings and factor spaces. These options can be denoted by $C-C$, $C-F$, $F-C$, and $F-F$, where C (F) signifies for covering (factor space) and first (second) letter signifies for CD (CP_2) and correspond to the spaces $(\hat{CD}\hat{\times}G_a) \times (\hat{CP}_2\hat{\times}G_b)$, $(\hat{CD}\hat{\times}G_a) \times \hat{CP}_2/G_b$, $\hat{CD}/G_a \times (\hat{CP}_2\hat{\times}G_b)$, and $\hat{CD}/G_a \times \hat{CP}_2/G_b$.

4. The groups G_i could correspond to cyclic groups Z_n. One can also consider an extension by replacing M^2 and S^2 with its orbit under more general group G (say tedrahedral, octahedral, or icosahedral group). One expects that the discrete subgroups of $SU(2)$ emerge naturally in this framework if one allows the action of these groups on the singular sub-manifolds M^2 or S^2. This would replace the singular manifold with a set of its rotated copies in the case that the subgroups have genuinely 3-dimensional action (the subgroups which corresponds to exceptional groups in the ADE correspondence). For instance, in the case of M^2 the quantization axes for angular momentum would be replaced by the set of quantization axes going through the vertices of tedrahedron, octahedron, or icosahedron. This would bring non-commutative homotopy groups into the picture in a natural manner.

About the phase transitions changing Planck constant

There are several non-trivial questions related to the details of the gluing procedure and phase transition as motion of partonic 2-surface from one sector of the imbedding space to another one.

1. How the gluing of copies of imbedding space at $M^2 \times CP_2$ takes place? It would seem that the covariant metric of CD factor proportional to $\hbar^2$ must be discontinuous at the singular manifold since only in this manner the idea about different scaling factor of CD metric can make sense. On the other hand, one can always scale the M^4 coordinates so that the metric is continuous but the sizes of CDs with different Planck constants differ by the ratio of the Planck constants.

2. One might worry whether the phase transition changing Planck constant means an instantaneous change of the size of partonic 2-surface in M^4 degrees of freedom. This is not the case. Light-likeness in $M^2 \times S^2$ makes sense only for surfaces $X^1 \times D^2 \subset M^2 \times S^2$, where X^1 is light-like geodesic. The requirement that the partonic 2-surface X^2 moving from one sector of H to another one is light-like at $M^2 \times S^2$ irrespective of the value of Planck constant requires that X^2 has single point of M^2 as M^2 projection. Hence no sudden change of the size X^2 occurs.

3. A natural question is whether the phase transition changing the value of Planck constant can occur purely classically or whether it is analogous to quantum tunneling. Classical non-vacuum extremals of Chern-Simons action have two-dimensional CP_2 projection to homologically non-trivial geodesic sphere S^2_I. The deformation of the entire S^2_I to homologically trivial geodesic sphere S^2_{II} is not possible so that only combinations of partonic 2-surfaces with vanishing total homology charge (Kähler magnetic charge) can in principle move from sector to another one, and this process involves fusion of these 2-surfaces such that CP_2 projection becomes single homologically trivial 2-surface. A piece of a non-trivial geodesic sphere S^2_I of CP_2 can be deformed to that of S^2_{II} using 2-dimensional homotopy flattening the piece of S^2 to curve. If this homotopy cannot be chosen to be light-like, the phase transitions changing Planck constant take place only via quantum tunnelling. Obviously the notions of light-like homotopies (cobordisms) are very relevant for the understanding of phase transitions changing Planck constant.

How could one fix the spectrum of Planck constants?

The question how the observed Planck constant relates to the integers n_a and n_b defining the covering and factors spaces, is far from trivial and I have considered several options. The basic physical inputs are the condition that scaling of Planck constant must correspond to the scaling of the metric of CD (that is Compton lengths) on one hand and the scaling of the gauge coupling strength $g^2/4\pi\hbar$ on the other hand.

1. One can assign to Planck constant to both CD and CP_2 by assuming that it appears in the commutation relations of corresponding symmetry algebras. Algebraist would argue that Planck constants $\hbar(CD)$ and $\hbar(CP_2)$ must define a homomorphism respecting multiplication and division (when possible) by G_i. This requires $r(X) = \hbar(X)\hbar_0 = n$ for covering and $r(X) = 1/n$ for factor space or vice versa.

2. If one assumes that $\hbar^2(X)$, $X = M^4$, CP_2 corresponds to the scaling of the covariant metric tensor g_{ij} and performs an over-all scaling of H-metric allowed by the Weyl invariance of Kähler action by dividing metric with $\hbar^2(CP_2)$, one obtains the scaling of M^4 covariant metric by $r^2 \equiv \hbar^2/\hbar_0^2 = \hbar^2(M^4)/\hbar^2(CP_2)$ whereas CP_2 metric is not scaled at all.

3. The condition that $\hbar$ scales as n_a is guaranteed if one has $\hbar(CD) = n_a\hbar_0$. This does not fix the dependence of $\hbar(CP_2)$ on n_b and one could have $\hbar(CP_2) = n_b\hbar_0$ or $\hbar(CP_2) = \hbar_0/n_b$. The intuitive picture is that n_b- fold covering gives in good approximation rise to $n_a n_b$ sheets and multiplies YM action action by $n_a n_b$ which is equivalent with the $\hbar = n_a n_b\hbar_0$ if one effectively compresses the covering to $CD \times CP_2$. One would have $\hbar(CP_2) = \hbar_0/n_b$ and $\hbar = n_a n_b\hbar_0$. Note that the descriptions using ordinary Planck constant and coverings and scaled Planck constant but contracting the covering would be alternative descriptions.

   This gives the following formulas $r \equiv \hbar/\hbar_0 = r(M^4)/r(CP_2)$ in various cases.

	$C-C$	$F-C$	$C-F$	$F-F$
r	$n_a n_b$	$\frac{n_a}{n_b}$	$\frac{n_b}{n_a}$	$\frac{1}{n_a n_b}$

Preferred values of Planck constants

Number theoretic considerations favor the hypothesis that the integers corresponding to Fermat polygons constructible using only ruler and compass and given as products $n_F = 2^k \prod_s F_s$, where $F_s = 2^{2^s} + 1$ are distinct Fermat primes, are favored. The reason would be that quantum phase $q = exp(i\pi/n)$ is in this case expressible using only iterated square root operation by starting from rationals. The known Fermat primes correspond to $s = 0, 1, 2, 3, 4$ so that the hypothesis is very strong and predicts that p-adic length scales have satellite length scales given as multiples of n_F of fundamental p-adic length scale. $n_F = 2^{11}$ corresponds in TGD framework to a fundamental constant expressible as a combination of Kähler coupling strength, CP_2 radius and Planck length appearing in the expression for the tension of cosmic strings, and I have considered the possibility that the powers of 2^{11} are favored as values of n_a in living matter.

How Planck constants are visible in Kähler action?

$\hbar(M^4)$ and $\hbar(CP_2)$ appear in the commutation and anticommutation relations of various superconformal algebras. Only the ratio of M^4 and CP_2 Planck constants appears in Kähler action and is due to the fact that the M^4 and CP_2 metrics of the imbedding space sector with given values of Planck constants are proportional to the corresponding Planck constants [20]. This implies that Kähler function codes for radiative corrections to the classical action, which makes possible to consider the possibility that higher order radiative corrections to functional integral vanish as one might expect at quantum criticality. For a given p-adic length scale space-time sheets with all allowed values of Planck constants are possible. Hence the spectrum of quantum critical fluctuations could in the ideal case correspond to the spectrum of $\hbar$ coding for the scaled up values of Compton lengths and other quantal lengths and times. If so, large $\hbar$ phases could be crucial for understanding of quantum critical superconductors, in particular high T_c superconductors.

Do factor spaces and coverings correspond to the two kinds of Jones inclusions?

What could be the interpretation of these two kinds of spaces?

1. Jones inclusions appear in two varieties corresponding to $\mathcal{M} : \mathcal{N} < 4$ and $\mathcal{M} : \mathcal{N} = 4$ and one can assign a hierarchy of subgroups of $SU(2)$ with both of them. In particular, their maximal Abelian subgroups Z_n label these inclusions. The interpretation of Z_n as invariance group is natural for $\mathcal{M} : \mathcal{N} < 4$ and it naturally corresponds to the coset spaces. For $\mathcal{M} : \mathcal{N} = 4$ the interpretation of Z_n has remained open. Obviously the interpretation of Z_n as the homology group defining covering would be natural.

2. $\mathcal{M} : \mathcal{N} = 4$ should correspond to the allowance of cosmic strings and other analogous objects. Does the introduction of the covering spaces bring in cosmic strings in some controlled manner? Formally the subgroup of $SU(2)$ defining the inclusion is $SU(2)$ would mean that states are $SU(2)$ singlets which is something non-physical. For covering spaces one would however obtain the degrees of freedom associated with the discrete fiber and the degrees of freedom in question would not disappear completely and would be characterized by the discrete subgroup of $SU(2)$.

   For anyons the non-trivial homotopy of plane brings in non-trivial connection with a flat curvature and the non-trivial dynamics of topological QFTs. Also now one might expect similar non-trivial contribution to appear in the spinor connection of $\hat{M}^2\hat{\times}G_a$ and $\hat{CP}_2\hat{\times}G_b$. In conformal field theory models non-trivial monodromy would correspond to the presence of punctures in plane.

3. For factor spaces the unit for quantum numbers like orbital angular momentum is multiplied by n_a *resp.* n_b and for coverings it is divided by this number. These two kind of spaces are in a well defined sense obtained by multiplying and dividing the factors of $\hat{H}$ by G_a *resp.* G_b and multiplication and division are expected to relate to Jones inclusions with $\mathcal{M} : \mathcal{N} < 4$ and $\mathcal{M} : \mathcal{N} = 4$, which both are labelled by a subset of discrete subgroups of SU(2).

4. The discrete subgroups of $SU(2)$ with fixed quantization axes possess a well defined multiplication with product defined as the group generated by forming all possible products of group elements as elements of $SU(2)$. This product is commutative and all elements are idempotent and thus analogous to projectors. Trivial group G_1, two-element group G_2 consisting of reflection and identity, the cyclic groups Z_p, p prime, and tedrahedral, octahedral, and icosahedral groups are the generators of this algebra.

   By commutativity one can regard this algebra as an 11-dimensional module having natural numbers as coefficients ("rig"). The trivial group G_1, two-element group G_2¡ generated by reflection, and tedrahedral, octahedral, and icosahedral groups define 5 generating elements for this algebra. The products of groups other than trivial group define 10 units for this algebra so that there are 11 units altogether. The groups Z_p generate a structure analogous to natural numbers acting as analog of coefficients of this structure. Clearly, one has effectively 11-dimensional commutative algebra in 1-1 correspondence with the 11-dimensional "half-lattice" N^{11} (N denotes natural numbers). Leaving away reflections, one obtains N^7. The projector representation suggests a connection with Jones inclusions. An interesting question concerns the possible Jones inclusions assignable to the subgroups containing infinitely manner elements. Reader has of course already asked whether dimensions 11, 7 and their difference 4 might relate somehow to the mathematical structures of M-theory with 7 compactified dimensions. One could introduce generalized configuration space spinor fields in the configuration space labelled by sectors of H with given quantization axes. By introducing Fourier transform in N^{11} one would formally obtain an infinite-component field in 11-D space.

5. How do the Planck constants associated with factors and coverings relate? One might argue that Planck constant defines a homomorphism respecting the multiplication and division (when possible) by G_i. If so, then Planck constant in units of $\hbar_0$ would be equal to n_a/n_b for $\hat{H}/G_a \times G_b$ option and n_b/n_a for $\hat{H}\hat{\times}(G_a \times G_b)$ with obvious formulas for hybrid cases. This option would put M^4 and CP_2 in a very symmetric role and allow much more flexibility in the identification of symmetries associated with large Planck constant phases.

6.7.2 Em cyclotron frequencies of biologically important ions

A detailed study of the cyclotron frequencies demonstrates that they indeed seem to correspond to important EEG frequencies. The cyclotron frequencies associated with other singly ionized atoms can be obtained by the formula

$$f = \frac{A}{20} \times f(Ca^{2+}) \qquad f(Ca^{2+}) \simeq 15\ Hz \ . \tag{6.7.1}$$

Here the strength of the magnetic field is assumed to be $B_{end} = .2$ Gauss $= 2\times 10^{-5}$ Tesla. Note that published material there was an erratic identification $B = B_E = .5$ Gauss due to the calculational error.

The following table lists cyclotron frequencies and their lowest multiples for some of the most important ions.

Elementary particle	f_1/Hz	J	f_L/Hz
e	5.6×10^5	1/2	2.8×10^5
p	300	1/2	419
Bosonic ions			
^6Li	50.1	1	88.3
O^{2-}	37.4	0	0
Mg^{++}	25.0	0	0
Ca^{++}	15.0	0	0
Mn^{2+}	11.4	5/2	520
Fe^{2+}	10.8	0	0
Co^{2+}	10.0	7/2	695
Zn^{2+}	9.4	0	0
Se^{2-}	7.6	0	0
Fermionic ions			
$^7Li^+$	42.9	3/2	489
N^+	21.4	1	60.6
F^-	15.8	1/2	395
Na^+	13.0	3/2	333
Al^+	11.1	5/2	546
Si^+	10.7	0	0
P^+	9.7	1/2	170
S^-	9.4	0	0
Cl^-	8.5	3/2	130
K^+	7.5	3/2	58.5
Cr^-	5.7	3/2	71.1
Cu^+	4.8	3/2	333.9
Ag^+	2.8	1/2	17
I^+	2.4	5/2	420
Au^+	1.5	3/2	21

Table 11. The first column gives cyclotron frequency in cycles per second for some ions in Earth's magnetic field assumed to have strength $B_{end} = .2 \times 10^{-4}$ Tesla. The remaining columns give spin or nuclear spin and Larmor frequency f_L.

6.7.3 Cyclotron frequencies of exotic ions and periodic table

Exotic em and Z^0 ions result when some color bonds in atomic nucleus become charged and are simultaneously ordinary ions. By magnetic flux quantization Z^0 magnetic cyclotron frequencies differ from their electromagnetic counterparts for singly charged ions only by charge ratio factors $Q_Z/Q_{Z,0}$. Hence it is convenient to represent electromagnetic cyclotron frequencies instead. The ions in various periods correspond to bands of EEG: it seems however that satellites of the harmonics of cyclotron frequencies beta and theta bands and that harmonics of frequencies in alpha band provides a more natural explanation for gamma and higher bands. For completeness cyclotron frequencies for all periods are given although the biologically important heavy ions are rather scarce.

Ions in Helium period correspond to beta and gamma bands

The table below lists the relevant data about ions in He period. Cyclotron frequencies are in the range $(15.8 - 75)$ Hz for nuclear exotic ionization which respects statistics. Note that Be and N atoms are exceptional being fermions in ground state. Li ion has rather high cyclotron frequency 42.9 Hz.

Ion	(Z,A,S)	f_1/Hz	Ion	(Z,A,S)	f_1/Hz
He	(2,4, F)	75	C	(6,12,F)	25.0
Li	(3,7, F)	42.9	N	(7,14,B)	21.4
Be	(4,9,B)	33.3	O	(8,16,F)	18.8
B	(5,11,F)	27.3	F	(9,19,F)	15.8

Table 12. Basic data for the ions in Helium period. Cyclotron frequency and nuclear spin for exotic ion with unit electric charge due to the charged color bond in nucleus. F or B tells the statistics of the electronically ionized atom (most atoms are bosons in ground state).

Ions in Neon period correspond to alpha band

For Neon period nuclear exotic ionization the frequencies span the range $8.5 - 15.0$ Hz: only 15 Hz cyclotron frequency of Ne belongs to beta band.

Ion	(Z,A,S)	f_1/Hz	Ion	(Z,A,S)	f_1/Hz
Ne	(10,20,F)	15.0	Si	(14,28,F)	10.7
Na	(11,23,F)	13.0	P	(15,31,F)	9.7
Mg	(12,24,F)	12.5	S	(16,32,F)	9.4
Al	(13,27,F)	11.1	Cl	(17,35,F)	8.5

Table 13. One can arrange the exotic ions in Neon period to one triplet of exotic ions allowing also spin flip qualia and to a quintet assigned with cyclotron qualia. For the meanings of various notations see previous table.

Ions in Argon period correspond to theta band

Singly ionized exotic ions in Argon period have cyclotron frequencies in the range ($3.6\ Hz < f \leq 7.5\ Hz$).

Ion	(Z,A,S)	f_1/Hz	Ion	(Z,A,S)	f_1/Hz
Ar	(18,40,F)	7.5	Co	(27,59,F)	5.0
K	(19,39,F)	7.5	Ni	(28,58,F)	5.2
Ca	(20,40,F)	7.5	Cu	(29,63,F)	4.8
Sc	(21,45,F)	6.7	Zn	(30,64,F)	4.7
Ti	(22,48,F)	6.3	Ga	(31,69,F)	4.3
V	(23,51,F)	5.9	Ge	(32,74,F)	4.1
Cr	(24,52,F)	5.7	As	(33,75,F)	4.0
Mn	(25,55,F)	5.5	Se	(34,80,F)	3.8
Fe	(26,56,F)	5.4	Br	(35,79,F)	3.8

Table 14. Basic data for singly charged exotic ions with frequencies in Argon period and having cyclotron frequencies in theta band.

Ions in Krypton period correspond to delta band

Krypton period provides an almost identical copy of Argon period. The cyclotron frequencies of Krypton band are in the range $2.3 - 3.5$ Hz.

Ion	(Z,A,S)	f_1/Hz	Ion	(Z,A,S)	f_1/Hz
Kr	(36,84,F)	3.6	Rh	(45,103,F)	2.9
Rb	(37,85,F)	3.5	Pd	(46,108,F)	2.8
Sr	(38,86,F)	3.5	Cd	(48,114,F)	2.6
Y	(39,89,F)	3.4	Ag	(47,107,F)	2.8
Zr	(40,90,F)	3.3	In	(49,115,F)	2.6
Nb	(41,93,F)	3.2	Sn	(50,120,F)	2.5
Mo	(42,98,F)	3.0	Sb	(51,121,F)	2.5
Tc	(43,99,F)	3.0	Te	(52,130,F)	2.3
Ru	(44,102,F)	2.9	I	(53,127,F)	2.4

Table 15. Basic data for singly charged exotic ions having [Kr] as ground state configuration. Tc does not allow stable isotopes but the lifetimes of two long-lived Tc isotopes are 1.5×10^6 years and 2.1×10^5 years.

Basic data for Xenon period

The table below lists ions with [Xe] ground state. Note that all ions in Xe band do not have stable isotopes and it is questionable whether any biologically interesting ions are in this period. Cyclotron frequencies of singly charged exotic ions in Xenon period vary in the range $1.5 - 2.2$ Hz.

Ion	(Z,A,S)	f_1/Hz	Ion	(Z,A,S)	f_1/Hz
Xe	(54,132,F)	2.3	Yb	(70,174,F)	1.7
Cs	(55,133,F)	2.3	Lu	(71,176,B)	1.7
Ba	(56,138,F)	2.2	Hf	(72,178,F)	1.7
La	(57,139,F)	2.2	Ta	(73,181,F)	1.7
Ce	(58,140,F)	2.1	W	(74,184,F)	1.6
Pr	(59,141,F)	2.1	Re	(75,187,F)	1.6
Nd	(60,142,F)	2.1	Os	(76,192,F)	1.6
Pm	(61,147,F)	2.0	Ir	(77,193,F)	1.6
Sm	(62,152,F)	2.3	Pt	(78,195,B)	1.5
Eu	(63,154,B)	1.9	Au	(79,197,F)	1.5
Gd	(64,158,F)	2.0	Hg	(80,202,F)	1.5
Tb	(65,160,F)	1.9	Ti	(81,205,F)	1.5
Dy	(66,164,F)	1.8	Pb	(82,206,F)	1.5
Ho	(67,165,F)	1.8	Bi	(83,209,F)	1.4
Er	(68,166,F)	1.8	Po	(84,209,F)	1.4
Tm	(69,?,?)	?	At	(85,211,F)	1.4

Table 16. Basic data for ions with having [Xe] as ground state configuration.

Bibliography

Books about TGD

[1] M. Pitkänen (2006), *Topological Geometrodynamics: Overview*. http://tgd.wippiespace.com/public_html/tgdview/tgdview.html.

[2] M. Pitkänen (2006), *Quantum Physics as Infinite-Dimensional Geometry*. http://tgd.wippiespace.com/public_html/tgdgeom/tgdgeom.html.

[3] M. Pitkänen (2006), *Physics in Many-Sheeted Space-Time*. http://tgd.wippiespace.com/public_html/tgdclass/tgdclass.html.

[4] M. Pitkänen (2006), *p-Adic length Scale Hypothesis and Dark Matter Hierarchy*. http://tgd.wippiespace.com/public_html/paddark/paddark.html.

[5] M. Pitkänen (2006), *Quantum TGD*. http://tgd.wippiespace.com/public_html/tgdquant/tgdquant.html.

[6] M. Pitkänen (2006), *TGD as a Generalized Number Theory*. http://tgd.wippiespace.com/public_html/tgdnumber/tgdnumber.html.

[7] M. Pitkänen (2006), *TGD and Fringe Physics*. http://tgd.wippiespace.com/public_html/freenergy/freenergy.html.

Books about TGD Inspired Theory of Consciousness and Quantum Biology

[8] M. Pitkänen (2006), *TGD Inspired Theory of Consciousness*. http://tgd.wippiespace.com/public_html/tgdconsc/tgdconsc.html.

[9] M. Pitkänen (2006), *Bio-Systems as Self-Organizing Quantum Systems*. http://tgd.wippiespace.com/public_html/bioselforg/bioselforg.html.

[10] M. Pitkänen (2006), *Quantum Hardware of Living Matter*. http://tgd.wippiespace.com/public_html/bioware/bioware.html.

[11] M. Pitkänen (2006), *Bio-Systems as Conscious Holograms*. http://tgd.wippiespace.com/public_html/hologram/hologram.html.

[12] M. Pitkänen (2006), *Genes and Memes*. http://tgd.wippiespace.com/public_html/genememe/genememe.html.

[13] M. Pitkänen (2006), *Magnetospheric Consciousness*. http://tgd.wippiespace.com/public_html/magnconsc/magnconsc.html.

[14] M. Pitkänen (2006), *Mathematical Aspects of Consciousness Theory*. http://tgd.wippiespace.com/public_html/mathconsc/mathconsc.html.

[15] M. Pitkänen (2006), *TGD and EEG*. http://tgd.wippiespace.com/public_html/tgdeeg/tgdeeg.html.

References to the chapters of the books about TGD

[16] The chapter *Construction of Quantum Theory: S-matrix* of [3].
http://tgd.wippiespace.com/public_html/tgdquant/tgdquant.html#towards.

[17] The chapter *Nuclear String Model* of [6].
http://tgd.wippiespace.com/public_html/paddark/paddark.html#nuclstring.

[18] The chapter *TGD and Astrophysics* of [4].
http://tgd.wippiespace.com/public_html/tgdclass/tgdclass.html#astro.

[19] The chapter *Quantum Astrophysics* of [4].
http://tgd.wippiespace.com/public_html/tgdclass/tgdclass.html#qastro.

[20] The chapter *Does TGD Predict the Spectrum of Planck Constants?* of [3].
http://tgd.wippiespace.com/public_html/tgdquant/tgdquant.html#Planck.

[21] The chapter *TGD and Cosmology* of [4].
http://tgd.wippiespace.com/public_html/tgdclass/tgdclass.html#cosmo.

[22] The chapter *Cosmic Strings* of [4].
http://tgd.wippiespace.com/public_html/tgdclass/tgdclass.html#cstrings.

References to the chapters of the books about TGD Inspired Theory of Consciousness and Quantum Biology

[23] The chapter *Three new physics realizations of the genetic code and the role of dark matter in bio-systems* of [12].
http://tgd.wippiespace.com/public_html/genememe/genememe.html#dnatqccodes.

[24] The chapter *The Notion of Wave-Genome and DNA as Topological Quantum Computer* of [12].
http://tgd.wippiespace.com/public_html/genememe/genememe.html#gari.

[25] The chapter *Quantum Model for Nerve Pulse* of [13].
http://tgd.wippiespace.com/public_html//tgdeeg/tgdeeg/tgdeeg.html#pulse.

[26] The chapter *Quantum Model for Hearing* of [13].
http://tgd.wippiespace.com/public_html//tgdeeg/tgdeeg/tgdeeg.html#hearing.

[27] The chapter *Semi-trance, Mental Illness, and Altered States of Consciousness* of [14].
http://tgd.wippiespace.com/public_html/magnconsc/magnconsc.html#semitrancec.

[28] The chapter *DNA as Topological Quantum Computer* of [12].
http://tgd.wippiespace.com/public_html/genememe/genememe.html#dnatqc.

[29] The chapter *Bio-Systems as Super-Conductors: part I* of [10].
http://tgd.wippiespace.com/public_html/bioware/bioware.html#superc1.

[30] The chapter *Homeopathy in Many-Sheeted Space-Time* of [11].
http://tgd.wippiespace.com/public_html/hologram/hologram.html#homeoc.

[31] The chapter *General Theory of Qualia* of [11].
http://tgd.wippiespace.com/public_html/hologram/hologram.html#qualia.

[32] The chapter *Negentropy Maximization Principle* of [8].
http://tgd.wippiespace.com/public_html/tgdconsc/tgdconsc.html#nmpc.

[33] The chapter *Topological Quantum Computation in TGD Universe* of [12].
http://tgd.wippiespace.com/public_html/genememe/genememe.html#tqc.

[34] The chapter *Biological Realization of Self Hierarchy* of [9].
http://tgd.wippiespace.com/public_html/bioselforg/bioselforg.html#bioselfc.

[35] The chapter *Semitrance, Language, and Development of Civilization* of [14].
http://tgd.wippiespace.com/public_html/magnconsc/magnconsc.html#langsoc.

Articles related to TGD

[36] M. Pitkänen (2007), *Further Progress in Nuclear String Hypothesis*, http://tgd.wippiespace.com/public_html/articles/nuclstring.pdf.

