

TGD BASED VIEW ABOUT LIVING MATTER AND REMOTE MENTAL INTERACTIONS

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

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

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

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

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

2-surfaces. Zero energy ontology and the interpretation of parton orbits as light-like "wormhole throats" suggests that virtual particles do not differ from 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 propagators are massless propagators but for on mass shell four-momenta. This gives a connection with the twistor approach and inspires the generalization of the Yangian symmetry to infinite-dimensional super-conformal algebras.

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

Matti Pitkänen

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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 - after this book sixteen - 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 Sidorov was extremely fruitful and she also helped me to survive economically through the hardest years. The inspiration for writing this particular book came also from a more recent contact with Lian.

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

In the situation in which the conventional scientific communication channels are strictly closed it is important to have some loop hole through which the information about the work done can at least in principle leak to the publicity through the iron wall of the academic censorship. Without any exaggeration I can say that without the world wide web I would not have survived as a scientist nor as individual. Homepage and blog are however not enough since only the formally published result is a result in recent day science. Publishing is however impossible without a direct support from power holders- even in archives like arXiv.org.

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

For a person who has had his sixty year birthday it is somewhat easier to overcome the hard feelings due to the loss of academic human rights than for an inpatient youngster. Unfortunately the economic situation has become increasingly difficult during the twenty years after the economic depression in Finland which in practice meant that Finland ceased to be a constitutional state in the strong sense of the word. It became possible to depose people like me from the society without fear about public reactions and the classification as dropout became a convenient tool of ridicule to circumvent the ethical issues. During last few years when the right wing has held the political power this trend has been steadily strengthening. In this kind of situation the concrete help from individuals

has been and will be of utmost importance. Against this background it becomes obvious that this kind of work is not possible without the support from outside and I apologize for not being able to mention all the people who have helped me during these years.

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Contents

1	Introduction	1
1.1	Motivations for the book	1
1.2	Basic Ideas of TGD	1
1.2.1	Background	2
1.2.2	TGD as a Poincare invariant theory of gravitation	2
1.2.3	TGD as a generalization of the hadronic string model	3
1.2.4	Fusion of the two approaches via a generalization of the space-time concept	3
1.3	The threads in the development of quantum TGD	4
1.3.1	Quantum TGD as spinor geometry of World of Classical Worlds	4
1.3.2	TGD as a generalized number theory	6
1.3.3	Hierarchy of Planck constants and dark matter hierarchy	8
1.3.4	TGD as a generalization of physics to a theory consciousness	10
1.4	The contents of the book	16
1.4.1	Topological Geometrodynamics: Basic Visions	16
1.4.2	Quantum Mind in TGD Universe	16
1.4.3	Quantum Mind, Magnetic Body, and Biological Body	17
1.4.4	Quantum Mind and Neuro Science	17
1.4.5	TGD inspired view about remote mental interactions and paranormal	18
2	Topological Geometrodynamics: Basic Visions	31
2.1	Introduction	31
2.2	Quantum physics as infinite-dimensional geometry	32
2.2.1	World of the classical worlds as the arena of quantum physics	32
2.2.2	Geometrization of fermionic statistics in terms of configuration space spinor structure	33
2.2.3	Construction of the configuration space Clifford algebra in terms of second quantized induced spinor fields	34
2.2.4	Zero energy ontology and WCW geometry	35
2.2.5	Hierarchy of Planck constants and WCW geometry	38
2.2.6	Hyper-finite factors and the notion of measurement resolution	42
2.2.7	Twistor revolution and TGD	45
2.3	Physics as a generalized number theory	48
2.3.1	Fusion of real and p-adic physics to a coherent whole	48
2.3.2	Classical number fields and associativity and commutativity as fundamental law of physics	49
2.3.3	Infinite primes and quantum physics	50
2.3.4	Quantum Mathematics and Quantum Mechanics	50
2.4	Physics as extension of quantum measurement theory to a theory of consciousness	53
2.4.1	Quantum jump as moment of consciousness	53
2.4.2	Negentropy Maximization Principle and the notion of self	53
2.4.3	Life as islands of rational/algebraic numbers in the seas of real and p-adic continua?	54
2.4.4	Two times	55
2.4.5	General view about psychological time and intentionality	56
2.4.6	T-duality and life	57
2.5	Implications of Quantum Classical Correspondence	60