Mathematics

[37] B. Shipman (1998) *The geometry of momentum mappings on generalized flag manifolds, connections with a c mechanics and the dance of honeybee.* http://math.cornell.edu/~oliver/Shipman.gif.
B. Shipman (1998), *On the geometry of certain isospectral sets in the full Kostant-Toda lattice.* http://nyjm.albany.edu:8000/PacJ/1997/Shipman.html.
B. Shipman (1998), *A symmetry of order two in the full Kostant-Toda lattice.* http://www.math.rochester.edu:8080/u/shipman/symmetrypaper/.

[38] *Gaussian Mersenne.* http://primes.utm.edu/glossary/xpage/GaussianMersenne.html.

Theoretical physics

[39] G. Baym (1969), *Lectures on Quantum Mechanics*, W. A. Benjamin, Inc..

Cosmology and astrophysics

[40] D. Da Roacha and L. Nottale (2003), *Gravitational Structure Formation in Scale Relativity.* astro-ph/0310036.

[41] *Age of the universe.* http://en.wikipedia.org/wiki/Age_of_the_universe.

[42] G. Elert (2005)*Electric Field on Earth.* http://hypertextbook.com/facts/1998/TreshaEdwards.shtml.

[43] A. Saleh (2001), *Capturing the Earth's songs.* ABC Science Online. http://www.abc.net.au/science/news/stories/s237849.htm.

Fringe physics

[44] For the descriptions of Hudson's findings see *Mono-atomic elements*, http://www.halexandria.org/dward479.htm, and
David Hudson at IFNS, http://www.halexandria.org/dward467.htm.

[45] *The Golden Mean and Heart Harmonics*, http://www.worldhealing.net/goldenmean.html.

Biology related references

[46] J. L. Kirschvink (1992), Comment on *Constraints on biological effects of weak extremely-low-frequency electromagnetic fields'*. Phys. Rev. A 43, 1039 (1991). http://prola.aps.org/abstract/PRA/v46/i4/p2178_1.

[47] S. Silberman (2003), *The Bacteria Whisperer*. Wired Magazine, Issue 11.04, April 2003 http://www.wired.com/wired/archive/11.04/quorum.html.

[48] *Nanobe*. http://en.wikipedia.org/wiki/Nanobe.

[49] K. S. Kruszelnicki, *Magnetic Bees*. http://www.abc.net.au/science/k2/trek/4wd/Over57.htm.

[50] *Nanobacterium*. http://en.wikipedia.org/wiki/Nanobacterium.

[51] M. Desoil *et al* (2005), *Definitive identification of magnetite nanoparticles in the abdomen of the honeybee Apis mellifera*. Journal of Physics: Conference Series 17, 45-49. http://ej.iop.org/links/q70/2pNVzYq3setVI3vrKSt,Eg/jpconf5_17_007.pdf.
See also
Social Insects and the Earth's Magnetic Field: Magnetite in Bees and Ants. http://www.honeybadger.co.za/ntba1_3.htm.

[52] (2005), *Why honeybees never forget a face?* , New Scientists 10 December, Vol 188, No 2529, p.22.

[53] *Virus*. http://en.wikipedia.org/wiki/Virus.

[54] S. Clement (1996), *Magnetic Microbes*. http://commtechlab.msu.edu/sites/dlc-me/curious/ca0c96SC.html.

[55] F. A. Popp, B.Ruth, W.Bahr, J. Boehm, P.Grass (1981), G.Grolig, M.Rattemeyer, H.G.Schmidt and P.Wulle: *Emission of Visible and Ultraviolet Radiation by Active Biological Systems*. Collective Phenomena(Gordon and Breach), 3, 187-214.
F. A. Popp, K. H. Li, and Q. Gu (eds.) (1992): *Recent Advances in Bio-photon Research and its Applications*. World Scientific, Singapore-New Jersey.
F.- A. Popp: *Photon-storage in biological systems, in: Electromagnetic Bio-Information*. pp.123-149. Eds. F.A.Popp, G.Becker, W.L.König, and W.Peschka. Urban & Schwarzenberg, Muenchen-Baltimore.
F.-A. Popp (2001), *About the Coherence of Bio-photons*.
http://www.datadiwan.de/iib/ib0201e1.htm.
F.-A. Popp and J.-J. Chang (2001), *Photon Sucking and the Basis of Biological Organization*.
http://www.datadiwan.de/iib/ib0201e3.htm.
F.-A. Popp and Y. Yan (2001), *Delayed Luminescence of Biological Systems in Terms of States*.
http://www.datadiwan.de/iib/pub2001-07.htm.

[56] J. P. Dobson *et al* (1993), *Evocation of epileptiform activity by weak DC magnetic fields*. American Geophysical Union Meeting, Baltimore, Maryland. EOS, v. 74, no. 16.
See also *Weak-Field Magnetic Stimulation of EEG-Recorded Brainwave Activity*. http://www.keele.ac.uk/research/istm/EEG.html.

Neuroscience

[57] C. C. Hiew (1995), *Hemi-Synch into creativity*. Hemi-Synch Journal, XII (1), pp. 3-5.

[58] K. Graesboll (2006), *Function of Nerves-Action of Anesthetics*. Gamma 143, An elementary Introduction. http://www.gamma.nbi.dk.

[59] , *Visual short term memory* http://en.wikipedia.org/wiki/Visual_short-term_memory.

[60] T. Heimburg and A. D. Jackson (2005),*On soliton propagation in biomembranes and nerves.* PNAS vol. 102, no. 28, p.9790-9795.

[61] T. Heimburg and A. D. Jackson (2005), *On the action potential as a propagating density pulse and the role of anesthetics.* arXiv : physics/0610117[physics.bio-ph].

[62] P. L. Nunez (2000), *Toward a Quantitative Description of Large Scale Neocortical Dynamic Function and EEG.* Behavioral and Brain Sciences, 23, (3): XX.

[63] *Brain.* `http://en.wikipedia.org/wiki/Brain`.

[64] S. H. Cardoso (1997), *Neurobiology of Dreams: Electrical Activity.* `http://www.epub.org.br/cm/n02/mente/neurobiologia_i.htm`.

[65] *Electroencephalography.* `http://en.wikipedia.org/wiki/Electroencephalography`.
E. Ackerman (1962), *Biophysical Science.* Prentice Hall.

[66] *Sleep spindle.* `http://en.wikipedia.org/wiki/Sleep_spindle`.

[67] *Physicists challenge notion of electric nerve impulses; say sound more likely.* `http://www.scienceblog.com/cms/physicists-challenge-notion-of-electric-nerve-impulses-say-sound-more-html`.

[68] *An Intro to Sleep: What is Sleep?.* `http://www.talkaboutsleep.com/sleep-disorders/archives/intro.htm`.

[69] *EEG correlates of consciousness during sleep: a pilot study.* `http://www.spiritwatch.ca/LL%209(2)%20web/mason%20article.htm`.

[70] *Frontal lobes.* `http://en.wikipedia.org/wiki/Frontal_lobes`.

[71] *Soliton model.* `http://en.wikipedia.org/wiki/Soliton_model`.

[72] G. Cheron *et al* (2004), *Inactivation of Calcium-Binding Protein Genes Induces 160 Hz Oscillations in the Cerebellar Cortex of Alert Mice.* The Journal of Neuroscience, January 14, 2004, 24(2): 434-441.`http://www.jneurosci.org/cgi/content/full/24/2/434`.

[73] *Short term memory.* `http://en.wikipedia.org/wiki/Short_term_memory`.

[74] *Limbic system.* `http://en.wikipedia.org/wiki/Limbic_system`.

[75] L. Feng *et al*(2000), *The Mammalian Pineal Gland May Be The Third Eye.* `http://clearwisdom.net/eng/2000/May/18/EM051800_2.htm`.

[76] D. McMillin (1991), "The Pineal", in *The Treatment of Schizophrenia.* A.R.E. Press, Virginia. `http://www.meridianinstitute.com/mh/pineal.html`.

[77] R. Hink *et al* (1980), *Binaural interaction of a beating frequency following response.* Audiology, 19, pp. 36-43.

Consciousness related references

[78] A. K. Engel *et al*(2000) *Temporal Binding, Binocular Rivalry, and Consciousness.* `http://www.phil.vt.edu/ASSC/engel/engel.html`.

[79] D. Yarrow (1990), *Spin the tale of the dragon.* review article on biomagnetism, `http://www.ratical.org/reatvlle/RofD2.html`.

[80] C. F. Blackman (1994), "Effect of Electrical and Magnetic Fields on the Nervous System" in *The Vulnerable Brain and Enviromental Risks, Vol. 3, Toxins in Air and Water* (eds. R. L. Isaacson and K. F. Jensen). Plenum Press, New York, pp. 331-355.

[81] Blackman, C. F., Benane, S. G., Kinney, L. S., House, D. E., and Joines, W. T., (1982), *Effects of ELF fields on calcium-ion efflux from brain tissue, in vitro*. Radiat. Res. 92:510-520.

[82] Blackman, C. F., Benane, S. G., Rabinowitz, J. R., House, D. E., and Joines, W. T., (1985), *A role for the magnetic field in the radiation-induced efflux of calcium ions from brain tissue, in vitro*. Bioelectromagnetics 6:327-337.

[83] Blackman, C. F., Kinney, L. S., House, D. E., and Joines, W. T., (1989), *Multiple power density windows and their possible origin*. Bioelectromagnetics 10(2):115-128.

[84] N. Cherry (2000), Conference report on effects of ELF fields on brain, `http://www.tassie.net.au/emfacts/icnirp.txt`.

[85] A. R. Liboff (1985), "Cyclotron resonance in membrane transport", in *Interaction between Electromagnetic Fields and Cells* (a. Chiabrera, C. Nicolini, and H.P. Schwan, eds.), NATO ASI Series A97, Plenum Press. New York, pp. 281-296.

[86] Jaan Suurkyla,*Transcendental Meditation - neuro-physiological transformation by way of a unique fourth state of consciousness*. `http://home.swipnet.se/tmdoctors/eng/tmunique.htm`.

[87] W. R. Adey (1992), "Collective properties of cell membranes" in *Interaction Mechanisms of Low-Level Electromagnetic Fields in Living Systems*. (eds. B. Norden and C. Ramel). Oxford University Press, Oxford. pp. 47-77.

[88] J. P. Blanchard and C. F. Blackman (1994), *A model of magnetic field effects on biological system with conforming data from a cell culture preparation* in "On the Nature of Electromagnetic Field Interactions with Biological Systems", edited by Allan H. Frey. R. G. Landes Company. Medical Intelligence Unit.

[89] R. O. Becker (1990), *Cross Currents*. Penguin Putnam Inc., New York.

[90] S. M. Bawin and W. R. Adey (1975), *Interaction between nervous tissue and weak environmental electric fields*. Ann. N.Y. Acad. Sci. 247:323-330.

[91] Mark Germine (2000), "Experimental verification of Stapp's theory'. `http://listserv.arizona.edu/lsv/www/quantum-mind.html`.

Chapter 7

Quantum Model for EEG

7.1 Introduction

In previous chapter the overall TGD based view about EEG was discussed. According to this view, the basic function of EEG is to induce cyclotron phase transitions at the magnetic body and thus allows magnetic body to share the standarded mental images produced by brain via negentropic quantum entanglement. Magnetic body would also produce what might be called higher level sensory qualia identified as emotions and cognitions. In this chapter the relationship between EEG and nerve pulse patterns is discussed in TGD framework.

7.1.1 Vision about EEG

The general model for EEG relies on the idea that EEG frequencies correspond to Josephson frequencies defined by membrane potentials and provide cognitive and one might also say emotional representation of the sensory input at the magnetic body in terms of cyclotron transitions. The perturbations of the membrane potentials caused by spikes, neurotransmitters affecting alertness reducing the magnitude of the resting potential induced frequency modulations of the membrane potentials and one can say that the cell is like a singing whale with evoked potentials and nerve pulse patterns coded to the varying frequency. Song is expression of this singing but also speech involves frequency modulation as one learns by playing slowly recorded spoken language.

The scale of the frequency 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.

The hypothesis that Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1 + i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241..\}$ (the number theoretical miracle is that all the four p-adic length scales sith $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm) define scaled up copies of electro-weak and QCD type physics with ordinary value of $\hbar$ and that these physics are induced by dark variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$, and the resulting picture finds support from the ensuing models for biological evolution and for EEG [20].

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.

An essential assumption is that cell membrane corresponds to almost vacuum extremal so that classical Z^0 field proportional to em field is present and leads to the replacement of ionic charges with effective charges much larger than ionic charges so that that membrane voltage corresponds to a photon energy in visible or UV range and the energies of biologically most important ions span half octave. From this it follows that for given ion and membrane voltage the value of r fixes completely the Josephson frequency. For instance 5 Hz frequency corresponds to $r = 2^{k_d}$, $k_d = 47$.

Armed with this picture one ends upd with a rather detailed quantitative model for EEG discussed already in [20]. In this chapter this model is applied in more detail. Features, synchronization, stochastic resonance, temporal codings, and what I have used to called scaling will be discussed.

7.1.2 Features

Walter Freeman has identified spatially amplitude modulated synchronous but non-periodic EEG patterns serving as correlates for conscious percepts. The duration of features is in the range 80-120 ms and there is spatial coherence but no strict periodicity but 1 ms temporal resolution so that one can speak of spatial amplitude modulation of a temporal pattern which is same over the spatial cross section of the feature. The basic patterns recur with a period of 5-7 Hz. The sizes of features are in the range 1-2 cm.

The model of EEG and biophotons in terms of large $\hbar$ Josephson radiation generated by cell membrane Josephson junctions predicts that the wavelength of Josephson photon with energy of visible or UV photon and scaling like $\hbar$ is dictated by the size scale of the structure generating ELF radiation with frequency scaling as $1/\hbar$. This hypothesis combined with the Mersenne hypothesis [20] allows to build a picture about the values of Planck constant involved with the features. Also the fact the causal diamonds (CDs) of d quark and electron correspond to kHz and 10 Hz frequencies is expected to be relevant for the model.

7.1.3 Synchronization

Synchronization in and between various cortical areas is known to occur with millisecond precision. Also disjoint brain regions can be in synchrony. This is difficult to understand without synchronizing agent oscillating at kHz frequency.

Again kHz frequency brings in mind d quark CD. kHz Josephson frequency is second candidate. If this frequency is also realized as cyclotron frequency identifiable as a scaled up alpha frequency, the value of the magnetic field must be by a factor 2^7 stronger than $B_{end} = .2$ Gauss and thus about 2 mTesla. The model for hearing requires the hierarchy of magnetic field values so that this hypothesis might make sense.

In TGD framework magnetic body and hierarchy of Planck constants inducing the scaling of p-adic length scales is the natural agent inducing the synchrony and MEs could induce the synchronization. Synchronization would naturally occur at the frequency corresponding to a duration of the bit of the memetic code. kHz frequency corresponds to the size scale of head and makes possible the synchronization of cortical areas.

7.1.4 Stochastic resonance

Concerning the mapping of EEG frequencies to nerve pulse patterns, stochastic resonance promotes itself as a basic mechanism. In bistable systems stochastic resonance allows to amplify very weak periodic signals by utilizing white noise. Stochastic resonance is known to be relevant also at the neuronal level as demonstrated by the autocorrelation functions for spike sequences exhibiting peaks at the harmonics of the signal frequency. Neuron is however far from being bistable system, and this raises the question whether bi-stability might be present at some deeper quantal level.

Nerve pulses generate EEG MEs and the frequency of the nerve pulses determines the rate at which EEG MEs are generated rather than the frequency of EEG MEs. TGD inspired model of nerve pulse assigns to the resting state of cell a propagating soliton sequence and nerve pulse corresponds to a perturbation which locally transformation propagation to oscillations. The states correspond to the states of the bistable system. The system in resting state is near criticality in the sense that rotation velocity is slightly above the minimum one so that reduction of membrane potential transforms rotation motion to oscillatory motion locally. Stochastic resonances makes itself visible in the autocorrelation function of the spike sequence and in this manner also in the membrane potential of say glial cells coupling to neurons. In fact, glial cells could play the role of listener of radio turning the knob (noise level) to tune the neurons to a particular spiking frequency.

7.1.5 Temporal codings

The conventional view that the information content of conscious experience is determined completely by rate coding from nerve pulse patterns does not seem plausible in TGD framework where massless extremals suggest a coding preserving phase information and based essentially on coherent summation of perturbations of membrane voltages coming from presynaptic neurons. The superposition of contributions to membrane voltage imply interference effects. It is known that spike interval statistics allows to regenerate recognizable speech artificially by stimulating neurons electrically. The destruction of phase information while keeping spike rate as such lhowever eads to a loss of experienced emotional content of artificial spike patterns. This suggests that the interference effects code for the emotional content of nerve pulse pattern and the outcome is cognitive and emotional representation at the magnetic body.

One can consider also cognitive codes for which only spike patterns are significant and analogous to the rhythmic patterns of music. Indeed, p-adic cognitive codes define an entire hierarchy of binary codes associated with the p-adic frequencies and frequency coding would apply only to the average intensity of the sensory input. For high stimulus intensities the duration of the bit of the p-adic cognitive codeword tends to become shorter. This is comparable to the increase of the speech rate during a high state of arousal, and conforms with the observed shift of EEG towards higher frequencies in this kind of situation. There is a lot of experimental evidence supporting the existence of various kinds of temporal codings, and these codings are discussed in TGD framework.

7.1.6 Scaling law

Scaling law provides bird's eye view about transitions which can represent conscious-to-us qualia at given level of the p-adic self hierarchy. The law relates two levels of self hierarchy corresponding to mental images associated with magnetic bodies of astrophysical size and with physical bodies, the latter with size not much larger than brain size. Scaling law assumes that self sizes L at given p-adic level k are between the p-adic length scales $L(k)$ and $L(k(next))$. Scaling law is of form $L = v/f$ and relates ELF self size characterized by ELF frequency f to the self size L and to the effective phase velocity v of the EEG wave.

Scaling law also suggested by the experimental work with the effects of ELF radiation in water [40]. As discussed in [16] scaling law can be explained in terms of phase transitions transforming large $\hbar$ photons to ordinary ones. The chapter ends with the discussion about possible implications of the scaling law concerning EEG.

7.2 EEG, MEG, nerve pulse and mini-potentials

In this section the basic facts about EEG, MEG, nerve pulse and mini-potentials are briefly reviewed.

7.2.1 EEG

E(lectro)E(ncephalo)G(ram) is the study (or graphing) of the electric potential on the surface of the skull [46]. EEG waves are oscillations of the membrane potential with frequency varying in the range 1-100 Hz. The amplitude of the oscillating membrane potential is typically 10^{-4} Volts and by a factor 10 smaller than postsynaptic potential. EEG waves is a vertebrate phenomenon, insect ganglia do not exhibit comparable potentials.

Four basic rhythms have been identified in EEG wave spectrum and their amplitude and frequency correlate strongly with the state of awareness [46]. It must be emphasized that the the boundaries of frequency ranges vary by few Hz depending on author.
i) α rhythm. f = 8-13 Hz and amplitude is about 20 micro-volts. α dominates in rest but not in the sleep state. A sudden illumination by light leads to the disappearance of the α component of EEG.
ii) β rhythm. f = 14-30 Hz with amplitude about 40-100 micro-volts. β dominates during a conceptual thinking.
iii) γ rhythm. f = 30-90 Hz with. Gamma rhythm is associated with temporal coding of sensory information.
iv) θ rhythm. f = 4-7 Hz. θ dominates during sleeping without dreams. Dreams in turn correspond to β waves.

v) δ rhythm. $f = 0.5$-3 Hz. δ corresponds to deep sleeping without dreaming.
In general the amplitude is smaller the larger the frequency is.

EEG reflects also alarm reaction and sensory responses. Various mental disorders, brain tumors and brain injuries reflect themselves in EEG. Epilepsy, which corresponds to hyperexcitability of some part of the nervous system induces characteristic changes in the EEG pattern. EEG varies also considerably during the development. EEG appears at the age of year as occasional bursts with frequency 4-8 Hz and the adult form of EEG is established before the age of 19.

The question whether all EEG waves genuinely propagate or not is not resolved experimentally yet. It is known that alpha waves propagate and that the propagation velocity is about $v \sim 10$ m/s. There is also evidence for the propagation of 40 Hz EEG waves [72, 70].

There is no doubt that EEG waves are deeply involved with the basic functioning of the brain but the origin and the exact function of EEG has remained a mystery. The EEG waves associated with two distant neurons are strongly correlated and this supports the view that EEG waves are related to the properties of the brain as a coherent quantum system.

7.2.2 MEG

This subsection gives a brief summary about magnetoencephalography (MEG). The motivation is that brain could act with MEs by acting effectively like magnetometer somewhat in the same way as SQUID magnetometer measures the magnetic fields generated by brain.

SQUIDs

SQUIDs [48, 61, 50] are instruments used to measure extremely weak magnetic field in the case that the resolution needed is below the magnetic flux quantum $h/2e$ ($\hbar = c = 1$) for magnetic flux in super conductor. An important application of SQUIDs is to the measurement of the weak magnetic fields generated by brain and having strengths as weak as fT. SQUID technology has been used to detect the weak magnetic fields created by brain (10^{-13} Tesla region) and quite an impressive knowledge exists about the magnetic correlates of the brain activity in ELF region [50].

A rough description of SQUIDs goes as follows.

1. The current in SQUID measures the deviation of the external magnetic field from a multiple of magnetic flux quanta which is reflected as a presence of a current in SQUID which creates magnetic field compensating this deviation.

2. The circuit equations can be written for the magnetic flux through SQUID and differ from the equations for RCL resonance circuit only by the presence of Josephson current non-linear with respect to the magnetic flux. If the super current is accompanied by a white noise with a correct intensity, SQUID amplifies the periodic signal in resonant manner. The stochastic resonance in SQUIDs has been demonstrated experimentally [51].

3. SQUID consists of a closed current loop decomposing to two parts connected by thin non-superconducting insulators. This makes possible rapid dissipation of the current to the minimal value needed by flux quantization. Small deviations from the quantized flux can be accurately measured by measuring the persistent supra current.

The basic equation governing the behavior of SQUID relies in the following simple model. SQUID is characterized by inductance L relating magnetic flux to current ($\Phi = LI$ modulo integer number of flux quanta). The potential difference around SQUID is by Faraday's induction law equal to $eV = d\Phi/dt$. SQUID can be regarded as a capacitor (capacitance C) formed by the two halves of SQUID coupled by the insulators to which one can assign internal resistance R. Insulating parts serve as Josephson junctions through which ordinary Ohmic currents run besides the Josephson current depending sinusoidally on the magnetic flux. The equation for the time derivative of the potential difference around the SQUID loop reads as

$$\begin{aligned} LC\frac{d^2\Phi}{dt^2} &= -\tau\frac{d\Phi}{dt} - \Phi - \beta sin(\Phi) - \xi \ , \\ \beta = \frac{Li_c}{\Phi_0} \ , \quad \tau &= \frac{L}{R} \ , \quad \Phi_0 = \frac{\hbar}{2e} \ . \end{aligned} \tag{7.2.1}$$

Here ξ denotes the white noise contribution to the Josephson current. Φ is measured in units of Φ_0 and in the equation above Φ denotes the deviation of Φ from an integer multiple of Φ_0. The equation is obviously invariant under the symmetry $\Phi \rightarrow \Phi + n2\pi$. i_c denotes the critical current for which the super current in the circuit becomes dissipative. Usually also an additional external current guaranteing a slight over-criticality is added. If the inertial term proportional to LC can be made small, the system rapidly dissipates to equilibrium configuration. For small deviations of Φ from a valued corresponding to a quantized magnetic flux system indeed exhibits stochastic resonance [51].

Magnetic fields associated with brain activity

SQUIDs (super-conducting quantum interference devices) have made it possible to measure the magnetic fields associated with the brain activity. The magnetic fields accompanying the evoked responses [49] and the background activity of brain are in the range $10-10^3$ fT, in general below the level of the geomagnetic noise but above the thermal magnetic noise produced by body which is roughly .1 fT. The frequency range is typically between 0-100 Hz in these measurements and corresponds to the frequency range of EEG. Alpha rhythm at 10 Hz generates a sharp peak with a peak value about 1-2 pT, which is slightly above the level of the geomagnetic noise. Eyes create static magnetic fields of about 10^{-11} T. Heart creates an oscillatory field with somewhat stronger intensity below 10^{-10} T and with the frequency of heart beat: this field is in the intensity region of the geomagnetic noise having frequencies above .01 Hz. Sensory stimuli generate typically responses with a strength of few hundred fT consisting of oscillations which start few tens of milliseconds after the stimulus and end few hundreds of milliseconds after the beginning of the stimulus (natural time scale is .1 seconds for the duration of the magnetic response.

The simplest model for the magnetic field associated with an evoked response is as being generated by a point like magnetic dipole or a collection of point like magnetic dipoles. This means that the measured fields are essentially superpositions of radiation fields generated by dipoles. It is possible to determine rather accurately the positions of these effective dipoles in brain and thus to localize various brain functions. Also the dependence of the shape of the frequency spectrum on brain function can be studied and the distribution of the net power in a given frequency range as a function of the location can be studied. Often the ratio of the responses before and after stimulus is measured as a function of position near the surface of the skull.

The simplest hypothesis is that far-away radiation fields decompose into MEs propagating in the radial direction. In TGD based model of EEG, brain is in electromagnetic bath provided by 'free' ELF MEs moving along the surface of cortex with the velocity of nerve pulse, and generating electromagnetic responses which decompose in far-away region into MEs propagating into the radial directions. In the induction region more complex flux quanta are possible. The criterion for the radiation region reads as $r \geq \sqrt{\lambda L}$ and relates the distance r between observation point and source, the size L of the source region, and the wavelength. For a point like source this criterion holds everywhere.

Dipole approximation is used in the analysis of the data to determine the position of evoked response. If λ corresponds to the wavelength of 10 Hz radiation and L is of order 10 microns, the the criterion for faraway region is roughly $r > 10$ meters and classical radiation fields measured in the region near brain are induction fields. Hence one cannot regard the magnetic fields induced by the brain activity as consisting of MEs in the measurement region. This is of course natural, since in radiation region a lot of information is lost since the system looks point like in this region.

On basis of EEG one can expect that the intensities of the magnetic fields associated with MEs providing the electromagnetic bath for brain are weaker than the intensities of the evoked fields. The intensity of ELF em radiation in delta band, which is of the same order of magnitude as the radiation associated with sferics [39], provides the first guess.