2.5.1	Strong form of holography and effective 2-dimensionality	60
2.5.2	Weak form of electric magnetic duality	61
2.5.3	TGD as almost topological QFT	62
2.5.4	Generalized Feynman diagrams and braids	64
2.5.5	The superposition of classical fields in TGD Universe	64
3	Quantum Mind in TGD Universe	79
3.1	Introduction	79
3.2	What are the problems of quantum mind theories?	81
3.2.1	Some philosophical problems of quantum physics	81
3.2.2	Basic philosophical problems of quantum mind theories	82
3.2.3	Basic problems of quantum biology and quantum neuroscience	82
3.2.4	Could anomalies help?	83
3.3	Some aspects of quantum TGD	84
3.3.1	New space-time concept	84
3.3.2	Zero energy ontology	85
3.3.3	The hierarchy of Planck constants	86
3.3.4	p-Adic physics and number theoretic universality	87
3.4	Consciousness theory as extension of quantum measurement theory	89
3.4.1	Quantum jumps as moment of consciousness	90
3.4.2	The notion of self	90
3.4.3	How experienced time and the geometric time of physicist relate to each other?	91
3.4.4	Quantum correlates of for various aspects of conscious experience	95
3.4.5	Self referentiality of conscious experience	97
4	Quantum Mind, Magnetic Body, and Biological Body	123
4.1	Introduction	123
4.2	Quantum mind and magnetic body	124
4.2.1	Living matter as ordinary matter controlled by dark matter at magnetic bodies	124
4.2.2	Magnetic body as intentional agent and experiencer	125
4.2.3	Time mirror mechanism can be seen as the basic mechanism of memory, intentional action, and metabolism	126
4.2.4	Biosystems as conscious holograms	126
4.2.5	High T_c superconductivity in living matter	127
4.2.6	Possible roles of the magnetic body in living matter	131
4.2.7	How to build a quantum computer from magnetic flux tubes	138
4.2.8	DNA as topological quantum computer	143
4.2.9	What is the role of magnetic body in DNA replication,mitosis, meiosis, and fertilization?	145
4.3	The relationship between information processing and metabolism in TGD Universe	147
4.3.1	Three different views about living matter as a macroscopic quantum system	147
4.3.2	New ideas related to metabolism	148
4.3.3	Pessimistic generalization of the second law of thermodynamics	152
4.3.4	How to understand differentiation and de-differentiation?	152
4.4	Exotic charge transfer between cell interior and exterior as fundamental control mechanism	153
4.4.1	Strange behavior of the intracellular water	153
4.4.2	Are channels and pumps really there?	154
4.4.3	Cytoplasm as gel	155
4.4.4	TGD based vision inspired by the findings	157
4.5	Quantum model for the direct currents of Becker	159
4.5.1	Connection between laser induced healing, acupuncture, and association of DC currents with the healing of wounds	160
4.5.2	Quantum model for effective semiconductor property	165
4.5.3	A model for remote gene expression	175
4.5.4	DNA, speech, music, and ordinary sound	177
4.6	Water and life	181

4.6.1	Latest view about water memory	181
4.6.2	Genes and water memory	185
4.6.3	Water electric as protocell	189
4.6.4	A model for chiral selection	192
4.6.5	Burning water and photosynthesis	194
4.7	Connections to the work of other researchers in the forefront	197
4.7.1	Mae Wan-Ho	197
4.7.2	Peter Gariaev	198
4.7.3	Luc Montagnier	199
4.7.4	Rupert Sheldrake	200
5	Quantum Mind and Neuro Science	225
5.1	Introduction	225
5.2	A general model for qualia	227
5.2.1	A possible classification of qualia	227
5.2.2	The mechanisms generating sensory qualia	228
5.2.3	Could some sensory qualia correspond to the sensory qualia of the magnetic body?	229
5.2.4	Summary about qualia	230
5.3	Model for sensory receptor	231
5.3.1	Capacitor model of sensory qualia	231
5.3.2	Could cell correspond to almost vacuum extremal?	232
5.3.3	General model for sensory receptor	238
5.3.4	Cell membrane as a map with pixels colored by qualia	239
5.4	Constraints on the fermionic realization of genetic code from the model for color qualia	243
5.4.1	Fermionic representation	244
5.4.2	Various options for the fermionic representation of A,T,C,G	244
5.4.3	Realization of color qualia for quark option	245
5.5	Model for nerve pulse	247
5.5.1	Background	247
5.5.2	New view about nerve pulse generation	247
5.5.3	The function of neural transmitters	248
5.5.4	Microtubular level	249
5.6	Model for EEG	249
5.6.1	Fractal hierarchy of EEGs	250
5.6.2	Basic aspects of EEG	251
5.6.3	The effects of ELF em fields on brain	251
5.6.4	Vision about biological evolution and evolution of brain	252
5.6.5	Does memory code exist?	252
5.7	Bio-photons	253
5.7.1	What bio-photons are?	253
5.7.2	Some phenomena related to bio-photons	254
5.7.3	General TGD based model for coherent bio-photons	255
5.7.4	The interpretation of biophotons and EEG as decay products of dark Josephson radiation	257
6	TGD inspired view about remote mental interactions and paranormal	279
6.1	Introduction	279
6.2	Brief summary of the basic vision around 2003 compared with the recent situation	279
6.2.1	TGD inspired theory of consciousness	280
6.2.2	TGD inspired quantum biology	282
6.3	Basic questions and basic ideas	284
6.3.1	Basic questions	284
6.3.2	Key ideas of the TGD inspired model of remote mental interactions	286
6.3.3	Some examples of remote mental interactions interpreted in TGD framework	287
6.4	Parapsychological phenomena	288
6.4.1	Extrasensory perception, precognition, and other parapsychic effects	288
6.4.2	Psychokinesis	290

6.4.3	Healing as rejuvenation?	296
6.4.4	Near death experiences	298
6.5	Conscious hologram and remote mental interactions	303
6.5.1	Big vision	303
6.5.2	Sketch for what could happen in a typical remote viewing experiment	304
6.5.3	About the physiological correlates of anomalous cognition	305
6.5.4	Local sidereal time, geomagnetic fluctuations, and remote mental interactions	306
6.5.5	Could magnetic flux tubes make possible effective holograms?	309
6.6	TGD inspired model for OBEs	310
6.6.1	OBEs, autoscapy, heautoscapy, and other strange experiences	310
6.6.2	Questions	312
6.6.3	Dark matter hierarchy, zero energy ontology, negentropic entanglement, OBEs	313
6.6.4	A model for OBEs	316
6.6.5	The role of the magnetic body in the case of other brain functions	319
6.7	Connection to the work of researchers in forefront	321
6.7.1	Simon Shnoll	321
6.7.2	Michael Persinger	322
6.7.3	William Tiller	322
7	How to test TGD based vision about living matter and remote mental interactions?	351
7.1	Introduction	351
7.2	Zero energy ontology	351
7.2.1	The hierarchy of CDs	352
7.2.2	Generalization of standard conservation laws in ZEO	352
7.2.3	Breaking of second law in standard form	352
7.2.4	Negative energy signals	353
7.3	p-Adic physics	353
7.3.1	p-Adic length scale hypothesis and Mersenne hypothesis in living matter	353
7.3.2	Negentropic entanglement	353
7.3.3	p-Adic-real phase transitions and intentional action and formation of cognitive representations	354
7.4	Magnetic body as carrier of dark matter	354
7.4.1	Dark matter as a hierarchy of phases with large value of Planck constant	355
7.4.2	Tests for the notion of magnetic body	356
7.4.3	Bio-superconductivity	357
7.4.4	Direct supra currents along magnetic flux tubes	358
7.5	TGD view about consciousness and biology	359
7.5.1	The notion of conscious hologram	359
7.5.2	TGD view about metabolism	361
7.5.3	The new view about DNA	363
7.5.4	Model of cell membrane as almost vacuum extremal	364
7.6	General model for remote mental interactions	364
7.6.1	Direct metabolic correlates for remote mental interactions	364
7.6.2	How to choose senders and receivers?	365
1	Appendix	389
A-1	Basic properties of CP_2	389
A-1.1	CP_2 as a manifold	389
A-1.2	Metric and Kähler structure of CP_2	389
A-1.3	Spinors in CP_2	392
A-1.4	Geodesic sub-manifolds of CP_2	392
A-2	CP_2 geometry and standard model symmetries	393
A-2.1	Identification of the electro-weak couplings	393
A-2.2	Discrete symmetries	396
A-3	Basic facts about induced gauge fields	397
A-3.1	Induced gauge fields for space-times for which CP_2 projection is a geodesic sphere	397