7.2.3 Nerve pulse

Nerve pulse is the tool used by the nerve cells to communicate information to each other [41, 54]. Nerve pulse is generated, when the potential difference through the cell membrane, rest potential, changes from its rest value about of -80 millivolts to about -50 millivolts, the threshold potential: after this the action potential about 40 millivolts is generated and begins to propagate along the axon with approximately constant velocity varying between 1-100 meters.

For resting potential the concentration of Na_+ ions, Ca_{++} and Cl_- concentrations are much larger outside the cell than in its interior whereas K_+ concentration is larger inside the cell. Thus in absence of constraints ($Na_+ - K_+$ pump) forcing membrane potential to its resting value Na_+, Ca_{++} and Cl_- would flow to cell interior: obviously, the flow of first two tends to reduce the resting potential. K_+ in turn would would flow out of cell interior. Nerve pulse is indeed generated when Na_+ conductance increase and Na_+ rush to cell interior, the return to resting state involves temporal flow of K_+ ions to cell exterior.

The generation of the nerve pulse involves the increase of Na and K conductivity through the cell membrane so that a flow of K and Na ions through cell membrane takes place and action potential is generated. The increase of the conductivity is caused by the opening of Na and K channels. According to the classical model of Hogkin and Huxley [41] the opening of the Na channels involves the participation of three so called m particles and one so called h particle. The rapid increase of Na conductivity is possible to understand only provided the charge of the m particles is -2 and they are electron pairs [41]. A possible identification is as Cooper pairs.

The axon consists of two kinds of segments. The first segment having typically a length of the order of 10^{-3} meters is surrounded by a myelin shell: in this region no Na and K currents appear. The velocity of the nerve pulse is of the order of 10^2 m/s in these regions. Between the myelinated regions appear unshielded regions, where Na and K flow appears: these have length of order of 10^{-6} meters: velocity is in general smaller in these regions. The function of the unmyelinated regions is probably to refresh the nerve pulse since the dissipation causes the decrease of the height of the pulse during the propagation through the myelinated regions. The completely unshielded propagation is not economical since metabolic energy gets wasted.

Nerve pulse either ends up to a muscle or is transferred to a neighboring cell through a synaptic connection. There are two kinds of synaptic connections. Gap junctions are direct contacts between two cells and the nerve pulse is transferred electrically to the second cell. In chemical synapses the axon is separated from the dendrite of the receiving cell by a synaptic cleft having width of the order of $10^{-8} - 10^{-7}$ meters. The nerve pulse is transferred chemically via the so called synaptic transmitter substance. The nerve pulse generated in the dendrite can be either excitatory or inhibitory depending on whether the sign of the voltage difference is favorable for the generation of the action potential or not. The value of the postsynaptic potential is about 10 millivolts.

Whether the nerve pulse is generated depends on the inputs received by the nerve cell. In neural network models the output is generated provided the sum of the inputs exceeds a certain threshold value. It is not at all clear however whether the inputs correspond to potentials or something else, but closely related to postsynaptic potentials. What seems to be clear is that this quantity can have only two values corresponding to exhibitory and inhibitory inputs respectively. The nerve pulses coming from the sensory organs obey frequency coding. The stronger the sensory input the greater the frequency of the nerve pulses. The duration of the nerve pulse, about few milliseconds, sets of course a limit for the frequency of the pulses.

To summarize, the propagation of the nerve pulse is a well understood process and the interpretation of the action potential as one bit of information is attractive. The idea that nerve pulse is generated, when the sum of inputs (in some sense) exceeds some threshold value seems to be well established. The details related to the generation of the threshold potential and the relationship of the nerve pulse generation to the general state of awareness and memory content of the brain is however unclear. Also the relationship between nerve pulses and EEG waves is unclear.

7.2.4 Miniature postsynaptic potentials

Miniature postsynaptic potentials have quantized amplitude of order .5 mV to be compared with the value of the rest potential, which is roughly 100 times larger [54]. Miniature potentials are generated in the postsynaptic neuron, when it has received nerve pulse. The quantized packets of neurotransmitters such as ACh give rise to the emission of miniature potentials. According to [54] miniature potentials might consist of superpositions of much smaller micro-potentials of amplitude of order .3 μV generated by single neurotransmitter molecule. One could however consider also the possibility that the minimum size for the quantized packet of neurotransmitter is dictated by the requirement that the packet is able to generate the mini-potential.

7.3 Features and synchronization

The model for sensory receptor discussed in the previous section is inspired by the general vision for how magnetic body controls biological body and receives information from it. The model generalizes straightforwardly to a model of features. What is new that features would most naturally be induced by W MEs affecting glial cell groups which in turn would induce the synchoronous neuronal firing.

Cyclotron phase transition at appropriate magnetic body induced by cyclotron and Josephson radiation generated by the corresponding biological body defines the feature. Both Josephson and cyclotron frequencies associated with scaled up EEG would scale as $r = \hbar/\hbar_0$. The modulated cyclotron frequency could place code a position of the representation at magnetic body representing some geometric quantity, say the distance of the object of perceptive field. The temporal modulation pattern of the amplitude of cyclotron radiation by some EEG frequency in turn would define the feature assigned at this position. One can distinguish between speech and song like features responsible for cognitive and emotional aspects of perception. Also spatial modulation is present but temporal pattern is same at all points of feature.

Genetic and and perhaps even memetic codons with duration of .1 seconds are good candidates for the "phonemes" of speech like features. Recurring feature corresponds to a plasma oscillation with frequency below 10 Hz generated by the charge entanglement by W ME inducing exotic ionization. Ca^{2+}, Mg^{2+} and possibly also other bosonic ion waves are physiological correlates of the features.

1 kHz synchronization frequency reduces in this picture to DNA cyclotron frequency associated with the scaled up variant $\lambda B \simeq .02$ Tesla of the magnetic field $B = B_{end}/2 = .1$ Gauss assignable to the right brain hemisphere and having cyclotron frequency .5 Hz and carrying single flux quantum $h_5 = 5h_0$. Also 2 kHz synchronization frequency is highly suggestive. The dark photons of this radiation could result as DNAs drop to excited cyclotron states at the magnetic flux sheets traversing through the sequences of DNA double strands defining lines of a page of a book represented by the flux sheet. The text line has an interpretation as a supergene expressed collectively during synchronous firing.

Also fractally scaled up variants of features with duration of short term memory and realized as modulations of EEG frequencies are predicted with alpha band taking the role of 1 kHz synchronization. Scaled up variants of memetic/genetic codons would code for information now. In this case the size scale of the features would be $\lambda \times .02 = 40$ m suggesting that collective mental images involving several brains are in question.

7.3.1 Features

The notion of p-adic cognitive representation seems to have an impressive explanatory power. These representations are however local in the spatial degrees of freedom, and the further challenge is to understand how the p-adic codons from various points of cortex are combined to more complex features/symbolic mental images. The work of Freeman with odor perception gives valuable guidelines in this respect [38]. The findings of Freeman suggest that neurons in a given cortical area define temporally synchronous patterns, features. The temporal synchrony would mean that all spatial points correspond to the same p-adic codon in the temporal domain. There is however an arbitrary dependence of the feature on the two transversal coordinates of the cortical surface for a given time value. Hence the situation is 3-dimensional but the third dimension is time rather than space.

Features as AM modulated EEG patterns

The coherence lengths for EEG inside cortex are in general much shorter than at the surface of the skull and complex patterns are encountered. In particular, synchronous cortical EEG patterns with coherence length of order 1-2 cm appear (size of Brodmann's areas). Freeman identifies these patterns as basic units, "features", of perceptual activity (the activity related to subjective experience rather than sensory input) [38], and calls these patterns mesoscopic activity as opposed to the microscopic activity represented by nerve pulse patterns. According to Freeman these patterns are observed besides olfactory bulb also in visual, auditory and somatic cortices.

These synchronous EEG patterns have a non-periodic time dependence which does not depend on position: this would be consistent with the frequency coding of the time span of declarative memory. The amplitude is spatially amplitude modulated. The AM patterns are measured at two-dimensional surface so that the question whether the spatial amplitude modulation is 3-dimensional or 2-dimensional remains open. The patterns are recurring 2-7 times per second, which corresponds to theta band in frequency space. This conforms with the assumption that memories are coded by the same features as direct experiences and that carrier frequency is in theta range unlike for purely symbolic representations of sensory experiences for which it is in gamma range. The duration of the patterns is $T = 80 - 120$ ms.

How to understand the time and length scales associated with the features

The first thing to be understood are the time scales and here TGD inspired model for EEG based on the identification of EEG and biophotons in terms of Josephson radiation generated by cell membrane acting as Josephson function is the natural starting point. This model is made quantitative by the Mersenne hypothesis to which TGD inspired model of EEG and also biological evolution is based [20].

1. The time scales bring in mind the causal diamonds (CDs) of d quark and electron with time scales of 100 ms and 1/1.28 ms. For u quark the time scale is 6 ms which corresponds to 160 Hz cerebellar synchrony. What is disturbing is the large relative variation of the durations. These time scales are in rest system of CD and Lorentz transform of CD scales up the time scale. The needed Lorentz boosts look however unrealistic since they would require relativistic velocities for electrons and would explain only the interval 100-120 ms but not 80-100 ms.

2. A more promising hypothesis is that the duration relates to the Josepson frequency of the cell membrane proportional to the resting potential which varies in rather wide limits: - 40 mV for visual receptors and -80-90 mV for glial cells. The ratio of the neuron resting potential -70 mV to the critical potential -55 mV for firing and average resting potential -70 mV is 1.2 whereas the ratio for durations is 1.5. The Josephson frequencies of the basic biological ions for almost vacuum extremal cell membrane are modified by the contribution of classical Z^0 field correspond to half octave range and the ratio of maximum to minimum membrane voltage is is quite near to $\sqrt{2} \simeq 1.4$ not too far from 1.5. This option looks the most promising one and would predict a discrete spectrum for the durations smoothed out partially by the variation of the resting potentials.

3. kHz frequency could correspond to Josephson frequency of membrane potential inducing an additive modulation of membrane voltage in turn inducing frequency modulation of Josephson frequencies of in nearby cells. For instance, glial cells could induce this modulation. The model for EEG would suggest that also 5-7 Hz frequency corresponds to a Josephson frequency for cell membrane and thus to $r = \hbar/\hbar_0 = 2^{k_d}$ if one accepts the Mersenne hypothesis to which TGD inspired model of EEG and also biological evolution is based [20]. This would suggest a hierarchy involving the Josephson frequencies 5-7 Hz, 8.4-12.5 Hz, and 1 kHz.

   A three-level hierarchy could be in question with the slowest frequency assignable to hippocampus, next frequency to the higher sensory areas, and kHz frequency possibly to head itself. The identification is supported by internal consistency: kHz frequency defines synchrony in the size scale of entire brain and corresponds to the p-adic length scale assignable to brain. This picture would conform with much more general hypothesis about brain as an orchestra with neurons and glial cells as instruments whose octave is specified by the value of Planck constant restricted by Mersenne hypothesis.

4. The question about interpretation of frequencies assignable to $\hbar_0$ CDs remains. One possibility is that the kHz Josephson radiation with large Planck constant decays to bunches of ordinary kHz quanta as its leaks to $\hbar_0$ page of the Big Book. Other transition would be a transformation to single $\hbar_0$ visible or UV photon having identification as a bio-photon.

One should also understand the size scale of features. Suppose in accordance with Mersenne hypothesis that Josephson wavelength define the structures as scaled up variants of the wave length assignable to $\hbar_0$ Josephson frequencies of basic biological ions, which corresponds to $k_{eff} = 163$ for 2 eV energy. This implies that 5 Hz Josephson frequency corresponds to to $k_{eff} = 210$ - a p-adic length scale, which is roughly 15 meters. 1 cm sized features would correspond to Josephson frequency of about 2×10^5 Hz rather than kHz frequency but one could argue that these features integrate to a larger structure during kHz syncrony making possible binding of mental image in the scale of entire brain. Of course, nothing prevents the presence of also 100 kHz frequency scale and for bats and sea mammals the hearing range extends up to 2×10^5 Hz [53].

MEs as AM patterns representing features

The identification of massless extremals (MEs) as representations of the features is suggestive since for MEs the time dependence is same for all points in the 2-D transversal cross section. Temporal coherence in turn corresponds to the arbitrary but synchronous dependence of the field pattern on the temporal coordinate at this cross section. Thus MEs are ideal for the communication of the information contained by features to the magnetic body.

MEs allow arbitrary direction and magnitude of transversal polarization and arbitrary time dependence which does not depend on position. 2-dimensional instead of 3-dimensional AM patterns are predicted but this is consistent with empirical data. Note that MEs in question are like light fronts going through the two-dimensional surface where the measurement is performed. One might argue that the character of MEs as topological field quanta of classical radiation means that they are not sufficiently general to model the nearby ELF fields in brain. This might be the case. On the other hand, the solution ansatz defining MEs is extremely general [25]. In geometric optics picture this means that paths of light rays inside MEs can be also curvilinear light like curves expressible as gradient lines for a Hamilton Jacobi functional S whereas the transverse polarization is defined by a gradient of a polarization function E.

The spectrum of durations for the synchronous time patterns encourages also to consider an interpretation of these patterns as an electromagnetic realization of genetic code words. Also more general p-adic codes can be considered. A compression of the memetic code words defined by the nerve pulse patterns giving rise to abstraction and classification could be in question. The representation would be achieved by the modulation of the alpha waves by higher harmonics of alpha frequencies analogous to ripples. Essentially an interference of slow alpha wave with faster wave containing frequencies up to kHz would be in question.

In the case of hearing the contraction could take place but one can also consider the possibility that entire 126 bit memetic code is realized and that the the large number of bits codes for information relation to delicate factors like the emotional coloring of the speech. This would explain the completely exceptional role of the language in cognition.

MEs need not nor cannot be purely electromagnetic and for far from vacuum extremal MEs with vanishing classical Z^0 field classical W fields are necessarily present. W MEs as possible realizers of the generalized motor actions of the magnetic body could induce plasma oscillations and ionic waves define also candidate for the inducers of AM patterns.

Genetic code and odors

The interpretation of AM patterns as sub-selves representing standardized mental images is natural. The average duration of these sub-selves is of 100 ms which is the duration of the memetic codeword [24]. According to Freeman, the time dependence of AM patterns is chaotic: this does not however mean that it is random. That also time coding is involved looks plausible because both temporal and spatial patterns of nerve pulses are crucial for the neural coding of odors [66].

The first thing to come in mind that temporal patterns correspond to memetic code words having length of almost 127 bits ($2^{127}-1$ patterns are possible) with bits represented by a pulse or absence of it. The presence of pulse would correspond to some minimum intensity of field. The first bit would be always 1 to signify the beginning of the codon which would give 126 bits. Also a formal representation as superpositions of Fourier components with frequencies $f_n = n/T$, $n = 1, ..., 127$ with coefficients can be considered but would not be so natural than pulse representation.

There are however objections against this identification.

1. p-Adic length scale hypothesis would predict duration of 100 ms for AM patterns representing memetic code words if .1 second time scale corresponds to the time scale assignable to electron CD. Quite wide length variation for MEs is however possible and 100 ms MEs predicted by p-adic length scale hypothesis could be interpreted as resonant MEs in this picture, ELF frequency counterparts of on mass shell particles whereas other durations would correspond to off-mass

shell 'virtual' MEs. This interpretation is consistent with the generalization of the ideas of Jaynes [21, 28].

2. That memetic code could be represented also in terms of MEs conforms with the computer metaphor which suggests myriads of representations of the memetic code. On the other hand, the highest frequency involved would be of order kHz and outside EEG range. Furthermore, AM patterns should represent abstraction and classification of temporal nerve pulse patterns associated with the memetic code words. The generalization of EEG to a fractal hierarchy of EEGs allows however to circumvent the objection.

The simplest thing one can imagine is that a compression of the $2^{127}-1$ neuronal memetic codewords to genetic code words having length of 7 bits giving 127 code words occurs: in this case the the highest frequency would be in the range $58.3-87.5$ Hz which relates very naturally to the EEG frequency range and is above the 40 Hz band and various lower bands related to the place coding. One can argue that just as at DNA level only the 64 mutually consistent Boolean statements amongst the $2^7-1=127$ Boolean statements are realized physically.

Genetic code could be also realized as nerve pulse patterns. This option looks natural in the case of rate coding with almost random time intervals between nerve pulses. If stochastic resonance forcing the autocorrelation function of the nerve pulse pattern to have peaks at the multiples of the forcing frequency is involved, then the number of distinguishable code words would be also around 64. Also the discrete values of the pulse rate varying from 0 to 64 pulses per .1 seconds could define genetic codons.

Magnetic representation of the genetic codewords

Genetic code for odors is consistent with the assumption that the modulation frequencies are in the range $20-80$ Hz. The cyclotron frequencies of all biologically important ions including DNA are above 1 kHz so that amplitude modulations at EEG frequencies are slow.

The modulated cyclotron frequencies would naturally represent carrier waves coding for some geometric data, for instance the distance of the object of perceptive field on the sensory magnetic canvas. This prediction could be tested by looking whether the attention directed to a moving object is accompanied by a shift of some cyclotron frequencies.

EEG waves with well defined frequencies would have interpretation in terms of frequency coding by sequences of "notes" whereas chaotic EEG waves such as beta waves might be assignable to the speech like representation. For "note" representation trivial code word would correspond to a mere alpha wave modulation. Alpha wave begins to dominate when eyes are closed which suggests alpha wave modulation represents "no sensory input". In the case of vision alpha wave would assign the color quale black and the mental image "darkness" to the region of the perceptive field. In the case of hearing the trivial codeword would represent the experience of silence, something different from the absence of auditory experience.

Data compression as frequency cutoff and threshold coding

Some comments about the compression process and about the plausibility of the representation of Boolean statements at the level of conscious experience are in order.

1. The compression process simply drops away the bits corresponding to the frequencies above 80 Hz. This kind of frequency cutoff is precisely what is carried out in quantum field theories when the effective action for low energy theory is constructed. For quantum field theorist this means functional integral over the frequencies and wavelengths above the cutoff frequency and cutoff wavelength. Thus brain would apply the counterpart of the same procedure as quantum field theorist or statistical physicist uses to build simplified models applying in time and length scales above the inverse of the cutoff frequency and cutoff wavelength.

2. The values of the EEG potentials need not be discrete to yield bit representation at the level of the conscious experience if magnetic quantum phase transition is induced only if the intensity of the oscillatory magnetic perturbation defined by ME is above certain threshold value. Threshold coding is actually what is expected since phase transitions should occur as a kind of domino

effect. There is also an upper bound for the harmonics of the cyclotron frequency which can be amplified to a macroscopic quantum phase transition. This yields automatically frequency cutoff even in absence of a frequency cutoff for EEG waves.

7.3.2 Synchronization

Cognitive functions like perception, memory and language are based on parallel and highly distributed information processing. What brain does is the analysis of the sensory input into bits. One of the major unresolved questions of brain science is how the information these bits can be integrated to sensory percept and how coherent representational states can be established. Temporal binding has been suggested as a mechanism making this possible. The synchronized neuronal firing has been proposed as an underlying mechanism of temporal binding inside and between various cortical areas. The assemblies of neurons firing synchronously could even define neuronal correlates for objects of perceptive field. Synchrony mechanism would apply also to motor actions and allow selection of perceptually and behaviorally relevant information. Temporal binding has been proposed by Crick and Koch as a necessary and sufficient condition for the generation of conscious percepts. It however seems that 40 Hz synchrony corresponds to generation of information as the experiments of

In TGD framework the synchronously firing neuronal assemblies are excellent candidates for sub...selves. Synchrony should result from the presence of a TGD counterpart of a computer clock ticking with a frequency of order kHz associated with the memetic code.

Empirical evidence for kHz synchronization

Neuronal synchronization is by now a well established phenomenon (see [68] and references therein).

1. Synchronization inside and between sensory, motor and associative areas has been established. Synchronization has been observed also inside subcortical structures such as lateral geniculate nucleus, superior colliculus and brain stem and even in retina [68]. Synchronization has also found even between areas belonging to different hemispheres.

2. Synchronization in visual system predicts synchronization inside visual areas and between areas across large cortical distances. These predictions have been verified. For instance, two neurons fire synchronically only if they respond to the same visual object but not otherwise. It has been found that the basic criteria for the gestalt formation (such as continuity and coherent motion), shown to support by perceptual grouping, are also important for the formation of a synchrony between the neurons of the visual cortical. Synchronization has been studied also in non-visual modalities: synchronization in the olfactory systems of various vertebrate and invertebrate species has been found and both auditory and somatosensory cortex has been demonstrated to show precise synchronization. Synchronization has been observed also in hippocampus and frontal cortex.

3. Synchronization has been observed in motor areas and between areas of sensory and motor system. For instance, the study of cats performing visuomotor tasks has shown that the synchronization between visual and parietal as well as visual and motor areas occurs in those task epochs where the animal processes attentively information to direct the required motor response.

4. Synchronization seems to serve as a neural correlate for conscious percepts [68]. For instance, in binocular rivalry, the neuronal activity in V1 does not change when the consciously perceived stimulus changes. However, highly synchronous firing is what distinguishes the perceived stimulus from the non-perceived one.

In TGD framework this would mean that the entanglement with magnetic body serving as the correlate for the directed attention would have synchronization as a neural correlate. The interpretation would be that without synchronization no coherent cognitive or emotional mental image is formed at the magnetic body.

Charge entanglement involving W MEs makes possible superpositions of several sensory percepts and state function reduction would select one of them. The possibility to build quantum superpositions of alternative percepts means metabolic economy since only single percept need to be realized in a given quantum parallel universe. The selection of percepts in binocular rivalry might be a basic example about state function reductions at the level of perception. Information processing resembling quantum computing could be realized using quantum superpositions of nerve pulse patterns. Same picture applies also to motor action. When a large number of similar systems (say sensory receptors) is involved, quantum statistical determinism guarantees reliable perception.

EEG and MEG studies demonstrate that high frequency components of sensory evoked potentials exhibit precise neuronal synchrony in the awake state but disappear in deep anesthesia [68]. A possible interpretation is that Josephson radiation at 1 kHz frequency ceases as a consequence of anesthesia. This conforms with the fact that anesthetes affect cell membrane. For instance, a phase transition changing the Planck constant associated with 1 kHz cell membranes by the action of anesthate could lead to the disappearence of 1 kHz frequency.

Also gamma (40 Hz) synchronization is enhanced during arousal and focused attention as well as during a conscious perception of distinct auditory events and of coherent visual stimuli during attentive visual search. Again the interpretation would be in terms of Josephson currents which get more intense or appear as a phase transition increasing the Planck constant by factor 4 for neuronal membranes with 10 Hz Josephson frequency. Note that 40 Hz Josephson frequency corresponds to Josephson wavelength of about 3 meters.

Dark Josephson frequencies and corresponding parts of the magnetic body scale like $r = \hbar/\hbar_0$ whereas the corresponding body parts would scale like $\sqrt{r}$. This gives the map of wavelengths to the sizes of the body parts suggested by the findings about water memory and which I have used to refer to as scaling law. Scaling law will be discussed in the last section.

Temporal binding by synchronization

The article of Engel *et al* [68] provides an excellent representation about the development, motivations and the recent empirical status of temporal binding by neuronal synchrony. The article contains also references to the original work and the references to the results represented below can be found from this article and are not separately mentioned.

There are many reasons why for binding by synchronization. Later also empirical evidence suggesting that synchronization accompanices only the formation of percept rather than percept itself is discussed.

1. Synchrony provides the counterpart of computer clock making possible a precise presynaptic summation of the neural inputs in turn implying fast and precise and fast neural processing. Synchrony makes also possible coordinated changes of the synaptic efficacies: this is of obvious importance for the associative learning at synaptic level. Also the robustness of neural processing is implied: army does not need single man.

2. Synchronized neuronal assemblies define natural candidates for the neural correlates of conscious percepts and synchronization might be a basic mechanism of attention.

3. The information processing in brain is known to be highly parallel and distributed: for instance, there are about 30 distinct visual areas in monkey brain. Synchronization between various sensory, motor and associative areas has been proposed as a candidate for the mechanism generating coherent gestalts.

4. Synchronization has been proposed as key element for functions like learning and short term memory. Quite generally, it seems that non-synchronized brain regions are analogous to a computer without a global computer clock and thus seats of neural chaos.

5. Synchronization has been also suggested by Crick and Koch to be a necessary and sufficient condition for conscious experience to occur. From the TGD point of view and on general philosophical grounds this hypothesis seems to be too far-fetched. Rather, synchronization seems to provide the counterpart of computer clock in TGD framework feeding order in neuronal chaos. Synchronized regions define however natural correlates for sub...selves.

What is the dynamics of volition and thought?

The proposed simplified view leaves open some fundamental questions which basically relate to how the geometric correlate of intentional action identified as p-adic–real transformations for space-time regions takes place at brain level. There are two basic questions.

1. How the dynamics of thought generation is realized?

The understanding of the feedback from the sensory (real) level to the cognitive (p-adic) level is required. More precisely, how sensory (real physics) input is transformed to cognition if the latter indeed involves the generation of p-adic MEs? There are also questions related to the role of neutrinos. What is the role of the spin flips of real cognitive neutrino pairs proposed to represent memetic codewords in this process [18] but not discussed in this chapter at all? Are also cognitive neutrino pairs needed? Recall that cognitive neutrino-antineutrino pair is identified as neutrino and antineutrino located at the opposite throats of a wormhole contact. The throats are quite generally identified as light-like 3-surfaces carrying parton quantum numbers. The question is basically about whether this kind of nearly zero energy particles existing simultaneously at two space-time sheets are important for the understanding consciousness and living matter.

2. How the dynamics of volition is realized?

In zero energy ontology volitional action would be in a formal sense time reversal of the sensory perception with signals initiating the action propagatin in time reversed direction from magnetic body to brain and eventually to the level of motor neurons.

Typically, the transformation of p-adic W MEs representing intentions to real ones with negative energy connecting magnetic body to some part of the cortex, presumably glial cell group, induces synchronous neural firing exciting or inhibiting some other regions. In excitatory case this should somehow lead to a cascade in which lower level p-adic MEs of excited regions are transformed to real ones. The basic question is what mechanism induces the transformation of the p-adic MEs to real ones.

p-Adic length scale hypothesis suggests that some kind of a resonance dynamics possible at kHz resonant frequency and involving a feedback between p-adic and real physics is involved. This leads to the following view about what is involved with volitional action and in the generation of thought.