A-3.2	Space-time surfaces with vanishing em , Z^0 , or Kähler fields	397
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List of Figures

Chapter 1

Introduction

1.1 Motivations for the book

The latest TGD inspired articles related to quantum biology, quantum mind, and remote mental interactions were published in JNLRMI around 2003. Several new ideas related to basic TGD, TGD inspired quantum biology and theory of consciousness have emerged during the subsequent 8 years: for a short summary about the development of ideas see the article *Evolution of TGD* [L24].

My original intention was to write just single article trying to give a summary about the progress of quantum TGD first and after that I will discuss the implications for quantum TGD based view about biology, consciousness and remote mental interactions and similar anomalies.

As usually happens, also now I realized that I am not able to write this kind of short article. The amount of topics has grown during years quite large and is scattered around to several books and gradually I began to feel desperate. I simply could not decide what should I take and what should I leave. Finally I drifted to the predictable outcome: I decided to write several articles with topic restricted to the recent state of quantum TGD itself, TGD inspired views about consciousness, and some basic aspects of biology, neuroscience, and remote mental interactions. The decision was made easy after recalling that I had written a series of three articles to the journal *Journal of Consciousness Exploration and Research* founded by Huping Hu. It was rather easy to add the developments that had happened during last three years to these articles and write a new article about remote mental interactions and about testing the vision. The final step was the realization that it is natural to organize the article in a form of book.

There are other arguments in defence of book format. For a long time the basic challenge of TGD has been to give a precise meaning for heuristic ideas and loosely formulated concepts. Why this kind of approach requiring scanning through of all what one has written is so fruitful is that it forces to realize that definitions which have seemed obvious, are not at all obvious after all. At this stage when so little is known, internal consistency is an extremely valuable constraint on free imagination. Although reprocessing all this topic requires patience, it helps so identify internal inconsistencies. There has been quite a flux of ideas during last years and it is also very useful to allow them to interact.

Therefore the outcome was six articles transformed into chapters of a book. The reader should not be scared. I have tried to write these chapters so that one could read them in any order and there are links to the material at my homepage.

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 Background

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

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

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

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

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

TGD forces the generalization of physics to a quantum theory of consciousness, and represent TGD as a generalized number theory vision leads naturally to the emergence of p-adic physics as physics of cognitive representations. The seven online books [K82, K61, K47, K45, K62, K70, K69] about TGD and eight online books about TGD inspired theory of consciousness and of quantum biology [K75, K9, K53, K7, K29, K35, K39, K68] are warmly recommended to the interested reader.

1.2.2 TGD as a Poincare invariant theory of gravitation

The first approach was born as an attempt to construct a Poincare invariant theory of gravitation. Space-time, rather than being an abstract manifold endowed with a pseudo-Riemannian structure, is regarded as a surface in the 8-dimensional space $H = M^4_{\times} CP_2$, where M^4 denotes Minkowski space and $CP_2 = SU(3)/U(2)$ is the complex projective space of two complex dimensions [A28, A14, A21, A12].

The identification of the space-time as a submanifold [A10, A27] of $M^4 \times CP_2$ leads to an exact Poincare invariance and solves the conceptual difficulties related to the definition of the energy-momentum in General Relativity.