1. Volition would be volition of the personal magnetic body and induce a cascade of volitional acts transforming p-adic MEs to negative energy real MEs in shorter length and time scales. p-Adic-to-real transformation of negative energy W ME could occur with a high probability when p-adic W ME oscillates with a frequency which corresponds to the duration of the bit of the p-adic code word which is related to an appropriate dark matter level and p-adic length scale in a simple manner. When out of tune, p-adic negative energy ME would transform to a real ME with a low probability.

   This would suggest the realization of volition by frequency tuning. Tuning would mean that p-adic and corresponding real ME would have a maximum number of common rational points. Volition is involved also with the selection between percepts (not always by us however) in situations like binocular rivalry. The difference of an imagined almost real motor action and actual motor action would be that the imagined motor action is not induced by the negative energy ME entangling with motor organs but with some higher level of motor pathways. For sensory imagination entanglement would also occur with some higher level of sensory pathway than sensory organ.

2. One can wonder whether also real-to-padic phase transitions could occur and whether the dynamics of thought could the reversal for the dynamics of volition. Again synchronization and resonance condition would be important. p-Adic length scale hypothesis favors synchronization frequencies which correspond to p-adic length scales. If this picture is correct, volition and thought would be in well a defined sense time reversals of each other with respect to subjective time development.

3. The counter intuitive aspect of the p-adic topology is that p-adic space-time sheets having arbitrarily large size in real sense can be arbitrarily small p-adically. Hence p-adic space-time sheet of infinitesimal size could have contact with systems separated by a real distance of the order of the size of the observable universe and even larger. If the energy of negative energy ME is by quantization argument of the order $E = 2\pi c/L$, negative energy ME of astrophysical size can result with very low energy costs as p-adic ME is transformed to a real one. These paradoxical aspects are however consistent with the view about the role of magnetic body and

MEs for consciousness, and the attempt to deduce in detail the implications might be very rewarding.

A general view about the role of synchrony

The hypothesis that synchronization is due to the presence of MEs suggests the following general view about how conscious brain functions.

1. The basic states for the various areas of brain could represent more or less chaotic neuronal activity without synchrony. During sleep primordial neuronal chaos might be realized in the scale of the entire cortex.

2. p-Adic W MEs representing intentions and these would transform to real negative energy W MEs and represent desires inducing generalized motor actions. Negative energy W MEs would select from the sea of cortical chaos islands of order and generate objects of perceptive field or behavior (by sensory-motor analogy one might perhaps speak of "behavioral field") realized as sub-selves. W MEs would obviously feed negentropy to the neuronal primordial chaos and generate macro-temporal quantum coherence and thus sharp sub-selves lasting for a sufficiently long time to contribute significantly to the contents of consciousness and behavior (note the analogy with a social group: very short-lived member does not contribute significantly to the development of the social group).

3. The question whether there exist non-neuronal correlates for consciousness is definitely settled in this framework: they do exist and correspond to both p-adic and real charged and neutral MEs both in the sense of electro-weak and color interactions and the synchronous firing of neurons provides a direct experimental evidence for these correlates visible already at the primary sensory areas.

4. The mesoscopic feature level visible in EEG and reflecting the synchrony MEs could represent a higher abstraction level in which memetic code words are compressed to the genetic code.

This view combined with the general vision about the realization of the various representations represents a reasonably coherent vision about how magnetic body controls brain. There remains of course challenges even at the level of principle. The question whether p-adic-to-real transitions and their reversals really make sense and occur is one of them. The fact that inertial energy is not positive definite in TGD Universe makes in principle possible this kind of transitions.

7.3.3 40 Hz synchrony and negentropic entanglement

If one accepts the vision about life as something in the intersection of real and p-adic worlds 40 Hz EEG synchrony can be interpreted as a correlate for the generation of negentropic entanglement between cortical neurons. Before proposing this interpretation let us first describe the experimental findings of a finnish neuroscientist Antti Revonsuo [47] challenging the simplest view about the role of 40 Hz synchrony in binding.

Findings

The interpretation for 40 Hz EEG frequency inspired by the binding hypothesis is as a synchronizing frequency necessary for the generation of unified percepts. This hypothesis has been studied using auto-stereograms [47]. There was no detectable difference in the power spectrum at 36-44 Hz range in the situation when auto-stereogram was experienced as a set of random dots as compared to the situation when it was perceived as a coherent, symmetrical gestalt. The situation was same also in 8-13 Hz and 13-20 Hz beta bands. The finding is consistent with the place coding hypothesis.

On the other hand, when the conscious percept was transformed from a random set of points to a coherent gestalt, there was a detectable increase in 40 Hz power in the occipital and right posterior sites for EEG electrodes in a time window 500-300 ms before the unified percept was reported. There could be also some time lapse between the unified percept and the report about it but probably this cannot explain the entire lapse. No increase of power in beta bands was detected: this might be due to the fact that the widths of the measured bands are much wider than the widths of the narrow sub-bands reported masked by other EEG activity according to [44]. Note that in the model for a hierarchy of EEGs based on dark matter hierarchy beta band correspond to data communicated to the magnetic body [20].

That the change in activity is associated with the emergence of a new percept suggests that the temporary increase of the EEG power could be assigned to the communications of the forming percept to the magnetic body.

Interpretation in terms of generation of negentropic entanglement

A fresh view about what really happens during 40 Hz synchrony came with the realization that negentropic entanglement is possible in the intersection of real and p-adic worlds. The generation of negentropic entanglement between two subselves means that the corresponding mental images are fused [8, 27]. The process is experienced by the fusing subselves as an expansion of consciousness whereas consciousness is lost when when bound state entanglement is generated. Also the meditative states begin with enchanged 40 Hz activity and the interpretation would be same. Quite generally, the generation of negentropically entangled neuron groups could be a correlate for the emergence of a new idea or a new holistic pattern emerging from a chaos. Synchronous firing would be a natural correlate for the synergic state resulting in this manner. The paradoxical looking reduction of the oxiditative metabolism associated with 40 Hz firing could be seen as a signature of reduced dissipation when dissipating ensemble of neurons forms a single quantum coherent system.

What could then be the interpretation of the 300-500 ms time scale and synchronous firing in TGD framework?

1. If one assumes that only brain is involved, one must answer whether the new percept emerges after such a long time period. One would naively expect that negentropic entanglement immediately gives rise to the percept. Negentropic entanglement however means that a quantum superposition of several alternative percepts is involved. In the beginning the new percept is present with only small probability so that one would only know that the moment of heureka is quite near (this is indeed the experience that one has) and in the final situation it dominates but not completely since it requires conscious effort to preserve the percept.

2. Also magnetic body should be involved in TGD framework. The natural question is "Why this synchronous neuronal firing?". The natural answer would be that it allows to communicate the new percept as a consequence of a generation of negentropic entanglement to the magnetic body. The frequency scale of 40 Hz corresponds to a time scale of 25 milliseconds and corresponds to a length scale involved is about $.75 \times 10^7$ m, a good candidate for the size of the part of the magnetic body involved. This time scale is much shorter than 300-500 seconds. If the layer of the magnetic body in question corresponds to the fundamental 100 millisecond time scale assignable to electron as is natural in case of sensory percepts, the time lapse could be essentially due to the communication. If one takes the time scale literally the value of Planck constant which is about 3 to 5 larger than its standard value would suggest itself. Of course, the development of the percept from a fuzzy inkling to the final heureka could involve several communication loops between brain and magnetic body so that the interpretation as a lapse due the slowness of communications need not be inconsistent with the first interpretation.

3. The time scale 300-500 ms could characterize the duration of negentropic entanglement but this is not necessarily the case since negentropic entanglement would be un-necessary after the percept has been represented symbolically so that one knows what is lurking behind the chaos.

7.4 Stochastic resonance and brain

This section begins with the review of the notion of the stochastic resonance. Also its applications to neuronal systems are reviewed. With motivations coming from conceptual difficulties of the proposed neuronal models, a reduction of the stochastic resonance to the quantum level, which is assumed to control the functioning of bio-systems, is developed by refining the quantum model for nerve pulse generation by specifying the interaction with MEs. Another key idea described in detail in [23] is that bio-systems correspond to flow equilibria for ions in the many-sheeted space-time with atomic space-time sheets having the role of a controlled system and super-conducting space-time sheets taking the role of the controlling system. The possibility that MEs generate by stochastic resonance soliton sequences associated with Josephson currents, is discussed.

7.4.1 Stochastic resonance

Background noise is usually seen as a mere nuisance in communications but under certain circumstances it can in fact improve, rather than hinder the performance. The notion of stochastic resonance [35] was originally put forward by Benzi and collaborators [37] in seminal papers where they study the problem of the periodically recurrent ice ages. The same suggestion was raised independently by C. Nicolis and G. Nicolis [34]. The planetary glaciation sequence has a period of about 10^5 years which happens to be same as the period of the planetary gravitational perturbations with a typical time scale of 10^5 years inducing an extremely small (of about .1 per cent) periodic variation of the solar constant which as such cannot explain ice ages. The system is modelled by a bistable potential in which the two potential wells represent the ice-covered Earth and the normal climate. Short term climate fluctuations are modelled by white noise and if the intensity of the white noise is correct, the weak periodic variation of Earth's temperature is amplified to a synchronized hopping between cold and warm climates.

The notion of stochastic resonance has been considerably generalized to include a number of different mechanisms. The unifying features are the increased sensitivity to small perturbations and phase locking for an optimal noise level. Stochastic resonance like features have been reported also for autonomous systems. Also the quantum version of the stochastic resonance taking into account quantum tunnelling has been studied. Stochastic resonance has been also generalized to coupled (that is higher-dimensional) systems and to excitable systems allowing only single stable state and meta-stable states. The interested reader can find references to the rich literature about stochastic resonance in [35].

Stochastic resonance has been verified for a wide variety of system such as Schmitt trigger, bistable ring laser, electron paramagnetic resonance, and super-conducting quantum interference devices (SQUIDs) [35]. An especially important application is to neuronal systems [36].

7.4.2 Basic model for stochastic resonance

The archetypal model of stochastic resonance involves a one-dimensional system equivalent with a particle with mass m moving in a double potential well

$$V(x) = -ax^2/2 + bx^4/2$$

under a friction force $\gamma dx/dt$ proportional to velocity, a weak periodic external driving force $A(t) = A_0 sin(\Omega t)$, and a random force which can be modelled as a white noise $\xi(t)$ with vanishing mean and correlation function

$$\langle \xi(t_1)\xi(t_2) = 2D\delta(t_1 - t_2) \ .$$

Here the parameter D characterizes the noise level.

The noise could be also a more general colored Gaussian noise with ultraviolet frequency cutoff. The fluctuational forces cause transitions between the potential wells with a rate given by the Kramers rate [33]:

$$r_K = \frac{\omega_0\omega_b}{2\pi\gamma} exp\left[-\frac{\Delta V}{D}\right] \ . \tag{7.4.1}$$

Here $\omega_0^2 = V''(\pm x_m)/m$ is square of the frequency of small oscillations at the bottom of well and $\omega_b^2 = -V''(x_b)/m$ is an analogous quantity estimated at origin which correspond to the maximum of the potential. ΔV denotes the height of the potential barrier separating the two minima.

If a periodic spatially constant force is applied to the particle, it induces a periodic variation in the shape of potential. At a given well the minimum of the potential barrier occurs periodically with frequency Ω and if the particle hops to second well when barrier height is minimum it experiences minimum height barrier in the second well after a half period. If the white noise is such that the rate r_K is twice the frequency Ω:

$$r_K = 2\Omega \ , \tag{7.4.2}$$

the rate for the jumps between potential wells is synchronized with the periodic variation of the external force. One can understand this relationship intuitively on basis of the previous simple observations.

Stochastic resonance is manifested as a phase locking of $x(t)$ to the external force and as maximum of the average amplitude as function of the parameter D characterizing the noise level when the resonance condition is satisfied. In linear response theory, which is appropriate when the condition $A_0x_m << D$ is satisfied, the approximate expressions for the average amplitude and phase shift read as

$$\begin{aligned} \overline{x} &= \frac{1}{m\gamma\omega\omega_b}\frac{A_0\langle x^2\rangle_0}{D}\frac{2r_K}{\sqrt{4r_K^2+\Omega^2}} \ , \\ \overline{\Phi}(D) &= arctan(\frac{\Omega}{2r_K}) \ . \end{aligned} \tag{7.4.3}$$

$\langle x^2\rangle_0$ denotes the variance for the unperturbed noisy system. The distribution of time intervals between hoppings has characteristic peaks at $T = 2\pi/\Omega$ and its integer multiples.

The phase averaged power spectral density $S(\omega)$ defined as the Fourier transform of the correlation function $\langle x(t+\tau)x(t)\rangle$

$$S(\omega) = \int_{-\infty}^{\infty} exp(-i\omega\tau)\langle x(t+\tau)x(t)\rangle d\tau \ , \tag{7.4.4}$$

exhibits delta peaks at frequencies $(2n+1)\Omega$ superposed to a noise background $S_N(\omega)$ whereas even multiples of Ω correspond to dips. This reflects the reflection symmetry of the double potential well. The heights of the spectral spikes behave as A_0^{2n} and since the periodic perturbation is assumed to be weak, it is possible to restrict the consideration to the first spike ($n = 1$). In the linear response theory one obtains following expressions for the noise density $S_N^0(\omega)$, total spectral density $S(\omega)$, and signal-to-noise ratio:

$$\begin{aligned} S_N^0(\omega) &= 4r_K\frac{\langle x^2\rangle_0}{\sqrt{4r_K^2+\Omega^2}} \ , \\ S(\omega) &= \frac{\pi}{2}\overline{x}(D)^2\left[\delta(\omega-\Omega)+\delta(\omega+\Omega)\right] + S_N(\omega) \ , \\ SMR &\equiv 2\left[lim_{\Delta\omega\rightarrow 0}\int_{\Omega-\Delta\omega}^{\Omega+\Delta\omega} d\omega\right]/S_N(\Omega) = \pi(\frac{A_0x_m}{D})^2 r_K \ . \end{aligned} \tag{7.4.5}$$

7.4.3 Stochastic resonance and neuronal systems

During the last decade stochastic resonance has become a well accepted paradigm in the biological and neurophysiological sciences [36]. This despite the fact that neuronal systems are excitable systems with only single stable ground state and a short-lived excited state with lifetime of order millisecond which can be short as compared to the typical driving frequency. The simplest models effectively assume that neuron is a bistable system. The most obvious functions of the stochastic resonance in neuronal systems are the amplification of weak periodic signals (such as the noise produced by a predator) and temporal coding (say in auditory nerve).

In TGD framework the natural question is whether the stochastic resonance really occurs at the neuronal level or at a deeper control level. If the latter option is correct, the simplest paradigm of bistable system might be enough to model the system.

Empirical evidence for stochastic resonance in neuronal systems

The encoding of acoustic information on the primary auditory nerve of mammals has been studied for a half century. It has been known that, in contrast to the conventional theory, the information about the frequency of the stimulus is coded also to the inter-spike distribution of the spike sequence. This correlation between neuronal input and output is known as phase locking in neurophysiology and presents one particular form of temporal coding [58]. It is needless to emphasize that various forms of temporal coding and its reverse process are absolutely crucial in TGD based model of qualia.

Longtin, Bulsa and Moss [64] observed that inter-spike interval histograms of periodically stimulated neurons of a cat exhibit a remarkable resemblance to the return time distributions of a periodically driven noisy bistable system with Gaussian noise for which correlation function decays exponentially:

$$\langle \xi(t)\xi(t')\rangle = \frac{D}{\tau_c} exp\left(-\frac{|t-t'|}{\tau_c}\right) \quad . \tag{7.4.6}$$

Return time is defined as the time for the system to be kicked from one well to another and back again. With only one fitting parameter it was possible to achieve an excellent agreement. Neuron is definitely not a bistable system and this forces to ask whether the assumption about the underlying bistable system might make sense at some deeper, controlling level.

Moss and collaborators studied also the behavior of the mechanoreceptor cell of a crayfish [65] by stimulating it with an input consisting of a sum of single tone and noise. The spectral properties of the action potentials were analyzed, yielding a power spectrum typified by a background noise plus sharp peaks at multiples of the frequency of the stimulus. Also signal-to-noise ratio was studied and was found to resemble the shape of the corresponding curve for a bistable system although the resonance peak as function of the noise intensity does not decrease so fast as for stochastic resonance in a bistable system.

Stochastic resonance has been demonstrated to occur also in the hair cell of cricket [56]. In this case the function of the stochastic resonance is to help the detection of a weak periodic signal (a coherent motion of air created by say predator) from a huge noisy background.

Models of stochastic resonance based on standard neuroscience

Several phenomenological models reproducing the stochastic resonance for inter-spike interval distributions have been proposed.

1. Neuron firing and Poissonian spike trains

The simplest model is based on the idea that neuron emits uncorrelated sharp spikes at random times [42] The spiking rate $r(t)$ is however sinusoidally modulated and the specification of $r(t)$ defines the model. One can express the phase averaged spectral density $S(\omega)$ for the spike train as a sum of frequency independent white noise term $\overline{r}$ and sum of delta peaks at frequencies $\omega = n\Omega$:

$$\begin{aligned} S(\omega) &= \overline{r} + 2\pi \textstyle\sum_{n=1}^{\infty} |r_n|^2 \delta(\omega - n\Omega) \ , \\ r_n &= \textstyle\frac{1}{T}\int_0^T r(t) exp(-in\Omega t) dt \ . \end{aligned} \tag{7.4.7}$$

The rate theory for noise-induced barrier crossing in the presence of a periodic external force suggest the generalization of the Kramers rate formula for the hopping rate r_D between potential wells to

$$r(t) = \nu \times exp\left[-\tfrac{\Delta V}{D} - \tfrac{A_0 x_m}{D} cos(\Omega t)\right] \quad . \tag{7.4.8}$$

Here ΔV is the barrier height in absence of forcing, D is noise strength, A_0 is the amplitude of the periodic driving force, and the scale factor x_m characterizes the position of the potential well. The pre-factor ν depends on the details of the process. This formula should make sense for sufficiently low frequencies Ω (adiabatic approximation).

By calculating the Fourier transform of $r(t)$ one obtains for the signal to noise ratio defined as the ratio

$$SNR = \frac{2\pi r_1^2}{\overline{r}} \simeq \frac{\pi x_m^2 A_0^2}{D^2} exp\left(-\frac{\Delta V}{D}\right) \quad . \tag{7.4.9}$$

Signal-to-noise ratio shows a behavior characteristic for stochastic resonance. The comparison with the data from the mechanically modulated mechanoreceptors of a crayfish shows qualitative agreement with this prediction although the decrease of SNR for large noise levels is overestimated by this model. The parametrization of $r(t)$ is based on the assumption that system is effectively bistable: this is of course not true at the neuronal level.

3. Integrate and fire model

Integrate and fire model assumes that the input of the neuron consists of a spike train $i(t)$ (cortical neurons) or a continuous signal (sensory neurons) [55, 35]. The membrane voltage $u(t)$ is obtained by integrating the input $i(t)$ represented as a current through the membrane. By representing cell membrane as a capacitance C and resistance R the equation of motion for the membrane potential reads as

$$\frac{d}{dt}u = -\frac{1}{\tau_{RC}}u + \frac{i(t)}{C} + \frac{\xi(t)}{C} \quad . \tag{7.4.10}$$

Here one has $\tau_{RC} = RC$. Gaussian white noise with a zero mean is assumed. In the case of a perfect integrator ($1/RC = 0$) the Fokker Planck equation for the probability distribution for the potential values as a function of time reads as

$$\frac{\partial P(u,t)}{\partial t} = -\left[i_0 + A_0 cos(\Omega t)\right]\frac{\partial P(u,t)}{\partial u} + D\frac{\partial^2 P(u,t)}{\partial u^2} \quad . \tag{7.4.11}$$

The equation states that probability is conserved for the flow in the phase space defined by u and velocity variable $\partial_t u$. Initial values are $P(u = b, t) = 0$ at threshold stating that particle is absorbed at $u = b$. The rate for crossing is given by $r(t) = dP(u = b, t)/dt$.

The distribution function for the inter-spike intervals is given by the mean-first-passage time distribution ρ which is essentially the probability $P(b \rightarrow b)$ that the random walk in the external driving force leads from the point $u = b$ representing the threshold for nerve pulse generation ends up for the first time back to $u = b$. This probability can be calculated using Wiener integral for a particle performing random walk in the external force field defined by the periodic perturbation at the half-line $u \geq b$. The first passage distribution shows a multi-peaked structure with higher peaks suppressed exponentially. For a sufficiently large stimulus the peaks are located at $t_n = nT$, $T = 2\pi/\Omega$. The heights of the peaks decay exponentially. The peaks heights run through a maximum as a function of the noise strength D.

This model is unrealistic for several reasons. For instance, the phase of the sinusoidal stimulus is reset after every spike so that the coherence of the stimulus is eliminated.

4. Neuron firing and threshold crossing

One can improve the integrate and fire model by allowing the resistance to be finite and modify it by assuming that the phase, rather than being reset, does not change at all in the emission of a nerve pulse [59, 35]. One can solve $u(t)$ from the previous equation in absence of the noise explicitly by assuming that the amplitude of the driving force is so small that the threshold is not crossed in the absence of the noise. This gives at large values of time

$$u_\infty(t) = i_0 R + \frac{A_0 R}{1 + \Omega^2 \tau_{RC}^2} sin(\Omega t - \phi_{RC}) \quad . \tag{7.4.12}$$

Here one has $tan(\phi_{RC}) = \Omega/t_{RC}$. The presence of the ohmic current induces the reduction of the threshold to $b - i_0 R$. Gaussian colored noise is assumed to cause the crossing and the generation of the nerve pulse, which is for simplicity idealized with a delta peak.

The problem of calculating the rate for the threshold crossing can be formulated mathematically as a random walk on half line $u \geq b$ in presence of an external force using a semiclassical approximation for the Wiener integral over all paths. This means a functional integration over small perturbations of an unperturbed solution to give the probability $P(t)$ that an arbitrary path of the particle leads to the threshold $u = b$ during time interval t. The rate $r(t)$ for the threshold crossing is given as $r(t) = dP(t)/dt$. In [59] $r(t)$ the threshold crossing rate is estimated for a colored Gaussian noise and one finds stochastic resonance also now. The formulas are not reproduced here: the interested reader can find them in [35].

This model effectively assumes that the membrane potential is driven by an external driving force and that the phase of the membrane potential is not appreciably affected by the emission of the spikes. This is consistent with the idea that there is some deeper control mechanism giving rise to the stochastic resonance and that neural level is only the controlled level.

7.4.4 How neuronal stochastic resonance could be realized at quantum level?

There is no doubt that neuronal systems exhibit stochastic resonance. The excellent fit of the inter-spike interval distribution by a return time distribution for a bistable system in the case of the auditory nerve of a cat suggests that genuine bistable system might be somehow involved. It is however not at all clear whether it is possible to understand the emergence of the stochastic resonance without leaving the framework of the standard Hodgkin-Huxley theory.

1. Neuronal systems are excitable media rather than bistable systems and it is not at all obvious whether excitable media allow stochastic resonance.

2. The time scale for the return of a neuron to the resting state is of order milliseconds and can be much shorter than the period of the driving external force. Thus the intuitive picture behind stochastic resonance need not make sense at neuronal level. Perhaps one should turn the attention to a more fundamental level, and interpret nerve pulse activity as a result of quantum control with the bistable system to be identified acting as a control system.

The previous model for sensory receptor applied to hearing suggests that perhaps a plausible model of stochastic resonance could be obtained by including besides neurons also a system able to represent sensory input as evoked potentials giving rise to cognitive and/or emotional representations in the manner discussed. This system could be sensory receptor such has hair cell or an aggregate of glial cells (the possible role of astrocytes for brain functioning has been discussed earlier in [19]).

As found, periodic signal and white noise affecting bistable system are the key factors in the stochastic resonance. Astrocytes would induce the spiking of nearby neurons whereas spike activity and/or microtubular input would generate perturbations of the astrocyte membrane potential which might perhaps allow idealization as white noise. In the case of sensory receptor the source of white noise could be neuronal and/or microtubular back projection.

The basic prediction is that the frequency of the stochastic resonance has an exponential sensitivity to $1/D$, where D characterizes the intensity of the white noise assumed to be generated by the neural activity. The noise level should correlate with the average firing rate if neurons are responsible for the white noise. Also microtubular white noise could be induced by the neuronal firing. The intensity of the white noise should be under automatic or conscious control so that important frequencies could be spotted out from the sensory input by "tuning to the correct wavelength" by varying the level of (possibly neural) noise. The reduction of the resting potential generates higher level of spontaneous firing so that the level of alertness would correlate directly with the value of the spotted frequency for neural noise option.

In the case of sensory organ the oscillatory signal would be contained in the sensory input represented as an evoked potential. In the case of astrocytes the oscillatory signal would be contained to the sensory signal mediated by microtubuli inducing oscillating evoked membrane potentials V. For hearing V could represent electric counterpart of a sound wave with a well-defined frequency. V would modulate Josephson frequency since it would appear as an additive component in membrane potential besides membrane voltage.

Stochastic resonance should transform a frequency associated with the sensory input V to a peak frequency in the autocorrelation function for spikes so that spike interval distribution would reflect the frequency of the sensory input and its harmonics. For sound frequencies sufficiently below kHz this is easy to understand since the membrane potential oscillates in the same rhythm as the sound wave. Above kHz frequency rate coding does not make sense.

If neuron is Josephson junction it could serve as a system allowing bistability and stochastic resonance. Josephson junctions are indeed known to allow stochastic resonance [32] but this situation applies to small oscillations of the phase difference Φ over the junction with regions $\Phi > 0$ and $\Phi < 0$ identified as the analogs of the two potential wells. The two state should correspond to firing and non-firing states of the neuron and the model for nerve pulse and EEG identifies the resting state as a state in which Josephson junction is mathematically analogous to a rotating pendulum but with so low a rotation velocity that small reduction of the rotation velocity leads to an oscillation mode. The reduction of membrane potential below the critical value for nerve pulse generation would reduce the rotation velocity and would reduce the rotation to oscillation and induce nerve pulse. The return to the original state would be automatic. The transition between the two states (no firing induced or firing induced) would be induced by the neuronal noise with Kramer rate equal to two times the frequency of the periodic stimulation.

Astrocyte system could control the level of the neural noise acting like a listener of the radio turning the knob to find the station. The position of knob would be replaced with the level of the neural noise. A feedback loop between the two systems would make possible to find the optimal noise level. Glutamine-glutamate cycle for astrocyte-neuron interaction could make this system possible.

7.5 Temporal codings

An impressive evidence exists for the temporal coding [58] despite the fact that the dominant view has for long time been that rate coding is all that is involved. The vision about MEs as quantum holograms suggests that nerve pulse patterns are coded to the pulse patterns of the light-like current along ME. The hierarchy of Planck constants and the model of EEG in terms of Josephson radiation suggests a quite precise realization for the brain as orchestra metaphor with frequency modulation used as the basic tool to represent information.

7.5.1 Basic structure of EEG in TGD framework

It is known that EEG decomposes to sum of two parts: the part consisting of relatively few fundamental frequencies and their harmonics and the quasi-continuous part, 'noise'. Both the amplitudes of harmonics and fundamental frequencies fluctuate.

Josephson current of particular ion is proportional to $sin(Q_{eff}\int(V_0+V_1+V_{noise})dt)$, V represents fundamental frequency, V_1 to spike contribution, and V_{noise} to the neural noise. The current and thus also Josephson radiation can be decomposed by basic trigonometric formula to the sum

$$sin[Q_{eff}\int(V_0+V_1)dt]\times cos[Q_{eff}\int V_{noise}dt]+cos[Q_{eff}\int(V_0+V_1)dt]\times sin[Q_{eff}\int V_{noise})dt] \ .$$

The integral over the noise is small so that one has $cos[Q_{eff}\int V_{noise}dt]\simeq 1$ and $sin[Q_{eff}\int V_{noise}dt]\simeq Q_{eff}\int V_{noise}dt$ giving a representation which might be consistent with the observations.

What is new that the noise level is amplitude modulated. If the frequency of the stimulus is high as compared to the Josephson frequency, the neuron automatically performs variation of the noise level in order to find ideal noise level for stochastic resonance during the period. This is like automaticized periodic turning of the knob back and forth to identify the correct wave length.

The fluctation of the frequencies would be due to the fluctuation of the membrane potentials and the fluctuation of the amplitudes due to the intensity of Josephson currents.

Due to the fact that the neuronal membrane is near to the threshold for firing the treatment of the noise as something small is justified only if the amplitude of the noise remains low enough. Indeed, stochastic resonance becomes possible and leads to neuronal firing in the rhythm defined by external perturbation.

7.5.2 TGD based overall view about temporal codings

The following is a summary about TGD inspired attempt to build an overall view about temporal codings.

Brain as orchestra metaphor

1. The prevailing neuro-scientific view is that the resonance frequencies of EEG can be assigned to resonances in neural circuits. In TGD inspired picture nerve circuits are not necessary and there are reasons to believe that this kind of resonances are too wide to explain kHz resonances frequency or even sharp EEG resonances. Rather, EEG frequencies are reduced to Josephson frequencies assignable to the effective cell membrane potential and are proportional to the membrane potential. The energies of corresponding dark photons are in visible and UV range and their decay gives rise to either EEG photons or bio-photons. The spectrum of frequencies is dictated by the spectrum of the preferred Planck constants and the scale of spectrum depends on ion and value of membrane potential.

   Singing whale provides a good metaphor for how EEG codes for the information carried by neuronal activity since the small perturbations of the membrane potential and even nerve pulse induce frequency modulation of the fundamental frequency. Depending on the character of perturbation the situation corresponds to singing or speech (when recorded speech is represented slowly it becomes clear that also now frequency modulation is involved). If preferred Planck constants come as powers of to dictated by Mersenne hypothesis then also brain as orchestra metaphor becomes surprisingly precise.

2. The interference of perturbations of the membane potential from presynaptic cells means that membrane potentials are summed up so that rate coding is only partial description and it is ineeded known that emotional aspects of speech cannot be produced using only this information. At the level of brain an attractive hypothesis is that the signals from neurons are transferred to glial cells as small perturbations and communicated to the magnetic body therefrom.

3. "Note" and "phoneme" representations (song and speech) defining emotional and cognitive representations would be realized as temporal patterns of evoked potentials at the level of sensory receptors and glial cells. Genetic or even memetic code could be realized in case of speech like representations. The hierarchy of Planck constants allows very complex hierarchy of frequency modulations induced by the interaction of nearby neurons and glial cells and by spike activity. The aggregates of glial cells could be in the role of highest level in the representational hierarchy. Orchestras have soloists and one can wonder whether soloists are now analogs of Grandma neurons or groups of neurons or glial cells producing especially intricate frequency modulation patterns. Features include also spatial modulation patterns.

4. That neural transmitters and modulators control resonance frequencies in neural circuits is also a natural hypothesis in neuroscience context. In TGD framework neural transmitters and modulators can affect average firing rates and also the intensity of neural activity by controlling the resting value of the membrane potential and sensitivity for the firing. Glial cells might also participate on this control in accordance with idea that they take the role of conductor.

Codings

Several kinds of codings reducing basically to frequency modulation can be considered and also here orchestra metaphor helps to imagine various options. First kind of could would rely on nerve pulse patterns and the perturbations induced by these.

1. The cortical representation of audible frequencies above 1 kHz requires representations using evoked potentials of glial cells and the transfer of sensory input as Josephson radiation along sensory pathway and/or as acoustic/electric oscillations of microtubuli to the glial cells is a necessary prerequisite of this representation. The cortical feedback via outer hair cells expands the audible frequencies above 1 kHz in the case of mammals and makes possible the representations of EEG frequencies as frequency modulations of the Josephson frequencies for the aggregates of glial cells. This representation would emerge in frontal lobes.

2. Also the coding of (say sound) frequencies based on spike interval statistics is supported by experimental findings and is possible for frequencies below 1 kHz. This representation might be induced from the above discussed representation at the level of glial aggregates and sensory receptors via stochastic resonance. Periodic signal and white noise affecting bistable system are basic elements of stochastic resonance. Astrocytes induce the spiking of nearby neurons whereas neuronal noise affects astrocytes. Suppose that astrocytes receive also sensory signals mediated by microtubuli inducing oscillating evoked membrane potentials V of astrocytes.

   Stochastic resonance would transform V to a peak frequency in the autocorrelation function for spikes. Glutamine-glutamate cycle for astrocyte-neuron interaction could define the neuron-astrocyte interaction with astrocytes taking the role of radio listener tuning the neurons to a specified wavelength by using the level of noise as a knob.

3. Rate coding defines the roughest coding and would relate to the perturbations of resting potentials of glial cells induced by spike patterns. For the rate conding the temporal pattern of spikes does not matter.

4. The proposal that nerve pulse patterns could realize genetic or even memetic code is one of the earliest TGD inspired conjectures. The time scales of CDs assignable to electron and d quark provide additional support for this idea. In the proposed framework the realization would be in terms of frequency modulation patterns induced by spikes and in principle could realize genetic code by allowing maximum flexibility. 10 Hz alpha rhythm would specify uniquely the time intervals containing the genetic codons. The discrete value of the firing rate expressed as the number of spikes per period of 10 Hz alpha wave would realize genetic codon as an integer $n \leq 63$. One can however argue that memetic code looks somewhat too rigid a representation to be used by a musician.

   The hint about what might be involved comes from the fact that music is also recorded and nowadays the recordings are digital. Millisecond and 100 ms time scales characterizing nerve pulse activity and features correspond to the standard value of $\hbar_0$. Maybe genetic and memetic code representations result via the interaction between large $\hbar$ space-time sheets with space-time sheets with the same time scale of CD but different Planck constant and p-adic prime. $\hbar_0$ space-time sheets would represent the lowest level of this interaction hierarchy. Mersenne hypothesis indeed relies on this interaction transforming dark weak bosons to their lighter counterparts with a lower value of Planck constant. This interaction would produce something analogous to a binary representation of music piece as a CD able to regenerate to the original experience to some degree and might be of special relevance for long term memory and cognition. The model for the sensory receptor provides a concrete representation for how this transformation could take place [20].

Objections against temporal coding can be circumvented in TGD framework

There are several objections against temporal coding which all involve in an essential manner the relationship between subjective and geometric time. If t=constant snapshot represents the reality, as believed in standard quantum physics, the inclusion of frequencies and temporal patterns does not make sense except phenomenologically. In TGD approach the problem disappears since quantum states are quantum histories. The quantum jump sequence represented by a nerve pulse pattern corresponds to subjective time development as hopping between geometric time developments characterized by EEG patterns. Each nerve pulse affects slightly the EEG pattern.

This raises the question whether EEG record represents the EEG spectrum associated with the space-time surface generated in the last quantum jump or whether it is some kind of an average over the EEG spectra over quantum jumps. If the recording of EEG is completely automatic process, it is updated in every quantum jump and represents EEG at the space-time surface generated in the last quantum jump and, rather paradoxically, is therefore changing all the subjective time. The experiments of Radin and Bierman support this view [69]. Also the experiments related to the timing in active aspects of consciousness suggest that the EEG of the past changes in the interval which is a considerable fraction of second [71] and long time scale compared to the millisecond time scale of nerve pulse patterns.

7.5.3 As if time really mattered

Not only physics, but also neuroscience is plagued by the tensions caused by the erratic identification of the subjective time with the geometric time. There are two views about how nerve pulses patterns code for the sensory data. The first, and still dominating, view is that firing frequency codes for the intensity of the sensory experience. Competing view is that temporal patterns of nerve pulses code for the sensory information (fore a review see [58]).

In TGD framework first approach can be seen as emphasizing the dynamics with respect to subjective time whereas temporal patterns with respect to geometric time are neglected. Both memetic code and spectroscopy of consciousness rely crucially on temporal patterns with respect to geometric time. Hence these approaches are in conflict with the standard view about time. The approach based on temporal coding in the framework of the classical field theory forgets the dynamics with respect to subjective time and concentrates on the dynamics with respect to the geometric time. One however ends up with philosophical paradoxes circulating around time-frequency uncertainty relation: it is difficult to understand how communication is possible at all in deterministic classical world.

Quantum jumps between quantum histories view fuses both of these approaches to a more general unified description. The excellent review article "As if time really mattered: Temporal strategies for neural coding of sensory information" by Peter Cariani about temporal coding will be referred to several times in the following discussion. This article also reviews the difficult problems of frequency coding approach [58].

7.5.4 Rate coding contra temporal coding

Rate coding is the dominating view about the representation of the sensory data in neuroscience and most neural net models rely on this approach. The approach is based on three assumptions.

1. Rate coding is the whole story: the average rate of firing defined by an interval with duration of ten to few hundred milliseconds codes the intensity of the sensory input.

2. Everything is ultimately coded into spatial patterns and spatial rate differences somehow code all relevant sensory information. The standard coding relies on rate-place scheme: average firing rate increases along one-dimensional axis. In TGD this hypothesis is generalized in the sense that brain is assumed to build miniature virtual world model of the space-time and that magnetic transition frequencies code for the values of the spatial and temporal coordinates.

3. A further element is connectionism: in some manner the architecture of the neural pathways gives rise to qualia associated with it.

Geometric time is completely absent from rate-coding based model of brain. This is what mere quantum statistical determinism neglecting the notion of quantum history and the physics of the classical em fields associated with them would leads to. In particular, EEG is mere epiphenomenon in this approach. What makes the situation so problematic is that neural net models describing information as purely spatial patterns can always reproduce the observed behavioral patterns by brute force by introducing a sufficiently complex neural network. From modelling perspective this might be nice but need not have anything to do with how Nature does it. The situation has been however changing during the last decade. The observations about the correlations of EEG patterns with conscious experience, the successes of neurofeedback [60], the realization of the potential importance of 40 Hz coherent oscillations in binding, and a rigorous experimental proof for the temporal coding of odors [66], are forcing the view about brain as a system in which classical em fields are important.

Temporal coding provides alternative and much more general approach but, as already noticed, has also its problems which relate to the fundamental confusions about the relationship between geometric and subjective time. There is empirical evidence for the occurrence of temporal coding in virtually every sensory system [58]. One can imagine many temporal coding mechanisms but the most important ones rely on spike interval statistics and latency-place representations.

Temporal coding provides solutions to the three basic difficulties of the rate coding paradigm: contrast degradation problem, pattern recognition problem and multiple object problem or "superposition catastrophe". Contrast degradation implied by the saturation of the firing rates at high stimulus intensities. Good example of pattern recognition problem is related to the perception of pitch. Same pitch can be generated in very many manners: by monochromatic sound; by a sequence of clicks; or even by a superposition of multiples of fundamental frequency not involving the fundamental frequency itself as in the case of periodic pitch phenomenon. It is very difficult to understand how the stimulus coded to a spatial representation based on mere firing rates could even contain the information needed to decode the pitch. For temporal coding these problems are almost trivial [58]. Superposition catastrophe is identity problem for different objects of perceptive field. For instance, how it is possible to identify the sound of a familiar person in large crowd of people or distinguish transparent object from a nontransparent one, and how it is possible to group sensory inputs to form objects of perceptive field? In temporal coding approach common temporal structures allow to define objects of perceptive field: for instance, points of perceptive field moving in the same direction or behaving synchronously belong to the same object.

7.5.5 Spike-statistics coding in TGD framework

The idea about temporal coding by spike-interval distributions or by some other distribution of time scales associated with the nerve pulse patterns (say intervals between spike bursts) resonates strongly with the spectroscopy of consciousness idea.

Spike-interval statistics and EEG

Spike interval statistics is rather successful. For instance, the information provided by single nerve fiber is enough to reproduce recognizable speech. The correlation of EEG with contents of consciousness experience could be understood by the effect of spike sequences on EEG waves. In the standard framework EEG waves are assumed to be excited by neuronal loops at subcortical level.

Several experiments described in [58] however suggest that spike-interval coding could occur also at subcortical level which supports the view that the necessary information is present already at the level of sensory receptors as indeed assumed in TGD inspired model. In TGD framework nerve pulse patterns would stimulate frequency modulations of EEG waves with frequencies identified as Josephson frequencies and since EEG waves transfer information about sensory data to the magnetic body, the success of the spike interval statistics can be understood.

Multiplexing and broadcasting

Multiplexing means the possibility of transmitting several messages simultaneously as superpositions of different harmonics. In TGD context this means frequency modulations coming as superpositions of this kind and are coded to the EEG waves directly. In the case of small oscillatory perturbations one can apply the product formula to the Josephson current to obtain an approximate linear superposition at the level of Josephson current.

Josephson radiation should affect also neurons and glial cells - in particular regeneration of sensory quale could be possible [20] - and the attractive possibility is that resonance like situation occurs when the period of the oscillatory perturbation co-incides with the average Josephson frequency of the receiving cell and leads to a selection of only this particular contribution from the signal.

This mechanism makes also possible broadcasting is possible: the same message or superposition of messages can be send as Josephson radiation propagating along axonal flux tubes or larger flux quanta at which axonal flux tubes are topologically condensed. This allows mass communications and depending on Josephson frequency of receiving cell, only part of the message is received.

This kind of communication mechanism -if it involves radiation at larger space-time sheets- would provide a mass media type communication mechanism depending only weakly on the connectivity of the neural circuitry. Brain as a neuron society metaphor indeed supports the view that besides neural chatting also mass communications are important. In particular, mass communications might be involved with the synchronous firing of the neuron groups. Combined with the possibility of simultaneous superposition of various data in EEG pattern, broadcasting mechanism replaces the rather poorly defined problem of computing the representation of the external world from spatial firing rate patterns by direct experiencing. The computational problem is transformed to understanding how experience of, say, motion is represented by magnetic quantum phase transitions. Of course, the very assumption that computation gives rise to conscious experience is completely ad-hoc hypothesis.

The role of transmitters and modulators in generating correct EEG frequencies?

The recovery periods for neurons vary from milliseconds to seconds. Recovery time can be affected by neurotransmitters as well as neuro-modulators. Many axons [58] show triphasic recovery period consisting of refractory period, super-excitable phase and depression phase. Clearly, neuron favors inter-spike intervals for which the next spike arrives in neuron during super-excitable phase. Many-levelled hierarchy of neuronal pathways could thus serve as a sequence of sieves selecting preferred frequencies. Emotions are known to affect strongly the information processing in brain but not to alter the information content and peptides as molecules of emotion expresses the importance of these molecules as correlates of the emotional state.

Josephson radiation is absent during recovery period. During the refractory period the Josephson frequency would be higher, during refractory period low, and depression phase presumably higher again. This would allow to code information about the state of the neuron in terms of the pitch of the neuronal song.

Neurotransmitters and neuro-modulators control among other things the value of the resting potential. Besides small scalings of the resting potential also phase transitions changing the value of Planck constant and leading to a new octave could take place. Neither of these changes afffects the information but could code for the emotional state. For instance, alpha and 40 Hz bands could relate by this kind of scaling and the TGD inspired model for EEG during sleep assumes that a phase transition increasing the value of Planck constant by a factor of two occurs twice [20]. It is known that 'hippocampal theta frequency' varies in wide limits [43] and that its value correlates with the state of arousal [45]. This could be due to both $\hbar$ changing phase transitions and smooth change of the resting potential.

Resonant generation of complex motor activities?

There is also the fascinating possibility that a characteristic EEG pattern induces complex self-organization patterns giving rise to the basic building blocks of motor actions or even patterns of them. If this is really the case, then characteristic EEG patterns could serve as names for self-organization processes. This idea is of course not new and is expressed eloquently already by Ernst Mach [58].

Multiplexing and mass communications based on the selective receival by resonance mechanism indeed makes possible for single temporal pattern to carry very complex superposition of EEG frequencies with each frequency coding for a particular spatiotemporal position in the virtual world of brain and exciting neuron in that particular position and leading to to a generation of a complex spatiotemporal pattern amplified to motor action by puppet in string mechanism.

7.5.6 Applications of spike interval coding

Spike interval statistics codes information in the temporal pattern. This information can be information about the temporal or spatial pattern of the sensory stimulus (audition, vibratory sense) or about the non-geometric quale (this might be the case in the case of color vision, tastes and odors).

Empirical data support following type of spike-interval coding. The dominating time interval ΔT in the spike sequence codes for the heard frequency below kHz: $f = 1/\Delta T$ in the case of audition. The intensity of experience is measured by the ratio of the power in dominant interval to the power in non-dominant intervals [58]. This relationship holds true generally. This code gives frequency coding by averaging.

The nice feature of temporal coding mechanism is the possibility of multiplex coding: same nerve pulse pattern can contain simultaneously several messages represented by spike patterns which are mutually orthogonal with respect to the inner product defined by Fourier transform. For instance, information about color, shape and temporal pattern of illumination might be coded as a superposition of nerve pulse patterns. In the following some well established examples about this mechanism [58] are discussed.

Hearing

Hearing involves both spatial coding of frequencies in the sense that special points of cochlea are especially sensitive to frequencies around the center frequency. This is not however the whole story.

Rather, it would seem that this frequency serves only as a carrier frequency for amplitude modulated messages generated by the pattern of nerve pulses. The spike sequences for nerve fibers specialized to a given center frequency contain spike intervals which code for various qualities of sound like pitch, timbre and phonemic identity. Rather remarkably, the spike distribution of single nerve fiber contains enough information about speech to make possible speech recognition [58].

One problem related to the pitch quale is that nerve pulse rates are able to code only for the frequencies considerably below kHz and one must understand the coding of frequencies above kHz. Coding of the frequency by the modulation frequency of Josephson radiation provides a solution to the problem. One could even assume that there is a resonance in the sense that the modulation frequency of the frequency equals to the frequency itself [18] so that the Josephson current decomposes into harmonics of the fundamental frequency. This would mean that EEG patterns would be analogous to harmonics sounds produced by music instruments. Of course, also non-haronic sounds can be considered.

In the phenomenon of periodic pitch superposition of the harmonics of fundamental frequency, which is not itself present in the superposition, generates experience of pitch at the fundamental frequency. Periodic pitch has also visual counterpart which can be understood as coding of the visual textures along lines to temporal patterns by scanning. Periodic pitch can be understood if one assumes coding of the temporal patterns to spike patterns. The point is that any superposition of Fourier components not containing constant term is periodic function with a period determined by the fundamental frequency and must have at least one zero in the period since the integral of this function vanishes and must therefore change its sign at least once in the period. Thus sensory stimulus vanishes at least once during the period which means that threshold crossing occurs periodically and generates spike train. This periodicity in turn implies that also EEG contains the fundamental frequency.

In TGD framework also the feedback from cortex via outer hair cells to the inner hair cells is needed to generate fundamental frequency as an artificial auditory input.

Two visual/auditory/tactile stimuli are experienced as separate if the time interval between them is longer than 25 ms/.01 ms/5 ms. For hearing the time interval is by a factor 1/100 shorter than the millisecond time scale of nerve pulse which suggests that nerve pulse patterns cannot code for the high frequency part of the auditory stimulus. The representations of the auditory stimulus as evoked potentials at hair cells and glial cells inducing frequency modulations of Josephson frequencies would resolve the problem.

One cannot avoid the temptation to understand these time scales in the framework provided by Mersenne hypothesis involving the Planck constants $r = 2^{k_d}$ with preferred values of k_d and the time scale hierarchy assignable to CDs. 25 ms corresponds to the CD time scale (secondary p-adic time scale) $T(125)$, 6.25 ms corresponds to $T(123)$ and to the time scale of CD assignable to u quark and .012 ms to $T(112)$. The values of k_d for these scales come from $T(k_d) = 2^{k_2} 1/f(2\ eV)$ are $k_d \in \{45, 43, 35\}$. They are all odd whereas the allowed values of k_d are even for the most stringent form of the Mersenne hypothesis. The corresponding p-adic length scales are 5.12 m, 2.56 m, and 32 cm, which corresponds to the size scale of head.

Tactile senses

Humans can perceive vibrations applied to skin in the range $5 - 1000$ Hz. The so called rapidly adapting receptors code for 5-100 Hz frequency range whereas Pacinian corpuscle receptors code for 30-1000 Hz. There is evidence that this ability relies on or at least involves spike statistics coding. The temporal patterns of the vibratory stimulus are evident in the temporal discharge patterns of all units at all stations in the ascending somatosensory pathway. In TGD framework the spike patterns would reflect the deeper coding in terms of glial evoked potential patterns.

It is known that the ordering of the inter-spike intervals is disrupted by jitter along neural pathway to cortex. Note that the loss of information about temporal ordering is not important for our sensory experience which is temporal average over quantum jumps over time interval of at least .1 seconds as suggested by the fact that temporal resolution of sensory experience is about .1 seconds. If the time separation between visual, auditory, or tactile stimuli is above 20 ms, their temporal ordering can be perceived correctly. It could be however that the reaction to the sensory input is associated with some lower level self and that at our level averaging over longer time scale occurs.

Spike interval codes has also been reported for pain, touch, temperature and nociception (for more details and references see [58]). These modalities are highly emotional which suggests that the temporal interference patterns of Josephson radiation code for the emotional content.

Chemical senses

Odor discrimination relies on spatiotemporal coding of odors [66]. The facts about olfaction and gustation does not fit well with the hypothesis that connection structure of the neural pathway somehow codes for the quale. This hypothesis requires that the connection structure should be more or less static. Both taste buds and olfactory neurons have limited lifespans. Cells of taste bud move from center to boundary during the life cycles and are innervated by different axons during their life cycle. In TGD framework these problems disappear.

Taste discrimination experiments [58] have demonstrated that electrical stimulation using the spike patterns stimulated by odorant reproduce the emotional expressions following the perception of the real odor. When temporal pattern is changed by keeping the firing rate same, emotional response disappears. This is consistent with the assumption that "emotional" representations experienced by us are realized at the level of glial cells and that neuronal spike patterns are enough to excite the frequencies involve with these representations. Second type experiments demonstrate that electrical stimulation of an individual taste bud generates taste experience. This would suggest that the frequency giving rise to taste quale is excited automatically by the sensory stimulus and that each cell of taste bud generates it own primary taste.

Vision

In the case of vision there is psychophysical evidence for the temporal coding of color, texture and form. Color sensations can be produced using achromatic temporal patterns. Any color can be induced by the appropriate pattern of luminal changes. Benham's top is a famous device used to achieve this [62]. Also electric stimulation of retina can directly induce color sensations. In TGD framework the color sensation in the case of Benham's top should result from the back projection from glial cells to the sensory receptors induced by the achromatic temporal pattern communicated to glial cells and would involve genuine generation of photons which could be also dark photons. The stimulation would take place by dark photons with energies in visible region but frequencies much lower than those of ordinary visible photons: 80 Hz frequency associated with retina is a good candidate for this frequency (this frequency corresponds to a dark p-adic length scale of 1.8 m).

Also ordinary visible photons could be transformed to dark photons before the arrival to the photoreceptors. It is known that photoreceptors are obscured by three or four coats of neurons. This has been traditionally represented as an example of not so intelligent design. One should be however rather cautious before making this kind of statements. It has turned out that these cells act as optical fibres [63]. One can however still wonder why this complex manouvre is needed. The possible answer is that in this manner communications from both brain and external world to retina are optimized. Optic fibres could also induce the leakage of these photons to dark space-time sheets.

In TGD framework color qualia could be seen as coding spatial gradients of the illumination at a particular wavelength (in consistency with the color constancy phenomenon) to subjective experience. The saccadic motion of the eye would code a spatial change in the illumination to a subjecto-temporal gradient represented by the increments of appropriate color quantum numbers in quantum jump. This phenomenon is related to the color sensations stimulated by suitable frequency patterns of achromatic illumination [58]. What would happen that some colors present in the achromatic illumination would be amplified more than others. How precisely the coding of spatial illumination gradients to color qualia occurs is a challenge for TGD approach but it seems obvious that classical color gauge fields accompanying always classical electromagnetic fields must be an essential element of this coding.

Scanning and saccadic motion suggests itself as a fundamental mechanism generating at neuronal level temporal maps of the surface texture. Each line of the perceptive field scanned by the saccadic motion could give rise to spikes at those moments when the line is crossed by the saccadic line. Neighboring neurons would in turn code the direction of the line to the direction of a line in space-time-plane: line would be like space-time orbit of particle. There is empirical evidence for multiplex coding of information about visual form and color (for more detail and references see [58]). Also information about changing illumination seems to be coded into spike-statistics.