It soon however turned out that submanifold geometry, being considerably richer in structure than the abstract manifold geometry, leads to a geometrization of all basic interactions. First, the geometrization of the elementary particle quantum numbers is achieved. The geometry of CP_2 explains electro-weak and color quantum numbers. The different H-chiralities of H -spinors correspond to the conserved baryon and lepton numbers. Secondly, the geometrization of the field concept results. The

projections of the CP_2 spinor connection, Killing vector fields of CP_2 and of H -metric to four-surface define classical electro-weak, color gauge fields and metric in X^4 .

1.2.3 TGD as a generalization of the hadronic string model

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

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

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

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

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

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

General Coordinate Invariance allows to identify the basic dynamical objects as space-like 3-surfaces at the ends of space-time surface at boundaries of CD : this means that space-time surface is analogous to Bohr orbit. An alternative identification is as light-like 3-surfaces at which the signature of the induced metric changes from Minkowskian to Euclidian and interpreted as lines of generalized Feynman diagrams. Also the Euclidian 4-D regions would have similar interpretation. The requirement that the two interpretations are equivalent, leads to a strong form of General Coordinate Invariance. The outcome is effective 2-dimensionality stating that the partonic 2-surfaces identified as intersections of the space-like ends of space-time surface and light-like wormhole throats are the fundamental objects. That only effective 2-dimensionality is in question is due to the effects caused by

the failure of strict determinism of Kähler action. In finite length scale resolution these effects can be neglected below UV cutoff and above IR cutoff. One can also speak about strong form of holography.

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

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

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

1.3 The threads in the development of quantum TGD

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

1.3.1 Quantum TGD as spinor geometry of World of Classical Worlds

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

1. Quantum theory for extended particles is free(!), classical(!) field theory for a generalized Schrödinger amplitude in the configuration space CH consisting of all possible 3-surfaces in H . "All possible" means that surfaces with arbitrary many disjoint components and with arbitrary internal topology and also singular surfaces topologically intermediate between two different manifold topologies are included. Particle reactions are identified as topology changes [A20, A30, A31]. For instance, the decay of a 3-surface to two 3-surfaces corresponds to the decay $A \rightarrow B + C$. Classically this corresponds to a path of configuration space leading from 1-particle sector to 2-particle sector. At quantum level this corresponds to the dispersion of the generalized Schrödinger amplitude localized to 1-particle sector to two-particle sector. All coupling constants should result as predictions of the theory since no nonlinearities are introduced.
2. During years this naive and very rough vision has of course developed a lot and is not anymore quite equivalent with the original insight. In particular, the space-time correlates of Feynman graphs have emerged from theory as Euclidian space-time regions and the strong form of General Coordinate Invariance has led to a rather detailed and in many respects un-expected visions. This picture forces to give up the idea about smooth space-time surfaces and replace space-time surface with a generalization of Feynman diagram in which vertices represent the failure of manifold property. I have also started introduced the word "world of classical worlds" (WCW) instead of rather formal "configuration space". I hope that "WCW" does not induce despair in the reader having tendency to think about the technicalities involved!
3. WCW is endowed with metric and spinor structure so that one can define various metric related differential operators, say Dirac operator, appearing in the field equations of the theory. The

most ambitious dream is that zero energy states correspond to a complete solution basis for the Dirac operator of WCW so that this classical free field theory would dictate M-matrices which form orthonormal rows of what I call U-matrix. Given M-matrix in turn would decompose to a product of a hermitian density matrix and unitary S-matrix.

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

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

The evolution of these basic ideas has been rather slow but has gradually led to a rather beautiful vision. One of the key problems has been the definition of Kähler function. Kähler function is Kähler action for a preferred extremal assignable to a given 3-surface but what this preferred extremal is? The obvious first guess was as absolute minimum of Kähler action but could not be proven to be right or wrong. One big step in the progress was boosted by the idea that TGD should reduce to almost topological QFT in which braids would replace 3-surfaces in finite measurement resolution, which could be inherent property of the theory itself and imply discretization at partonic 2-surfaces with discrete points carrying fermion number.