7.5.7 Latency-place representations

Latency-place representations use relative time-of-arrival differences to code information about the intensity of the sensory stimulus. Since latency typically decreases with intensity, the contrast degradation problem is circumvented. As absolute latencies decrease, so do the variances of latency distributions. Latency differences can be amplified more centrally by lateral inhibition since the impulses can excite inhibitory units which can inhibit regions surrounding the region with the shortest latency. This mechanism might be involved with the generation of space-time sheets representing objects of perceptive field. Variants of the latency-place representation can be involved with vision (motion perception), electroception, auditory, somatosensory, olfactory and gustatory systems.

Co-incidence detection is basic mechanism related with the formation of latency-place representations for position or direction. There is evidence that pyramidal neurons in cortex apply co-incidence detection [58]. In the case of hearing, which is the most studied case, co-incidence detection occurs in brain stem. In many vertebrates, inter-aural time differences are used to deduce the azimuthal direction of the sound source at frequencies above kHz whereas at lower frequencies phase differences between waves entering into separate ears are used for this purpose. The general mechanism uses pathways from corresponding positions of right and left ear to an array of co-incidence detectors in brain stem such that the length difference for the pathways varies linearly with the array coordinate. Only that part of array fires for co-incidence for which the delay caused by the length difference between right and left pathways compensates the time lapse between signals to separate ears. The time difference for the arrival times of the signal to two ears is thus coded to spatial coordinate and this coordinate represents information about azimuthal angle characterizing the direction of the sound source.

It is interesting to notice that music metaphor reflects itself also at the level of brain anatomy [58]. Brain resembles piano in that distances along axes coding different temporal or spatial frequencies depend logarithmically on frequency ratios: this guarantees the invariance of the sensation with respect to the scaling of frequencies. It might have also something to do with the hallucinatory states in which objects of the external world are perceived as gigantic or miniature sized: perhaps hallucinatory state leads to anomalous frequency-scales for some objects of the perceptive field.

In TGD the comparison of parallel supra-currents representing sensory inputs to be compared makes possible co-incidence detection at quantum level. When two identical supra currents flowing in parallel super conductors and forming Josephson junctions enter at same time they are in the same phase, resonant Josephson current is generated and wakes up sub-self giving rise to mental image about co-incidence and also generates nerve pulse activity giving rise to further experiences.

7.5.8 Do brain areas correspond to particular EEG resonance frequencies?

The scaling law of homeopathy inspires the guess that the information processing hierarchy, which starts from the primary sensory organs and contains besides sub-cortical nuclei also primary, secondary, etc... sensory areas, corresponds to a hierarchy of increasing EEG resonance wavelengths. This is consistent with the idea that primary, secondary and higher sensory areas of the cortex correspond to the periods of the periodic table in increasing order such that gamma band corresponds to the primary areas. Similar hierarchy should be realized at the motor areas.

This hierarchy should be realized dynamically by resonantly amplifying the EEG MEs with fundamental frequencies near the resonance frequency associated with a particular brain area. Neural circuits generating nerve pulse patterns, whose autocorrelation function contains the resonance frequency, could form a part of the mechanism. Alfven resonance could be even more important. If the magnetic flux loops associated with the magnetic body of a given brain area have a particular length L, one expects that the ELF MEs passing around the magnetic loop acting as a wave guide are amplified, when the fundamental frequency of the ELF ME satisfies certain resonance condition. This passage might involve several reflections but one might hope that only single curvilinear ME parallel to the magnetic flux loop acting as an Alfven wave guide is needed. In this case the length L of the magnetic flux tube would correspond to the resonance frequency $f = c/L$.

The generalization of this argument to the case of super-symplectic resonance frequencies would suggest the following scenario.

1. Primary sensory areas correspond to tertiary excitations of $k = 5_2^3$ algebra with the fundamental frequency of 40 Hz to primary excitations of $k = 251$ with fundamental frequency of 28 Hz. It is

also possible that $k = 83_3$ excitations with frequency 56 Hz are associated with primary sensory areas and subcortical areas.

2. Secondary sensory areas correspond to secondary excitations of $k = 127$ with fundamental frequency of 10 Hz, average frequency in alpha and fundamental frequency associated with memory.

3. Tertiary association areas turn correspond to $k = 2^8 = 256$ with fundamental frequency 5 Hz belonging to theta band.

4. Unimodal association areas correspond to $k = 257$ with fundamental frequency of 3.5 Hz, the upper end of delta band.

5. Multimodal association areas would correspond to secondary excitations of $k = 131$ with fundamental frequency .63 Hz.

Of course, one could shift the positions of p-adic length scales along cortex but the assignment of 40 Hz to primary sensory cortex suggests that the identification could be correct. The mirror mechanism of long term memories suggests that an analogous hierarchy is realized at much lower frequency scales in terms of MEs and magnetic flux loops.

7.6 Scaling law

Scaling law provides bird's eye view about transitions which can represent conscious-to-us qualia at given level of the p-adic self hierarchy. I ended up with the scaling law much before the realization that sensory representations could reside outside the brain and have same sizes as EEG MEs. The hypothesis that scaling law relates the sizes of the magnetic flux tube structures outside the body serving as a magnetic canvas to the sizes of the sensory representations inside brain implies that the view about hierarchy of magnetic body becomes rather quantitative. The scaling law has several forms and the latest of them is based on the hierarchy of Planck constants.

7.6.1 Various forms of scaling law

Scaling law relates two levels of self hierarchy corresponding to mental images associated with magnetic bodies of possibly astrophysical size and with physical bodies, the latter with size not much larger than brain size. Scaling law assumes that self sizes L at given p-adic level k are between the p-adic length scales $L(k)$ and $L(k(next))$. Scaling law is of form

$$L = \frac{v}{f} = \frac{v}{c}\lambda \ , \tag{7.6.1}$$

and relates ELF self size characterized by ELF frequency f (wave length λ) to the self size L and to the effective phase velocity v of the EEG wave.

With the discovery how non-episodal/declarative long term memories could be realized, came the realization that the scaling law could also relate the sizes of magnetic loops involved with positive frequency MEs propagating with sub-luminal effective phase velocity v along magnetic flux tubes and negative frequency MEs propagating with light velocity along much larger flux loops. Quite generally, it would seem that it is magnetic structures associated with positive and negative energy MEs, whose sizes are related by the scaling law.

The input from the work of Cyril Smith [40] led to a variant of the scaling law stating the existence of imprinted frequency pairs (f_h, f_l) such that the presence of f_h implicates the presence of f_l and vice versa and satisfying

$$\frac{f_h}{f_l} \simeq 2 \times 10^{11} \ . \tag{7.6.2}$$

Also other values for the ratio can be considered. Scaling law in this form is discussed in the chapters [16] and [19]. One can interpret this scaling law in terms of $L = v/f_l$ law if one identifies the ratio of frequencies as velocity $v = f_l/f_h$.

The hierarchy of Planck constants leads to a further development in the understanding of the scaling law. For dark matter hierarchy the scaling law relates the time scale defined by Josephson frequency f expressible as

$$\begin{aligned} f &= rf_0 \ , \ L = \frac{\sqrt{r}}{f_0} = \sqrt{r}\lambda \ , \\ r &\equiv \frac{\hbar}{\hbar_0} \ . \end{aligned} \tag{7.6.3}$$

The second form of the scaling law corresponds to

$$\frac{f_h}{f_l} = \sqrt{r} \tag{7.6.4}$$

with $r = 4 \times 10^{22} \simeq 5 \times 2^{75} = .944 \times 2 \times 10^{11}$. The error is 6 per cent. Note that the value of Planck constant would correspond to a ruler and compass integer but would be more general than allowed by Mersenne hypothesis. The imprinting process associated with the water memory would correspond to phase transitions changing the value of Planck constant. One of them transforms large $\hbar$ dark photons to ordinary photons with same energy having interpretation as biophotons and also the reversal of this transformation is possible. Second one transforms large $\hbar$ photons to bunches of photons of generalized EEG photons with the same frequency and probably does not have reversal.

If one assumes also the first form of the scaling law, one can conclude that there is a velocity parameter given by the expression

$$\frac{v}{c} = \sqrt{\frac{1}{r}} \ . \tag{7.6.5}$$

This velocity could have several interpretations. It could correspond to the velocity of nerve pulse conduction, of propagating EEG wave, or of Ca^{++} wave. The velocities of the latter waves vary in extremely wide range. If EEG corresponds to Josephson radiation then the effective velocity of EEG wave could correspond to the disturbance of the propagating soliton sequence induced by the resting potential, which is most naturally at rest in the rest system of the soliton sequence. Hence the propagation of EEG wave could be interpreted as the conduction velocity of the solitons sequence or equivalently that of the nerve pulse.

If this interpretation is correct, the value of the Planck constant assignable to a given neural pathway are glial cell cluster could be measured. Nerve pulse velocities vary in the range 1-100 m/s and increase with the radius of axon. One would have $r \in \{2^{43}, 3\times 2^{55}\}$ and $r \simeq 10^{14}$ would correspond to 5 Hz EEG frequency. The corresponding frequency range would be 80 Hz-.032 Hz. The latter scale corresponds to .51 minute period for the generalized EEG. These bounds look realistic.

If v corresponds to a velocity of EEG wave (it is not clear whether they indeed propagate), one can deduce the corresponding value of Planck constant and frequency from v as well as the size scale of the body part involved. This gives the consistency condition

$$\frac{f}{f_0} = r = (\frac{c}{v})^2 \tag{7.6.6}$$

allowing to test the hypothesis. Here f_0 is the photon frequency (around 2 eV for -50 mV resting potential: see the tables of [20]) defined by the energy of the dark Josephson photon and is proportional to the membrane potential and thus varies with certain limits. The right-hand side is constant so that the Josephson frequency must be proportional to EEG and different ions must correspond to different brances of generalized EEG. If EEG waves are assumed to propagate with the same velocity as EEG waves the hypothesis reduces to the above case, which seems to be consistent with what is known about the range of EEG frequencies.

The phase velocity of the soliton sequence can be either $v < c$ or $v = c^2/V > c$, $V < c$ and this suggests that these velocities correspond to two kinds of EEG waves. $v = c^2/V > c$ gives standing solitons at the limit $V \rightarrow 0$: in practice even $v = c$ gives effectively standing waves. The phase velocities larger than light velocity would formally correspond to the values of Planck constant smaller than the standard value. Physically these waves would correspond to the firing of the entire axon simultaneously and are excluded.

If one accepts the identification of velocity in terms of Planck constant completely generally and allows only sub-luminal velocities, then only integer valued Planck constants are possible because otherwise the velocities could exceed light velocity. Hence only singular coverings of CD and CP_2 would be allowed. Once the value r of Planck constant is known the coverings of CD and CP_2 correspond to different decompositions of r to a product of integers for this option. If singular factors spaces are allowed, an infinite number of decompositions are possible.

7.6.2 Scaling law for the qualia about brain structure of given size scale

The classical fields associated with MEs are expected to code information about the contents of conscious experience at various levels of self hierarchy. EEG represents one level in this hierarchy. This coding is crucial for the realization of declarative memory as classical communications from the geometric past. p-Adic length scale hypothesis to estimate how wide the range of frequencies responsible for coding information about conscious experience at given level of self hierarchy is. The model makes a prediction for the number of EEG harmonics representing information about conscious experience at a given level of self hierarchy, and suggests a general law telling what transition frequencies correlate with experiences conscious-to-us.

Relationship between self size and EEG frequency

Scaling law in its basic form reads as

$$\begin{aligned} v &= \lambda f \ , \\ L &= \lambda \ . \end{aligned} \tag{7.6.7}$$

Here v denotes the effective phase velocity associated with the EEG wave, λ corresponding wavelength, and f EEG frequency. L denotes the size of the sub-self and is assumed to be multiple of the effective wavelength associated with the EEG wave. The sub-self in question can give rise to a sensory mental image at the level of primary sensory organs or to a symbolic or cognitive representation at the level of brain.

In TGD Universe effective EEG phase velocities correspond basically to the effective phase velocity for MEs drifting along the relevant brain structure or a closed magnetic loop. The sub-luminal phase velocity results because positive energy ME tends to hop towards geometric future in quantum jump with some average rate while the space-time sheet representing environment is stationary. This velocity can be super-luminal for negative energy MEs if they dissipate since dissipation in this case would mean gradual shifting of ME backwards in the geometric time. Whether the dissipation really occurs significantly is not at all clear. If the frequency of the negative energy ME corresponds to an energy above thermal energies, the probability that negative energy can be absorbed is very low. This makes negative energy MEs ideal for generating time-like quantum entanglement, which is the prequisite for the sharing of mental images. This process is the key element of long term memory, and even of the ordinary sensory experience and motor activity.

TGD based model for nerve pulse and EEG relates effective EEG phase velocities to the effective phase velocities of MEs moving along axon and generating the nerve pulse and also cell membrane oscillations [17]. The dropping of ions to the magnetic flux tubes of the Earth's magnetic field during the process generates positive energy EEG MEs propagating along magnetic flux tubes of the personal magnetic body with sub-luminal phase velocity and representing in their modulation pattern information about the contents of sensory experience presumably crucial for declarative long term memories.

1. Ordinary states of consciousness and scaling law

One can argue that for the states of consciousness deriving only from ordinary sensory data by information processing in CNS, L cannot be larger than brain or body size for normal states of consciousness. The reason is that ELF self gains the sensory information from nerve circuits when it scans the relevant brain region and it does not make sense to scan regions much larger than brain size. This obviously implies $v < c$.

A stronger hypothesis making sense for ordinary states of consciousness encouraged by the empirical data [44] is that apparent phase velocity is actually equal to the conduction propagation velocity of the nerve pulses in the neural pathway involved:

$$v = v_{cond} . \tag{7.6.8}$$

2. Transpersonal states of consciousness and scaling law

One could argue that transpersonal levels of consciousness (during sleep perhaps) provide sensory information from several brains simultaneously. Also states of transpersonal consciousness and even cosmic consciousness are difficult unless one allows self sizes much larger than brain size. That this kind of experiences might be possible is suggested by out-of-body experiences in which person sees her own body in eyes of outsider.

1. The first guess was that transpersonal states of consciousness correspond by $L = v/f$ law super-luminal effective phase velocities $v = c^2/V > c$ associated with the Lorentz boosts of time-like soliton sequences. The soliton sequences can be assigned with the possible existing Josephson junction structures connecting parallel super-conducting magnetic flux tubes. The potential differences associated with the junctions are extremely weak and correspond to the EEG frequencies via the formula $\omega = Q_{eff}eV/\hbar$.

2. The second guess is that they correspond to negative energy MEs for which EEG frequencies predict length of the order of the Earth's circumference. Negative energy MEs are indeed natural correlates for the generation of the bound state entanglement and the generation of macrotemporal quantum coherence accompanied by experiences of "one-ness". Negative energy MEs make also possible telepathic sharing of mental images. Episodal (sensory) long term memories would involve negative energy MEs with ultra low frequency scale. The generation of negative energy MEs could also provide metabolic energy by buy now-let others pay mechanism and might explain the claims about the ability of yogis and meditators to survive with minimum nutrition.

It might be that negative energy MEs associated with semitrance mechanism (semitrance mechanism is described in chapters [21] and [28] and possibly also with the initiation of motor actions. Positive energy MEs would in turn be involved with long term declarative memories involving classical communication with a sub-luminal phase velocity along closed magnetic loops of size $L = v/f$. These communications could be more or less automatic and the active memory recall could only mean a decision to receive the signal. Hippocampus and amygdala are good candidates for the parts of brain responsible for generating the positive energy MEs responsible for inducing the non-episodal memories.

Memory circuits could be also indirectly responsible for the generation of long term episodal memories. It is indeed known that removal of these structures leads to a loss of, say, hallucinations induced by say LSD [45]. In [29] the mechanism of synesthesia is discussed with the cautious conclusion that the activity in the hippocampal region indirectly induces the generation of long term episodal memories. The over-activity in the memory circuits would induce a "starvation" in certain cortical regions. In order to get metabolic energy these starving regions would apply buy now-let others pay mechanism and generate negative energy MEs inducing a time-like entanglement with the geometric past and a sharing of mental images resulting in episodal memories.

Maximal number of harmonics at given level of p-adic hierarchy

The general vision is that we can have experiences mediating information about several levels of the p-adic length scale hierarchy associated with body. Both primary and secondary and even higher p-adic length scales are allowed in this hierarchy. The sharing of mental images made possible by negative energy MEs and classical communications made possible by positive energy MEs are the main mechanisms involved. Classical communications involve some code translating information to the shape of the classical fields and/or vacuum currents associated with positive energy ME propagating with sub-luminal phase velocity.

To build a model one can make more detailed technical assumptions.

1. For a given p-adic length scale $L(k)$ the self sizes between $L(k)$ and $L(k_{next})$ contribute to the experiences about that level. $v = Lf$ law in turn allows to estimate for a given fundamental transition frequency f how many harmonics contribute to the classical field of ME in question at level k. The number of harmonics determines the maximum information content of the experience generated by the classical signal carried by ME at that level.

2. For a given transition frequency and nerve pulse velocity v_{cond}, which could be for definiteness assumed to be equal to EEG phase velocity, there is some minimal p-adic prime $k(min)$ nearest to the length scale v_{cond}/f:

$$L(k_{min}) \leq \frac{v_{cond}}{f} \quad . \tag{7.6.9}$$

The minimal p-adic length scale does not in general allow maximal sensory acuity since v/f is not in general infinitely near to $L(k_{min})$.

The next k:s can however give maximal number of transition frequencies corresponding to $[k_{next}-k]/2$ octaves if the spectrum of self sizes is maximal. The frequency band for a given k is filled by starting from the frequency corresponding to the lowest possible 'bodily self' size $L(k)$, which is the largest possible frequency for that k, and proceeding to smaller frequencies corresponding to larger values of self size. This means that the hierarchy of p-adic length scales coming as octaves of the basic scale very precisely corresponds to the hierarchy of conscious experiences about various length scales. Every p-adic length scale is like music instrument producing $[k_{next} - k]/2$ octaves of musical notes.

Scaling law leads to rather strong predictions when combined with the formula identifying self size as the apparent wave length associated with EEG waves.

For instance in the case of $k = 199$ characterizing the size of brain, there are 6 octaves of frequencies between $L(199)$ and next primary p-adic length scale $L(211)$. Rather interestingly, the range $1.5 - 90$ Hz of EEG frequencies spans also 6 octaves. ELF self can have also experiences about what it is to be brain hemisphere ($k = 197$): this is possible for suitably tuned drift velocity range of ELF self, in this case the maximal frequency range would be 2 octaves. Amygdala would presumably correspond to $k = 193$ and in this case three octaves of EEG frequencies are possible. One must also consider the possibility that secondary and higher p-adic length scales are involved. In this case $L_3(67) = 32$ cm corresponds the p-adic length scale next to $L(199) = 16$ cm .

Communication between different levels of the self hierarchy and fractal scalings

Communication between different levels of p-adic hierarchy means mapping of various functions representing sensory information from a given level p to another level p_1. The obvious manner to realize this mapping is simply to scale by the ratio $p_1/p = 2^{(k_1-k)/2}$. Music piece is transposed to $(k_1 - k)/2$ octaves higher. For instance, actual EEG pattern corresponding to virtual motor activity would be simply its fractally scaled version containing virtual nerve pulse pattern as a repeated command (*'Do this- do this-...'*). It is known that motor neurons indeed serve as low pass filters [31] noticing only low frequencies and this might correspond to this kind of fractality. Unconscious fine structure of motion could result from unconscious-to-us processing by this kind of fractal scaling. This kind of temporal scaling fits nicely with the paradigm of 4-dimensional brain.

Super Virasoro frequency scales $f(n_1, k_1)$ and $f(n_2, k_2)$ discussed in [26] differ from each other by power of 2 when both n_1 and n_2 are even or odd. This means that for a given prime super-symplectic transition frequency spectrum is fractal and contains the frequency spectra associated with shorter p-adic length scales as sub-spectra and thus can generate resonantly Super Canonical transitions in shorter p-adic length scales. Similar fractality might be realized for magnetic frequencies. The scaling law $B \propto 1/L^2(k)$ for magnetic field strengths suggested by p-adic fractality would imply that magnetic transition frequency scale scales as $f(k) \propto 1/L^2(k)$.

Is there a correlation between brain size and apparent EEG phase velocity?

A natural assumption is that self sizes at level k are in the range $[L(k), L(k_{next})]$. $L(k_{next})$ can be also secondary or even higher p-adic length scale such that brain size is in the range $[L(k), L(k_{next})]$. This would give

$$\frac{v}{f} \in [L(k), L(k_{next})] \ . \tag{7.6.10}$$

An interesting possibility is that there is correlation between brain size and nerve pulse conduction velocity in the neural pathways contributing to consciousness:

$$\frac{v_1}{v_2} = \frac{L(k_1)}{L(k_2)} \ , \tag{7.6.11}$$

where $L(k_i)$ are the p-adic length scales associated with the brains of the organisms 1 and 2 and v_i are velocities in corresponding neural pathways. If this assumption holds true then the maximal information content of the field pattern of ME depends only weakly on the size of the brain since the frequency ranges are more or less the same. That velocity of conduction should increase with the size of organism sounds rather natural since axons get thicker.

It is possible to make definite estimates about conscious qualia for given species using information about nerve pulse velocities involved and about brain size. There is indeed some evidence for the correlation between brain size and inverse of the peak frequency of EEG [44]. For instance, it is known that in the case of dog intracranial phase velocities of alpha waves are in the range $.3-1.2$ m/s [44]. These data suggests that the sizes of alpha wave selves for dog are in the range $3-12$ cm so that dog's alpha consciousness would correspond to $L(197) = 8$ cm, which is the length scale associated with single brain hemisphere for humans. The result supports the view that the sizes of self correlate with brain size. Large animals like whales could have in ordinary wake-up state sensory input from p-adic length scales above $L(199)$ [$L_3(67) = 32$ cm, $L_2(101) = 45$ cm, $L_2(103) = 180$ cm].

If the phase velocity of the alpha waves is same along the entire magnetic flux loops associated with the magnetic body, the values $.3-1.2$ m/s *resp.* 14 m/s for the phase velocities of dog *resp.* human would mean that the time span for the long term non-episodal memories would be at least by a factor 1.2/14 shorter for dogs than for humans. This would roughly conform with the dog/human life time ratio.

Consider some examples illustrating what this hypothesis predicts assuming that the velocity range $(v_l, v_u) = (3, 7)$ m/s applies to EEG waves associated with the entire brain and that the doubled velocity range $6-14$ m/s applies to single brain hemisphere. Table 1. helps to get overall view about the important p-adic lengths scales.

1. For $k = 199$ corresponding to entire brain the maximal self size L_m, when identified as the next p-adic scale, is $L_3(67) = 32$ cm if tertiary p-adic length scales are allowed. Otherwise L_m is $L_2(101) \simeq .45$ meters. By $v = L/f$ law the ratio $L_m/L(199)$ should be smaller than the ratio $v_u/v_d = 7/3 \simeq 2.3$. $L_2(101)/L(199) = 2\sqrt{2} \simeq 2.8$ is larger than the ratio $7/3 \simeq 2.3$ whereas $L_3(67)/L(199) = 2$ satisfies the constraint so that $k = 67$, which corresponds to rather closely to the length scale of head, is favored.

2. The EEG frequency ranges correlating with qualia conscious-to-us are predicted to be $9.4-21.9$ Hz for $k = 67$ and $6.7-15.6$ Hz for $k = 101$. The frequency range associated with $L(199)$ is $19.0-43.8$ Hz.

3. For $k = 197$ corresponding to brain hemisphere one has $L(k_{next}) = L(199)$ and frequency range corresponding to the velocity range $7-14$ m/s is $43.8-102$ Hz and for $L(197)$ the range is $87.6-204$ Hz.

k	191	193	97_2	197	199	67_3	101_2	103_2
L_p/m	.01	.02	2.8	.08	.16	.32	.45	1.8

Table 1. p-Adic length scales $L(k,n)$ possibly relevant to consciousness and life at length scales relevant to human brain and body. k characterizes p-adic prime via $p \simeq 2^k$ and $n = 1,2,3$ tells whether primary, secondary, or higher p-adic length scale is in question. $n > 3$ n-ary scales are assumed to be un-important.

Lower bounds for "bodily" self sizes from the range of nerve pulse conduction velocities

The range for nerve pulse conduction velocities associated with EEG waves does not correspond to the entire range of nerve pulse velocities in somatosensory system ranging from .5 m/s to 120 m/s [31]. Thus our brain anatomy could allow much wider spectrum of sizes for mental images than allowed by the rather narrow range $3-14$ m/s of propagation velocities for alpha waves.

Nerve pulse conduction velocity as a function of the axon thickness obeys the approximate law [31]

$$v = kv_0 \times \frac{d}{d_0} \ , \quad v_0 = 1 \ \ m/s \ , \quad d_0 = 1 \ \ \mu m \ .$$

The value of k is about 6 for thickly myelinated axons and between 1.5 and 5 for thinly myelinated axons. The variation ranges of conduction velocities in somatosensory (!) system are in ranges $80-120$ m/s, $35-75$ m/s, $5-30$ m/s and $.5-2$ m/s for unmyelinated axons. Conduction velocity varies in rather wide range $(.5-120)$ m/s: 'quale key' can vary in a range of almost 8 octaves. The lowering the conduction velocity of nerve pulses by reducing myelinization or thickness could make it possible for us to have qualia about length scales of brain nuclei.

It is interesting to look for the lower bound $L(min)$ of self sizes assuming that 90 Hz is upper bound for transition frequencies representing experiences possibly conscious to us. The values of L_{min} are .89 m for $80-120$ m/s range; .39 cm for $35-75$ m/s range; 5 cm for the range $5-30$ m/s and .5 mm for the range $.5-2$ m/s associated with the unmyelinated axons.

The following table gives the length scales below which electron, proton and ionic cyclotron consciousness is possible assuming that the nerve pulse velocities vary in the range described above. These ranges of nerve pulse conduction velocities are associated with somatosensory system and actual 'phase velocities' of EEG waves seem to vary in much narrower ranges.

$v/(m/s)$	$.5-2$	$5-30$	$35-75$	$80-120$
$L(1,e)/\mu m$	.8-3.2	8-48	58-125	133-200
$L(1,p)/mm$	$.27-1.0$	$2.7-5.9$	$19-41$	$44-66$
$L(1,Li_+)/cm$	$.1-.5$	$1.2-7.1$	$8.3-17.9$	$19.0-28.6$
$L(1,Ca^{++})/dm$	$.3-1.2$	$2.9-17.1$	$20-43$	$46-69$
$L(1,Co_+)/m$	$.1-5$	$1.2-7.0$	$8-17$	$18-28$

Table 2. The table gives the length scales below which electron, proton and ionic consciousness is possible assuming that the nerve pulse velocities vary in the ranges associated with somatosensory system.

From the table one finds that electronic cyclotron consciousness is possible in p-adic length scales $L(173) = 20$ μm and $L(179) = 160$ μm but not above this length scale. Also the length scale $L(169)$ might be possible. Protonic cyclotron consciousness is possible at all length scale above $k = 169$ up to $k = 193$.

7.6.3 Scaling law and evolution

Scaling law, when combined with general ideas about consciousness, allows to build speculative models for the evolution of consciousness at both biological and cultural level. What would be new and nontrivial would be the strong correlation between cultural and electromagnetic evolution (strictly speaking, also the evolution field bodies is involved). Cultural evolution could be perhaps seen as evolution of memes with memetic code playing the role of genetic code. There are good reasons to believe that the intronic portion of DNA codes for memes represented dynamically as field patterns associated with MEs [24]. The portion of the introns in genome is indeed large for humans (99 per cent).

Scaling law contra biological, cultural, and spiritual evolution

One can distinguish between two kinds of developments of individual: the neural development of child in the p-adic length scales relevant to body and the evolution of magnetic body and of communications between magnetic body and biological body. Besides the personal magnetic bodies also the magnetic body of Earth, magnetosphere, is expected to carry sensory, cognitive and symbolic representations resulting through entanglement with various organisms. Negative energy MEs in EEG range are natural in this respect. These representations would give rise to multi-brained magnetospheric selves [22]. The development at ELF frequency range corresponds by *ontogeny recapitulates phylogeny principle* to the evolution of civilization.

There are good reasons to believe that brain anatomy has remained more or less the same in time scales much longer than the evolution of civilization from bicamerality to modern man. This would mean that the evolution of our consciousness and civilization is basically electromagnetic rather than genetic evolution and corresponds to the evolution of EEG and ZEG during ontogeny. The evolution of magnetospheric consciousness might be a crucial factor in this development. These evolutions are not completely independent since $L = v/f$ $(v < c)$ relationship correlates these developments to each other.

1. Scaling law and the relationship between cultural and biological evolution

A fascinating challenge would be to understand the detailed relationship between cultural evolution and the evolution of field body. In particular, there are many interesting questions related to the relationship between self-hierarchy and Freud's ideas. Is super ego above EEG length scales or above the body length scale? Could one regard the counterpart of Id as a species consciousness, some kind of biological superego, in length scales larger than body size but considerably below ELF length scales representing cultural aspects of consciousness? Can one speak of cultural superego? Is the time scale of the phenomenon direct measure for the p-adic length scale of the corresponding self?

It is important to notice that $v = Lf$ relationship defines mapping $k \rightarrow f(k)$ between the biological and electromagnetic length scale hierarchies such that ELF self at particular p-adic level has sensory experiences about experiences of particular self at bodily level? Very roughly this mapping would correspond to the scaling

$$L(k) \rightarrow [\frac{c}{v} L(k)] \equiv L(f(k)) \ ,$$

where $[L]$ is shorthand for the nearest p-adic length scale below length scale L. More explicit manner to define this mapping would be as

$$k \rightarrow [k + log_2(c/v)] \ ,$$

where $[k]$ now denotes the nearest power of prime below k. If this kind of mapping is involved then the evolutions at these two widely different length scales might correspond to each other rather closely.

Evolution at the level central nervous system

The natural implication of the proposed picture is that the biological (as also electromagnetic) evolution of the central nervous system (CNS) proceeds from shorter to longer p-adic scales. Jump in the evolution correspond to emergence of new p-adic length scale when the size of self becomes equal to next p-adic length scale.

This vision about evolution of central nervous system can be tested immediately. Magnetic spectroscopy of consciousness predicts that there are seven levels between $k = 169$ level of neuron and brain and they correspond to the primary p-adic length scales associated with $k = 173, 179, 181, 191, 193, 197, 199$. Central nervous system indeed has 7-levelled hierarchy corresponding to spinal chord, medulla, pons, midbrain, diencephalon, brain hemisphere, brain and higher levels of this hierarchy have indeed emerged one-by-one during evolution. The eight levels of the hierarchy (perhaps it is worth to notice the amusing connection with the eight-fold way of Buddhism and the idea of Lily about eight levels of consciousness) would correspond to the next level of bio-consciousness $k = 211$ which might be already present at delta and theta frequencies.

Geometric consciousness at the level of spinal chord geometric consciousness should at least correspond to multiples of electron cyclotron frequencies. Electronic consciousness is not possible at higher levels. This picture explains why the activities of autonomous nervous system is more or less unconscious to us. Hypothalamus and thalamus and presumably also many other brain nuclei would correspond to the level $k = 193$ in the hierarchy. Their sizes are indeed above 2 cm and below 8 centimeters. Thus autonomous nervous system should correspond to lower level of the p-adic hierarchy of selves so that the contribution to our consciousness would involve several averageings. Note that protonic cyclotron consciousness is still possible at at this level but not at higher levels for typical conduction velocities of nerve pulses.

Scaling law and ontogeny

During the early development neural pathways myelinize gradually [44] and this means gradual increase of the conduction velocities $v = Lf$. This suggest that various versions of quale about given p-adic length scale $L(k)$ labelled by the harmonics of the fundamental frequency emerge gradually one by one as nerve pulse propagation velocities in neural pathway increase. First pops up $n = 1$ version of quale, then $n = 3$ version, etc.. One could visualize this as drift of various versions of quale from shorter to longer p-adic length scales.

This predicts that the sensory acuity of infant increases in stepwise manner at critical values of the nerve pulse propagation velocity making possible new harmonic of EEG pattern representing particular quale. The critical values of the nerve pulse propagation velocity for secondary experiences about events at level k are given by

$$v(n) = nf \times L(k) \ . \tag{7.6.12}$$

This applies also to motor expression which in TGD framework is very much like virtual sensory experiencing amplified to macroscopic motor activity by puppet-in-string mechanism. For instance, coordination and control of motor activities improves and emotional expression in speech becomes more refined.

This option is not the only one that one can imagine. Also EEG develops during the development of individual. The fact that the peak frequency of EEG moves gradually from delta band to alpha during the first ten years allows to consider the possibility that the sizes L of mental images, stay more or less constant during maturation. This requires that both that nerve pulse velocity and the harmonic of the fundamental frequency giving the dominating contribution to the quale gradually increase. An interesting possibility is that the sizes of selves correlate with body size or with the size of relevant body part during development of individual.

$$L = \frac{v}{f} = k \times L(body\ part) \ .$$

This would mean that all ions correspond to the same self size for given value of nerve pulse conduction velocity.

Transition from bicamerality to modern consciousness

TGD based vision about the evolution of civilization relies on *ontogeny recapitulates phylogeny principle* stating that the development of child's electromagnetic body is fractally scaled version of the development from bicamerality to modern consciousness. In particular, the hypothesis has been that this development meant the emergence of higher level emotion and cognition and of the semitrance mechanism in which collective self gave commands and advices to the bicameral.

The proposed model for the evolution of qualia concretizes this general vision considerably. The picture about what might have happened in the transition might perhaps look like follows.

1. Semitrance mechanism

Semitrance mechanism made possible for the collective higher level ELF self to communicate commands and advices to the bicamerals. This higher level ELF self presumably had also higher level sensory experiences about entire social group in some p-adic length scale larger than body size. $L(211) = 10$ meters and $L(223) = 640$ meters are the most obvious length scales involved. The emergence of new ELF frequencies to EEG meant also that the sensory and emotional acuity of bicameral man improved. It is not absolutely clear whether semitrance is communication of higher level selves to us or sensory experiencing of transpersonal levels of consciousness or both. The predicted lifetimes of transpersonal selves are however measured in years which suggests that they are closely involved with long term memories.

2. Development of speech

The emergence of modern man involved the development of speech faculty. This evolution must have been proceeding in two directions. We have self-narrative in rather long time scales and someone must tell it to us: this implies that ELF MEs corresponding to $k = 127_2, 2^8, 257, 131_2, 263, 89_3, 269, 271, 137_2, 277, 139_2, ...$ should have emerged gradually. This could have also meant development of amplitude modulation hierarchy and increasingly complicated linguistic structures. Note that the time scale starting from .1 seconds ($k = 127_2$) and ending up to 6.1 seconds ($k = 139_2$) contains especially many primary, secondary and tertiary p-adic time scales. This also meant development of increasingly refined linguistic structures in short time scales: words decomposed to syllables and syllables to phonemes presumably identifiable as memetic codewords at $k = 127_2$ level and this made possible development of written language.

In conflict with the standard beliefs about our position in the hierarchy of consciousness, this picture suggests that to some extend both speech and internal speech are speech of higher level self. It is indeed well-known that it is almost impossible to speak fluently if one tries to control what one is saying: one must simply let it go. Also body unconscious-to-us language can be interpreted as talk of higher level self using limbic brain as instrument of expression: this would explain why we express emotional reaction before becoming conscious about the emotion.

3. Emergence of long term memory

What Jaynes believes could be translated to the statement that the transition from bicamerality to modernity involved the emergence of the long term memory and its evolution from a direct sensory memory to declarative memory [67]. Sensory memory means direct re-experiencing by the sharing of mental images made possible by time-like entanglement. Declarative memory would be based on a symbolic representation of the data, and would be communicated classically (communication would be ultra-slow!) from the geometric past as a response to the shared mental image representing the desire to remember.

A possible model for long term declarative memories is based on the generalization of the frequency representation of the memetic code. What is presumably coded, are perhaps not details of particular experience but sequence for names of 'program modules' realizing particular kind of experience. Thus very high level coding would be in question. In this model long term memories could perhaps be represented as a modulation of the carrier frequency of 'hippocampal theta frequency' varying in the range $4 - 12$ Hz [30] by multiples of some lower ELF frequency representing higher level of self hierarchy.

The large range of variation for hippocampal frequencies suggest that they could correspond to magnetic transition frequencies of various ions subject to homeostatic regulation. It is indeed known that the state of arousal correlates with the hippocampal frequency. The modulating level would correspond naturally to the ELF self associated with multimodal association regions which project via entorhinal cortex to hippocampus. If the tertiary time scale associated with $k = 251$ (28 Hz) corresponds to primary sensory areas, this region must correspond to $k = 131$ and frequency of .63 Hz and cycle of 1.6 seconds which sounds sensible. If this is the case, long term memories should have natural time unit of 1.6 seconds.

The motion of the peak frequency of child's EEG from delta band to alpha band during the first ten years looks paradoxal against the idea that lower frequencies correspond to higher levels of consciousness. One interpretation for the presence of low frequencies is that the child is in a semitrance state and that the presence of the low frequencies reflects control from the higher levels of self hierarchy. A second interpretation allowing to get rid of the paradox is that the carrier frequency evolves gradually from delta to alpha band while fundamental modulation frequencies stay constant. This would mean that the number of multiples fundamental frequency which can appear in the modulation increases and information storage capacity increases.

This kind of coding is not the only possibility and it is quite possible that entire fractal hierarchy of codings are involved such that single codeword at higher level corresponds to an equivalence class of codewords at lower level. For instance, hippocampal theta period could define the duration for the codeword of a lower level code realized by modulation using gamma frequencies. There is evidence for temporal coding in the sense that the relative temporal shift of the spike sequence with respect to the 'hippocampal theta frequency' codes for the position of moving rat [57]. This would mean the coding of rat's position to the overall phase of the complex Fourier components representing $n > 1$ harmonics of the memetic codeword ($n = 1$ would correspond to 'hippocampal theta frequency') and can be understood if the motion of rat is coded to periodically occurring nerve pulse patterns inducing reset of theta oscillator.

4. Schizophrenic as a modern bicameral?

Schizophrenic is regarded by Jaynes as a modern bicameral. According to Jaynes, schizophrenics seem to have amazing ability to tolerate pain and to work hardly for long times without experiencing fatigue. For instance, catatonics can stay in same bodily posture for hours. Perhaps this is due to the fact that they do not experience pain in same sense as normal persons do. Jaynes also explains by this the architectural feats of ancient civilizations impossible for modern man using the primitive tools available for bicamerals.

Our emotions are partially generated by the feedback loop in which the lower level emotions expressed by the limbic brain are perceived by the cortical levels and amplified and in turn affect limbic brain. If this loop is not working properly (say due to the inhibited emotional expression), nociception is not accompanied by the experience of pain. If the transition to modernity meant also evolution of emotions and their expression, the emotional expression of bicamerals must have been primitive so that this loop cannot have been so effective as it is in the case of modern man. One can also consider the possibility that bicamerals spent a considerable fraction of time in semitrance in which regions of the emotional right brain were entangled with higher level selves or with large selves and were thus unconscious and unable to feel pain. The myth about exile from paradise would reflect that the newly developed ability to experience strong emotional pain.

Schizophrenics have often also unusually high sensory acuity: this is probably due to the weakened sensory censorship eliminating from sensory landscape unessential features. The fact that the attention of schizophrenic is more easily distractable is also consistent with this.

5. Child as a small bicameral?

Scaling law suggests that child is during the first years of her life more or less the modern counterpart of the bicameral man of Jaynes [67] receiving commands and advices of the higher level selves as sensory, in particular auditory hallucinations as suggested in the chapters [21] and [28]. Semitrance hypothesis is consistent with the fact that REM occur during wakefulness and sleep. REM is also found to occur few moments after an infant begins to engage in nutritional sucking. Even modern man has day dreams with the same 90-120 minute period as he has REM period during sleep. That small children comment their activities from third person view (*'Now John is going to do this'*) is consistent with semitrance hypothesis.

Delta wave dominance of EEG (see below) is indeed consistent with the hypothesis that child spends long times at transpersonal levels of consciousness seeing her body with eyes of outsider. The fact that the speech of child however lacks much of the emotional component present in the speech of adult is consistent with the idea that emotional expression develops gradually more refined when also generalized sensory experience about state of body becomes more refined. It has been indeed noticed already by Rousseau that child's speech lacks much of the emotional color involved with the speech of adults.

It is known delta band dominates during childhood and that the EEG intensity in delta band is reduced during ageing. A possible interpretation is that the attention is during childhood more directed to transpersonal levels and gradually shifts to more bodily level (perhaps for the simple reason that the unpleasant side effects of ageing require more and more attention to the state of body!). This would suggest that ageing could but need not mean spiritual degeneration. The shift to higher frequencies could mean that higher harmonics of the cyclotron frequency in delta band begin to dominate. On the other hand, sensory acuity gets poorer when individual gets older. This could have purely anatomical reasons but could also involve gradual increase of the average cyclotron frequency associated with the quale so that also harmonics of low cyclotron frequencies responsible for high sensory acuity tend to disappear from EEG. Also the timing accuracy of the temporal patterns of nerve pulses could become worse during ageing. As a consequence, the frequencies of EEG waves would not be sufficiently near to the harmonics of low cyclotron frequencies anymore.

6. The role of Earth's magnetic field in the evolution of civilization?

The fundamental frequencies associated with exotic super-symplectic representations are constants of Nature. As far as the proposed role of these frequencies is considered, this is very satisfying feature. Many basic frequencies associated with exotic super-symplectic representations in EEG range are however very near to Schumann frequencies (inversely proportional to the circumference of Earth) and to important cyclotron frequencies proportional to Earth's magnetic field. This suggests the possibility of a resonant interaction so that the value of Earth's magnetic field could have played important role in the evolution.

During last thousand years Earth's magnetic field has reduced by a factor of one half. For instance, the cyclotron frequency of Co^{++} ion (probably closely involved with 10 Hz bio-clock in pineal gland), which is 10 Hz for present value of about $.5 \times 10^{-4}$ Tesla of Earth's magnetic field, has reduced by a factor two during this period. The considerations of the chapter [22] raise the question whether the reduction of the magnetic field might have something to do with the exponential evolution of the civilization during this period.

7.6.4 Scaling law and sensory maps

The vision about sensory maps realized using magnetic canvas outside the body inspires the hypothesis about a hierarchy formed by the primary and secondary sensory organs inside brain with levels labelled by the p-adic length scales. The radius of the approximately spherical structures from which the radial magnetic flux tubes serving as magnetic canvas emanate should be roughly given by the relevant p-adic length scale L. ELF MEs define the projection of the sensory image from the (possibly secondary) sensory organ to the magnetic canvas by place-frequency coding. This requires that the thickness of the magnetic flux tube depends weakly on the distance from the projecting sensory organ. A stronger assumption is that the magnetic structure serving as a sensory canvas has the same size as EEG MEs: $L(magn) \sim L(EEG)$. Hence sensory images would be magnetic giants in TGD framework whereas in standard neuroscience they would be miniatures defined by the cortical neural activity patterns.

By scaling law the sizes $L(EEG)$ of ELF selves relate to the sizes L of brain structures: $L(EEG) = (c/v)L$. Here v is the velocity of motion of EEG ME along axon, or equivalently nerve pulse conduction velocity, and f is the EEG frequency. The consistency with the scaling law is achieved if secondary sensory organs, which could be approximately spherical structures analogous to eyeball, have radii $L \sim v/f$ approximately given by various p-adic length scales $L = L_p$. As will be found later, the resulting sensory hierarchy correlates nicely with the brain anatomy, with the band structure of EEG and with the structure of the periodic table.

It is of interest to apply the scaling law at the level of eye. Amazingly, the sizes of the lense (about $L(191) \simeq 1$ cm) and retina (about $L(193) \simeq 2$ cm) are just at the lower bound of the p-adic length scale range allowing the EEG frequency to be in the range of cyclotron frequencies in Earth's magnetic field. For $v = 3$ m/s, which is the lower bound for the velocities of alpha waves, $f = v/L$ gives proton cyclotron frequency $f_c = 300$ Hz for lense size $L \sim 1$ cm and deuterium cyclotron frequency $f_c = 150$ Hz for retina size $L \sim 2$ cm or more naturally proton cyclotron frequency for a two times larger value of Planck constant. Note that higher harmonics cyclotron frequency are possible even if the lowest one is not and could thus allow deuteronic cyclotron consciousness. For retina $v = 6$ m/s gives proton cyclotron frequency for retina. He_4 consciousness would require $v \sim 1.5$ m/s, which is possible only for unmyelinated axons: the axons from retina are myelinated.

Thus it seems that the lowest level or perhaps even two lowest levels of visual consciousness could be possible at the level of lense and retina. The size of the pupil correlates with the state of consciousness. An interesting question is whether these two levels of retinal consciousness could correlate with the size of pupil. For instance, the velocity of nerve pulse conduction in the axons from retina could correlate with the size of the pupil. Contracted pupils might correspond to the most primitive form of retinal consciousness and dilated pupils to consciousness with the value of Planck constant which is two times larger. The projection to the exterior world would be determined by the input from the next level of the visual hierarchy and would be directed backwards rather than to the visual field of the retina. Retinal visual selves could thus represent the lowest level of the visual self hierarchy above EEG and would be unconscious to us as also 40 Hz visual consciousness at the primary sensory areas seems to be. What is encouraging is that the size of retina fits nicely with the general vision about hierarchy of visual selves starting already at the level of the primary sensory organ.

The lowest level in the hierarchy of the sensory consciousness would correspond to electron with cyclotron frequency $f_c \simeq 6 \times 10^5$ Hz in Earth's magnetic field. The size of the the projecting organ would be about 5 micro–ns for the minimal value of $v = 3$ m/s of alpha wave velocity. This would suggest that even neurons can represent sensory input on the magnetic canvas and have senses just as we do. TGD neurons would be considerably more complex creatures than the fire-doesn't fire neurons of computationalist. This is of course what fractal self hierarchy predicts on completely general grounds. From the scaling law the size of the neuronal sensory image represented by electronic magnetic transitions would be of order 10^4 meters. A possible test for this view is whether radiation at electron's cyclotron frequency or its multiples has direct effects at neuronal level.

7.6.5 Does the structure of neocortex correlate with the hierarchy of p-adic frequencies?

p-Adic frequencies differing by appropriate scalings by a power of square root two would correspond naturally to the brain structures and organizational hierarchy of brain and CNS. The nice aspect of this hypothesis would be universality and prediction of the cognitive codes.

The $v = Lf$ scaling law described earlier implies the existence of a mapping

$$L(k(bio)) \rightarrow L(k(ELF))$$

between biological length scales $L(k(bio))$ and cultural length scales $L(k(ELF))$. The mapping means that ELF self characterized by $k(ELF)$ receives sensory input from corresponding biological length scale $L(k(bio))$ and presumably has corresponding biological selves as sub-selves. This mapping is illustrated in the table below. For instance, the selves at length range 8-16 cm corresponding to the size of brain hemisphere and to tertiary sensory areas are scanned by ELF selves at theta frequencies.

By $L = v/f$ correspondence the structures of neocortex correspond to definite ELF selves containing at least the p-adic length scales $L_2(2^5)$, $L(251)$, $L_2(127)$, $L(2^8)$, $L(257)$, $L_2(131)$, ... with fundamental Super Virasoro frequencies $f(k, n)$ equal to 40 Hz, 28.2 Hz, 10 Hz, 5.0 Hz, 3.5 Hz, .63 Hz,... Note that the fundamental frequencies correspond to gamma, beta, alpha, theta and delta bands. The table below provides a concise summary of the proposed correspondences. The length scale $L_3(83)$ corresponds to $f(1, 0) = 56$ Hz contained also in the EEG range and is not given in the table.

k(bio)	191	193	97_2	197	199	101_2 (67_3)
L(k(bio))/cm	1	2	2.8	8	16	45 (32)
k(ELF)	2^5_2	251	127_2	$2^8 = 256$	257	131_2
f(k,n)/Hz	40.0	28.2	10.0	5.0	3.5	.63
sensory area	I	I	II	III	IV	V
EEG band	gamma	beta	alpha	theta	delta	delta
period	He	He	Ne	Ar	Kr	Xe

Table 4. The table gives the correspondence between biological and ELF length scales suggested by $v = L(k)f$ relationship assigning to the 'biological' length scale $L(k(bio))$ (not larger than body size) ELF frequency $f(k, n)$ and corresponding 'cultural' p-adic length scale, which is of order of Earth circumference for 8 Hz EEG frequency. Also the proposed assignments of the sensory areas of neocortex to these length scales are given. The lower index associated with the exponent k tells whether the scale is secondary or tertiary in the case that it is not primary (one has $p \simeq 2^k$ by p-adic length scale hypothesis).

Acknowledgements

I want to thank for Daniel Dubois and Peter Marcer for providing the opportunity to participate CASYS'2000 conference. It was the very enlightening representation of Peter Marcer experimental data concerning the effects of laser light on DNA which re-stimulated the work with massless extremals and quantum antenna hypothesis and led to the realization of connection with the spectroscopy of consciousness. An important stimulus came from Claude Rifat to whom I am also grateful. I want also to express my gratitude to Gene Johnson for sending all kinds of material as well as enlightening debates concerning the relation between quantum brain to neuroscientist's brain. I want to thank also Lian Sidoroff for very fruitful discussions.

Bibliography

Books about TGD

[1] M. Pitkänen (2006), *Topological Geometrodynamics: Overview.* http://tgd.wippiespace.com/public_html/tgdview/tgdview.html.

[2] M. Pitkänen (2006), *Quantum Physics as Infinite-Dimensional Geometry.* http://tgd.wippiespace.com/public_html/tgdgeom/tgdgeom.html.

[3] M. Pitkänen (2006), *Physics in Many-Sheeted Space-Time.* http://tgd.wippiespace.com/public_html/tgdclass/tgdclass.html.

[4] M. Pitkänen (2006), *p-Adic length Scale Hypothesis and Dark Matter Hierarchy.* http://tgd.wippiespace.com/public_html/paddark/paddark.html.

[5] M. Pitkänen (2006), *Quantum TGD.* http://tgd.wippiespace.com/public_html/tgdquant/tgdquant.html.

[6] M. Pitkänen (2006), *TGD as a Generalized Number Theory.* http://tgd.wippiespace.com/public_html/tgdnumber/tgdnumber.html.

[7] M. Pitkänen (2006), *TGD and Fringe Physics.* http://tgd.wippiespace.com/public_html/freenergy/freenergy.html.

Books about TGD Inspired Theory of Consciousness and Quantum Biology

[8] M. Pitkänen (2006), *TGD Inspired Theory of Consciousness.* http://tgd.wippiespace.com/public_html/tgdconsc/tgdconsc.html.

[9] M. Pitkänen (2006), *Bio-Systems as Self-Organizing Quantum Systems.* http://tgd.wippiespace.com/public_html/bioselforg/bioselforg.html.

[10] M. Pitkänen (2006), *Quantum Hardware of Living Matter.* http://tgd.wippiespace.com/public_html/bioware/bioware.html.

[11] M. Pitkänen (2006), *Bio-Systems as Conscious Holograms.* http://tgd.wippiespace.com/public_html/hologram/hologram.html.

[12] M. Pitkänen (2006), *Genes and Memes.* http://tgd.wippiespace.com/public_html/genememe/genememe.html.

[13] M. Pitkänen (2006), *Magnetospheric Consciousness.* http://tgd.wippiespace.com/public_html/magnconsc/magnconsc.html.

[14] M. Pitkänen (2006), *Mathematical Aspects of Consciousness Theory.* http://tgd.wippiespace.com/public_html/mathconsc/mathconsc.html.

[15] M. Pitkänen (2006), *TGD and EEG.* http://tgd.wippiespace.com/public_html/tgdeeg/tgdeeg.html.

References to the chapters of the books about TGD Inspired Theory of Consciousness and Quantum Biology

[16] The chapter *Homeopathy in Many-Sheeted Space-Time* of [11].
http://tgd.wippiespace.com/public_html/hologram/hologram.html#homeoc.

[17] The chapter *Quantum Model for Nerve Pulse* of [13].
http://tgd.wippiespace.com/public_html//tgdeeg/tgdeeg/tgdeeg.html#pulse.

[18] The chapter *Quantum Model for Hearing* of [13].
http://tgd.wippiespace.com/public_html//tgdeeg/tgdeeg/tgdeeg.html#hearing.

[19] The chapter *Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin* of [11].
http://tgd.wippiespace.com/public_html/hologram/hologram.html#metab.

[20] The chapter *Dark Matter Hierarchy and Hierarchy of EEGs* of [13].
http://tgd.wippiespace.com/public_html/tgdeeg/tgdeeg.html#eegdark.

[21] The chapter *Semi-trance, Mental Illness, and Altered States of Consciousness* of [14].
http://tgd.wippiespace.com/public_html/magnconsc/magnconsc.html#semitrancec.

[22] The chapter *Magnetospheric Sensory Representations* of [14].
http://tgd.wippiespace.com/public_html/magnconsc/magnconsc.html#srepres.

[23] The chapter *Bio-Systems as Super-Conductors: part II* of [10].
http://tgd.wippiespace.com/public_html/bioware/bioware.html#superc2.

[24] The chapter *Genes and Memes* of [12].
http://tgd.wippiespace.com/public_html/genememe/genememe.html#genememec.

[25] The chapter *Quantum Antenna Hypothesis* of [10].
http://tgd.wippiespace.com/public_html/bioware/bioware.html#tubuc.

[26] The chapter *General Theory of Qualia* of [11].
http://tgd.wippiespace.com/public_html/hologram/hologram.html#qualia.

[27] The chapter *Negentropy Maximization Principle* of [8].
http://tgd.wippiespace.com/public_html/tgdconsc/tgdconsc.html#nmpc.

[28] The chapter *Semitrance, Language, and Development of Civilization* of [14].
http://tgd.wippiespace.com/public_html/magnconsc/magnconsc.html#langsoc.

[29] The chapter *Quantum Model for Sensory Representations*
of [8].
http://tgd.wippiespace.com/public_html/tgdconsc/tgdconsc.html#expc.

Mathematics

[30] *Theta function*. http//en.wikipedia.org/wiki/Theta_function.

Theoretical physics

[31] C. Itzykson, Hubert Saleur, J-B. Zuber (Editors) (1988):*Conformal Invariance and Applications to Statistical Mechanics*, Word Scientific.

Condensed matter physics

[32] G. Ambika *et al* (2005), *Aspects of stochastic resonance in Josephson junction, bimodal maps and coupled map lattice.* Pramana Vpol. 64, No 4pp. 535-542. `http://www.ias.ac.in/pramana/v64/p535/fulltext.pdf`.

[33] H. Kramers (1940), Physica (Utrecht)7, 284.

[34] C. Nicolis and G. Nicolis (1981), Tellus 33, 225.

[35] Luca Gammaitoni *et al* (1998) *Stochastic Resonance.* Rev. Mod. Phys. 70, 223-288, January. `http://www.umbrars.com/sr/`.

[36] K. Wiesenfeld and F. Moss (1995), Nature (London) 373,33.

[37] T. Benzi *et al* (1981), J. Phys A 14, L453.

Cosmology and astrophysics

[38] P. E. Freeman *et al* (2006), *Examining the Effect of the Map-making Algorithm on Observed Power Asymmetry in WMAP Data.* The Astrophysical Journal, 638:1-19, February 10. astro-ph/0510406.

[39] A. Saleh (2001), *Capturing the Earth's songs.* ABC Science Online. `http://www.abc.net.au/science/news/stories/s237849.htm`.

Biology related references

[40] C. Smith (2001), *Learning From Water, A Possible Quantum Computing Medium.* talk in CASYS'2001, 5th international conference on Computing Anticipating Systems held in Liege, Belgium, August 13-18. Abstract book published by Chaos.

[41] Volkenstein, M., V. (1983): *Biophysics* . Mir Publishers, Moscow.

Neuroscience

[42] K. Wiesenfeld *et al* (1993), Phys. Rev. Lett. 72, 2125.

[43] Vanderwolf, C.H. (1969), *Hippocampal electrical activity and voluntary movement in the rat.* Electroencephalography and Clinical Neurophysiology, 26, 407-18.

[44] P. L. Nunez (2000), *Toward a Quantitative Description of Large Scale Neocortical Dynamic Function and EEG.* Behavioral and Brain Sciences, 23, (3): XX.

[45] R. Joseph (2000), *Hippocampus.* `http://www.brain-mind.com/Hippocampus.html`.

[46] *Electroencephalography.* `http://en.wikipedia.org/wiki/Electroencephalography`.
E. Ackerman (1962), *Biophysical Science.* Prentice Hall.

[47] A. Revonsuo (1998), *Is synchronization the direct neural correlate of visual consciousness?.* `http://www.phil.vt.edu/ASSC/engel/revonsuo1.html`.

[48] J. C. Jaklevic *et al* (1964), Phys. Rev. Lett. 12, 159.

[49] S. J. Williamson, L. Kaufman, and D. Brenner (1979). *Evoked neuromagnetic fields of the human brain.* J. Appl. Phys., 20:2418-2421.

[50] S. J. Williamson, L. Kaufman (1981). *Magnetic fields of the cerebral cortex.* In S. N. Erne, H.-D, Hahlbohm, and H. Lubbig, eds., *Biomagnetism.* pages 353-402, Waleter de Gruyter, Berlin.

[51] A. D. Hibbs *et al* (1995), J. Appl. Phys. 77, 2582.
T. Rouse *et al* (1995), Appl. Phys. Lett. 66, 108.

[52] J. Goldberg, the popular articles *The Quivering Bundles That Let Us Hear* and *Locating a Mouse by Its Sound*. `http://www.hhmi.org/senses/`.

[53] Scott Makeig (1993),*Auditory Event-Related Dynamics of the EEG Spectrum and Effects of Exposure to Tones*. Electroencephalogr. clin. Neurophysiol. , 86:283-293.

[54] S.W. Kuffler and J.G. Nicholls (1976), *From Neuron to Brain* Sinauer Associates Inc. Publishers, Sunderland, Massachusetts.

[55] A.S. Bulsara *et al* (1996), Phys. Rev. E53, 3958.

[56] J. E. Levin and J. P. Miller (1996)), Nature (London) 380, 165.

[57] Jensen, O., Lisman, J. E. (1996). Hippocampal CA3 region predicts memory sequences: accounting for the phase precession of place cells. Learning & Memory, 3, 279.

[58] P. Cariani (1995), *As if time really mattered: Temporal strategies for neural coding of sensory information*. Communican and Cognition-Artificial Intelligence (CC-AI), March, Vol 12, nos. 1-2, pp. 157-219.

[59] P. Jung (1995), Phys. Lett. A 207, 93.

[60] S. Othmer, S..F Othmer and D. A. Kaiser (2000), *EEG Biofeedback: A Generalized Approach to Neuroregulation*. to apper in "Applied Neurophysiology & Brain Biofeedback".

[61] D. Cohen (1972), *Magnetoencephalography: detection of Brain's Electrical Activity with a Superconducting Magnetometer*. Science, 175, 664-666.

[62] *Benham's top*. `http://en.wikipedia.org/wiki/Benham's_top`.

[63] K. Franze *et al* (2007), *Mueller Cells are Living Optical Fibers in the Vertebrate Retina*. Proc. Natl. Acad. Sci. 104, 8287 (2007). `http://www.pnas.org/content/104/20/8287.full`.

[64] A. Longtin *et al* (1991), Phys. Rev. Lett. 67, 656.

[65] J. K. Douglass *et al*(1993), Nature (London) 365, 337.

[66] J. P. Miller (1996), *Brain Waves Deciphered*. article about the work of Wehr and Laurent in Nature, vol 384 (14 November).

Consciousness related references

[67] Julian Jaynes (1982), *The origin of consciousness in the breakdown of the bicameral mind*. Princeton University Press.

[68] A. K. Engel *et al*(2000) *Temporal Binding, Binocular Rivalry, and Consciousness*. `http://www.phil.vt.edu/ASSC/engel/engel.html`.

[69] D. J. Bierman and D. I. Radin (1998), *Anomalous unconscious emotional responses: Evidence for a reversal of the arrow of time*. `http://www-psy.uva.nl/resedu/pn/PUBS/BIERMAN/1998/tucson/tucson3.html`.

[70] J. Newman (1997), *Thalamocortical foundations of conscious experience*. `http://www.phil.vt.edu/assc/newman/`.

[71] B. Libet(1982), E. W. Wright, C. A. Gleason (1982), *Readiness potentials preceding unrestricted spontaneous and preplanned voluntary acts*. Electroencephalography and Clinical Psychology 54, 322-325.
See also the article *Libet's Research on Timing of Conscious Intention to Act: A Commentary* of Stanley Klein. `http://cornea.berkeley.edu/pubs/ccog_2002_0580-Klein-Commentary.pdf`.

[72] Llinas, Ribary, Joliot and Wang (1994), *Content and context in temporal thalamocortical binding.* In G-Buzsaki *et al.*(Eds.). *Temporal Coding in Brain.* Berlin: Springer Verlag.

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

$$(z^1, z^2, z^3) \equiv \lambda(z^1, z^2, z^3) \ . \tag{A-1.1}$$

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 oordinate 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 [16] will be used and their relation to the complex coordinates is given by

$$\begin{aligned} \xi^1 &= z + it \ , \\ \xi^2 &= x + iy \ . \end{aligned} \tag{A-1.2}$$

These are related to the "spherical coordinates" via the equations

$$\begin{aligned} \xi^1 &= rexp(i\frac{(\Psi + \Phi)}{2})cos(\frac{\Theta}{2}) \ , \\ \xi^2 &= rexp(i\frac{(\Psi - \Phi)}{2})sin(\frac{\Theta}{2}) \ . \end{aligned} \tag{A-1.3}$$

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

$$ds^2 = g_{a\bar{b}} d\xi^a d\bar{\xi}^b \ , \tag{A-1.4}$$

where the Hermitian, in fact Kähler metric $g_{a\bar{b}}$ is defined by

$$g_{a\bar{b}} = R^2 \partial_a \partial_{\bar{b}} K \ , \tag{A-1.5}$$

where the function K, Kähler function, is defined as

$$\begin{aligned} K &= log(F) \ , \\ F &= 1 + r^2 \ . \end{aligned} \tag{A-1.6}$$

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

$$\frac{ds^2}{R^2} = \frac{(dr^2 + r^2\sigma_3^2)}{F^2} + \frac{r^2(\sigma_1^2 + \sigma_2^2)}{F} \ , \tag{A-1.7}$$

where the quantities σ_i are defined as

$$\begin{aligned} r^2\sigma_1 &= Im(\xi^1 d\xi^2 - \xi^2 d\xi^1) \ , \\ r^2\sigma_2 &= -Re(\xi^1 d\xi^2 - \xi^2 d\xi^1) \ , \\ r^2\sigma_3 &= -Im(\xi^1 d\bar{\xi}^1 + \xi^2 d\bar{\xi}^2) \ . \end{aligned} \tag{A-1.8}$$

R denotes the radius of the geodesic circle of CP_2. The vierbein forms, which satisfy the defining relation

$$s_{kl} = R^2 \sum_A e_k^A e_l^A \ , \tag{A-1.9}$$

are given by

$$\begin{aligned} e^0 &= \frac{dr}{F} \ , & e^1 &= \frac{r\sigma_1}{\sqrt{F}} \ , \\ e^2 &= \frac{r\sigma_2}{\sqrt{F}} \ , & e^3 &= \frac{r\sigma_3}{F} \ . \end{aligned} \tag{A-1.10}$$

The explicit representations of vierbein vectors are given by

$$\begin{aligned} e^0 &= \frac{dr}{F} \ , & e^1 &= \frac{r(sin\Theta cos\Psi d\Phi + sin\Psi d\Theta)}{2\sqrt{F}} \ , \\ e^2 &= \frac{r(sin\Theta sin\Psi d\Phi - cos\Psi d\Theta)}{2\sqrt{F}} \ , & e^3 &= \frac{r(d\Psi + cos\Theta d\Phi)}{2F} \ . \end{aligned} \tag{A-1.11}$$

The explicit representation of the line element is given by the expression

$$ds^2/R^2 = \frac{dr^2}{F^2} + \frac{r^2}{4F^2}(d\Psi + cos\Theta d\Phi)^2 + \frac{r^2}{4F}(d\Theta^2 + sin^2\Theta d\Phi^2) \ . \tag{A-1.12}$$

The vierbein connection satisfying the defining relation

$$de^A = -V^A_B \wedge e^B \ , \tag{A-1.13}$$

is given by

$$\begin{array}{lllllll} V_{01} & = & -\frac{e^1}{r} \ , & V_{23} & = & \frac{e^1}{r} \ , \\ V_{02} & = & -\frac{e^2}{r} \ , & V_{31} & = & \frac{e^2}{r} \ , \\ V_{03} & = & (r-\frac{1}{r})e^3 \ , & V_{12} & = & (2r+\frac{1}{r})e^3 \ . \end{array} \tag{A-1.14}$$

The representation of the covariantly constant curvature tensor is given by

$$\begin{array}{lllllll} R_{01} & = & e^0\wedge e^1 - e^2\wedge e^3 \ , & R_{23} & = & e^0\wedge e^1 - e^2\wedge e^3 \ , \\ R_{02} & = & e^0\wedge e^2 - e^3\wedge e^1 \ , & R_{31} & = & -e^0\wedge e^2 + e^3\wedge e^1 \ , \\ R_{03} & = & 4e^0\wedge e^3 + 2e^1\wedge e^2 \ , & R_{12} & = & 2e^0\wedge e^3 + 4e^1\wedge e^2 \ . \end{array} \tag{A-1.15}$$

Metric defines a real, covariantly constant, and therefore closed 2-form J

$$J = -ig_{a\bar{b}}d\xi^a d\bar{\xi}^b \ , \tag{A-1.16}$$

the so called Kähler form. Kähler form J defines in CP_2 a symplectic structure because it satisfies the condition

$$J^k_{\ r}J^{rl} = -s^{kl} \ . \tag{A-1.17}$$

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

$$J = dB \ , \tag{A-1.18}$$

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

$$\begin{array}{lll} B & = & 2re^3 \ , \\ J & = & 2(e^0\wedge e^3 + e^1\wedge e^2) = \frac{r}{F^2}dr\wedge(d\Psi + cos\Theta d\Phi) + \frac{r^2}{2F}sin\Theta d\Theta d\Phi \ . \end{array} \tag{A-1.19}$$

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

$$\begin{array}{lll} B & = & \sum_{k=1,2} P_k dQ_k \ , \\ J & = & \sum_{k=1,2} dP_k\wedge dQ_k \ . \end{array} \tag{A-1.20}$$

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 [19]. 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: $e^A = R^A_B e^B$ 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 $R^A_B(v)$ 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 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 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^k_α (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 [17] 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

$$S^2_I \ : \ \xi^1 = \bar{\xi}^2 \ \text{ or equivalently } \ (\Theta = \pi/2, \Psi = 0) \ ,$$

$$S^2_{II} \ : \ \xi^1 = \xi^2 \ \text{ or equivalently } \ (\Theta = \pi/2, \Phi = 0) \ .$$

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^2_I. S^2_{II} 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 [18] 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

$$\begin{aligned} V_{01} &= -\frac{e^1}{r} \ , & V_{23} &= \frac{e^1}{r} \ , \\ V_{02} &= -\frac{e^2}{r} \ , & V_{31} &= \frac{e^2}{r} \ , \\ V_{03} &= (r - \tfrac{1}{r})e^3 \ , & V_{12} &= (2r + \tfrac{1}{r})e^3 \ , \end{aligned} \tag{A-2.3}$$

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

$$A_{ch} = 2V_{23}I_L^1 + 2V_{13}I_L^2 \ , \tag{A-2.5}$$

where one have defined

$$\begin{aligned} I_L^1 &= \frac{(\Sigma_{01} - \Sigma_{23})}{2} \ , \\ I_L^2 &= \frac{(\Sigma_{02} - \Sigma_{13})}{2} \ . \end{aligned} \tag{A-2.6}$$

A_{ch} is clearly left handed so that one can perform the identification

$$W^{\pm} = \frac{2(e^1 \pm ie^2)}{r} \ , \tag{A-2.7}$$

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

$$\begin{aligned} X &= re^3 \ , \\ Y &= \frac{e^3}{r} \ , \end{aligned} \tag{A-2.8}$$

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

$$\begin{aligned} \bar{\gamma} &= aX + bY \ , \\ \bar{Z}^0 &= cX + dY \ , \end{aligned} \tag{A-2.9}$$

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

$$\begin{aligned} A_{nc} &= [(c+d)2\Sigma_{03} + (2d-c)2\Sigma_{12} + d(n_+1_+ + n_-1_-)]\bar{\gamma} \\ &+ [(a-b)2\Sigma_{03} + (a-2b)2\Sigma_{12} - b(n_+1_+ + n_-1_-)]\bar{Z}^0 \ . \end{aligned} \tag{A-2.10}$$

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

$$c = -d \ . \tag{A-2.11}$$

Using this result plus previous equations, one obtains for the neutral part of the connection the expression

$$A_{nc} = \gamma Q_{em} + Z^0(I_L^3 - sin^2\theta_W Q_{em}) \ . \tag{A-2.12}$$

Here the electromagnetic charge Q_{em} and the weak isospin are defined by

$$\begin{aligned} Q_{em} &= \Sigma^{12} + \frac{(n_+1_+ + n_-1_-)}{6} \ , \\ I_L^3 &= \frac{(\Sigma^{12} - \Sigma^{03})}{2} \ . \end{aligned} \tag{A-2.13}$$

The fields γ and Z^0 are defined via the relations

$$\begin{aligned} \gamma &= 6d\bar{\gamma} = \frac{6}{(a+b)}(aX + bY) \ , \\ Z^0 &= 4(a+b)\bar{Z}^0 = 4(X - Y) \ . \end{aligned} \tag{A-2.14}$$

The value of the Weinberg angle is given by

$$sin^2\theta_W = \frac{3b}{2(a+b)} \ , \tag{A-2.15}$$

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

$$F_{nc} = 2R_{03}\Sigma^{03} + 2R_{12}\Sigma^{12} + J(n_+1_+ + n_-1_-) \ , \tag{A-2.16}$$

where one has

$$\begin{aligned} R_{03} &= 2(2e^0 \wedge e^3 + e^1 \wedge e^2) \ , \\ R_{12} &= 2(e^0 \wedge e^3 + 2e^1 \wedge e^2) \ , \\ J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) \ , \end{aligned} \tag{A-2.17}$$

in terms of the fields γ and Z^0 (photon and Z- boson)

$$F_{nc} = \gamma Q_{em} + Z^0(I_L^3 - sin^2\theta_W Q_{em}) \ . \tag{A-2.18}$$

Evaluating the expressions above one obtains for γ and Z^0 the expressions

$$\begin{aligned} \gamma &= 3J - sin^2\theta_W R_{03} \ , \\ Z^0 &= 2R_{03} \ . \end{aligned} \tag{A-2.19}$$

For the Kähler field one obtains

$$J = \frac{1}{3}(\gamma + sin^2\theta_W Z^0) \ . \tag{A-2.20}$$

Expressing the neutral part of the symmetry broken YM action

$$
\begin{aligned}
L_{ew} &= L_{sym} + fJ^{\alpha\beta}J_{\alpha\beta} \ , \\
L_{sym} &= \frac{1}{4g^2}Tr(F^{\alpha\beta}F_{\alpha\beta}) \ ,
\end{aligned} \tag{A-2.21}
$$

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

$$
\begin{aligned}
X &= -\frac{K}{2g^2} + \frac{fp}{18} \ , \\
K &= Tr\left[Q_{em}(I_L^3 - sin^2\theta_W Q_{em})\right] \ ,
\end{aligned} \tag{A-2.22}
$$

In the general case the value of the coefficient K is given by

$$
K = \sum_i \left[-\frac{(18+2n_i^2)sin^2\theta_W}{9}\right] \ , \tag{A-2.23}
$$

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

$$
sin^2\theta_W = \frac{9\sum_i 1}{(fg^2 + 2\sum_i(18+n_i^2))} \ . \tag{A-2.24}
$$

In the scenario where both leptons and quarks are elementary fermions the value of the Weinberg angle is given by

$$
sin^2\theta_W = \frac{9}{(\frac{fg^2}{2} + 28)} \ . \tag{A-2.25}
$$

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 [20].

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 [15].

The action of the reflection P on spinors of is given by

$$
\Psi \rightarrow P\Psi = \gamma^0 \otimes \gamma^0 \Psi \ . \tag{A-2.26}
$$

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

$$
\begin{aligned}
m^k &\rightarrow T(M^k) \ , \\
\xi^k &\rightarrow \bar{\xi}^k \ , \\
\Psi &\rightarrow \gamma^1\gamma^3 \otimes 1\Psi \ .
\end{aligned} \tag{A-2.27}
$$

The operation bearing closest resemblance to the ordinary charge conjugation corresponds geometrically to complex conjugation in CP_2:

$$\begin{array}{lll} \xi^k & \rightarrow & \bar{\xi}^k \ , \\ \Psi & \rightarrow & \Psi^\dagger \gamma^2 \gamma^0 \otimes 1 \ . \end{array} \quad \text{(A-2.28)}$$

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

$$\gamma = (\frac{3}{4} - \frac{sin^2(\theta_W)}{2})Z^0 \simeq \frac{5Z^0}{8} \ .$$

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

$$\begin{aligned} \Psi &= k\Phi \ , \\ (3+2p)\frac{1}{r^2F}(d(r^2)/d\Theta)(k+cos(\Theta)) &+ (3+p)sin(\Theta)=0 \ , \end{aligned} \quad \text{(A-3.3)}$$

hold true. The conditions imply that CP_2 projection of the electromagnetically neutral space-time is 2-dimensional. Solving the differential equation one obtains

$$\begin{aligned} r &= \sqrt{\frac{X}{1-X}} \ , \\ X &= D\left[|\frac{(k+u}{C}|\right]^{\epsilon} \ , \\ u &\equiv cos(\Theta) \ , \ C=k+cos(\Theta_0) \ , \ D=\frac{r_0^2}{1+r_0^2} \ , \ \epsilon=\frac{3+p}{3+2p} \ , \end{aligned} \quad \text{(A-3.4)}$$

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

$$sign(u+k)\times[\frac{1+r_0^2}{r_0^2}]^{\frac{3+2p}{3+p}}\leq k+1 \ ,$$

where $sign(x)$ denotes the sign of x.

The expressions for Kähler form and Z^0 field are given by

$$\begin{aligned} J &= -\frac{p}{3+2p}Xdu\wedge d\Phi \ , \\ Z^0 &= -\frac{6}{p}J \ . \end{aligned} \quad \text{(A-3.5)}$$

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

$$\begin{aligned} ds^2_{eff} &= (s_{rr}(\frac{dr}{d\Theta})^2 + s_{\Theta\Theta})d\Theta^2 + (s_{\Phi\Phi} + 2ks_{\Phi\Psi})d\Phi^2 = \frac{R^2}{4}[s^{eff}_{\Theta\Theta}d\Theta^2 + s^{eff}_{\Phi\Phi}d\Phi^2] \ , \\ s^{eff}_{\Theta\Theta} &= X \times \left[\frac{\epsilon^2(1-u^2)}{(k+u)^2} \times \frac{1}{1-X} + 1 - X\right] \ , \\ s^{eff}_{\Phi\Phi} &= X \times \left[(1-X)(k+u)^2 + 1 - u^2\right] \ , \end{aligned} \tag{A-3.7}$$

and is useful in the construction of vacuum imbedding of, say Schwartchild 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 guaranteing the absence of edges are satisfied.

For instance, the vanishing of the electromagnetic fields implies that the condition

$$\Omega \equiv \frac{\omega_2}{n_2} - \frac{\omega_1}{n_1} = 0 \ , \tag{A-3.9}$$

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.

Bibliography

[1] M. Pitkänen (2006), *Topological Geometrodynamics: Overview.*
`http:/tgd.wippiespace.com/public_html/tgdview/tgdview.html`.

[2] M. Pitkänen (2006), *Quantum Physics as Infinite-Dimensional Geometry.*
`http:/tgd.wippiespace.com/public_html/tgdgeom/tgdgeom.html`.

[3] M. Pitkänen (2006), *Quantum TGD.*
`http:/tgd.wippiespace.com/public_html/tgdquant/tgdquant.html`.

[4] M. Pitkänen (2006), *Physics in Many-Sheeted Space-Time.*
`http:/tgd.wippiespace.com/public_html/tgdclass/tgdclass.html`.

[5] M. Pitkänen (2006), *TGD as a Generalized Number Theory.*
`http:/tgd.wippiespace.com/public_html/tgdnumber/tgdnumber.html`.

[6] M. Pitkänen (2006), *p-Adic length Scale Hypothesis and Dark Matter Hierarchy.*
`http:/tgd.wippiespace.com/public_html/paddark/paddark.html`.

[7] M. Pitkänen (2006), *TGD and Fringe Physics.*
`http:/tgd.wippiespace.com/public_html/freenergy/freenergy.html`.

[8] M. Pitkänen (2006), *TGD Inspired Theory of Consciousness.*
`http:/tgd.wippiespace.com/public_html/tgdconsc/tgdconsc.html`.

[9] M. Pitkänen (2006), *Bio-Systems as Self-Organizing Quantum Systems.*
`http:/tgd.wippiespace.com/public_html/bioselforg/bioselforg.html`.

[10] M. Pitkänen (2006), *Quantum Hardware of Living Matter.*
`http:/tgd.wippiespace.com/public_html/bioware/bioware.html`.

[11] M. Pitkänen (2006), *Bio-Systems as Conscious Holograms.*
`http:/tgd.wippiespace.com/public_html/hologram/hologram.html`.

[12] M. Pitkänen (2006), *Mathematical Aspects of Consciousness Theory.*
`http:/tgd.wippiespace.com/public_html/genememe/genememe.html`.

[13] M. Pitkänen (2006), *TGD and EEG.*
`http:/tgd.wippiespace.com/public_html/tgdeeg/tgdeeg.html`.

[14] M. Pitkänen (2006), *Magnetospheric Consciousness.*
`http:/tgd.wippiespace.com/public_html/magnconsc/magnconsc.html`.

[15] Björken, J. and Drell, S. (1965): *Relativistic Quantum Fields*. Mc-Graw-Hill, New York.

[16] Eguchi, T., Gilkey, B., Hanson, J. (1980): Phys. Rep. 66, 6.

[17] Helgason, S. (1962): *Differential Geometry and Symmetric Spaces*. New York: Academic Press.

[18] Huang, K. (1982): *Quarks,Leptons* & *Gauge Fields*. World Scientific.

[19] Pope, C., N. (1980): *Eigenfunctions and* $Spin^c$ *Structures on* CP_2 D.A.M.T.P. preprint.

[20] Zee, A. (1982): *The Unity of Forces in the Universe* World Science Press, Singapore.

Index