1. TGD as almost topological QFT vision suggests that Kähler action for preferred extremals reduces to Chern-Simons term assigned with space-like 3-surfaces at the ends of space-time (recall the notion of causal diamond (*CD*)) and with the light-like 3-surfaces at which the signature of the induced metric changes from Minkowskian to Euclidian. Minkowskian and Euclidian regions would give at wormhole throats the same contribution apart from coefficients and in Minkowskian regions the $\sqrt{g_4}$ factor would be imaginary so that one would obtain sum of real term identifiable as Kähler function and imaginary term identifiable as the ordinary action giving rise to interference effects and stationary phase approximation central in both classical and quantum field theory. Imaginary contribution - the presence of which I realized only after 33 years of TGD - could also have topological interpretation as a Morse function. On physical side the emergence of Euclidian space-time regions is something completely new and leads to a dramatic modification of the ideas about black hole interior.
2. The manner to achieve the reduction to Chern-Simons terms is simple. The vanishing of Coulombic contribution to Kähler action is required and is true for all known extremals if one makes a general ansatz about the form of classical conserved currents. The so called weak form of electric-magnetic duality defines a boundary condition reducing the resulting 3-D terms to Chern-Simons terms. In this manner almost topological QFT results. But only "almost" since the Lagrange multiplier term forcing electric-magnetic duality implies that Chern-Simons action for preferred extremals depends on metric.

3. A further quite recent hypothesis inspired by effective 2-dimensionality is that Chern-Simons terms reduce to a sum of two 2-dimensional terms. An imaginary term proportional to the total area of Minkowskian string world sheets and a real term proportional to the total area of partonic 2-surfaces or equivalently strings world sheets in Euclidian space-time regions. Also the equality of the total areas of strings world sheets and partonic 2-surfaces is highly suggestive and would realize a duality between these two kinds of objects. String world sheets indeed emerge naturally for the proposed ansatz defining preferred extremals. Therefore Kähler action would have very stringy character apart from effects due to the failure of the strict determinism meaning that radiative corrections break the effective 2-dimensionality.

1.3.2 TGD as a generalized number theory

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

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

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

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

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

1. What is the relationship of p-adic non-determinism to the classical non-determinism of the basic field equations of TGD? Are the p-adic space-time region genuinely p-adic or does p-adic topology only serve as an effective topology? If p-adic physics is direct image of real physics, how the mapping relating them is constructed so that it respects various symmetries? Is the basic physics p-adic or real (also real TGD seems to be free of divergences) or both? If it is both, how should one glue the physics in different number field together to get *The Physics*? Should one perform p-adicization also at the level of the configuration space of 3-surfaces? Certainly the p-adicization at the level of super-conformal representation is necessary for the p-adic mass calculations.

2. Perhaps the most basic and most irritating technical problem was how to precisely define p-adic definite integral which is a crucial element of any variational principle based formulation of the field equations. Here the frustration was not due to the lack of solution but due to the too large number of solutions to the problem, a clear symptom for the sad fact that clever inventions rather than real discoveries might be in question. Quite recently I however learned that the problem of making sense about p-adic integration has been for decades central problem in the frontier of mathematics and a lot of profound work has been done along same intuitive lines as I have proceeded in TGD framework. The basic idea is certainly the notion of algebraic continuation from the world of rationals belonging to the intersection of real world and various p-adic worlds.

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

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

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

The role of classical number fields

The vision about the physical role of the classical number fields relies on the notion of number theoretic compactification stating that space-time surfaces can be regarded as surfaces of either M^8 or $M^4 \times CP_2$. As surfaces of M^8 identifiable as space of hyper-octonions they are hyper-quaternionic or co-hyper-quaternionic- and thus maximally associative or co-associative. This means that their tangent space is either hyper-quaternionic plane of M^8 or an orthogonal complement of such a plane. These surface can be mapped in natural manner to surfaces in $M^4 \times CP_2$ [K73] provided one can assign to each point of tangent space a hyper-complex plane $M^2(x) \subset M^4$. One can also speak about $M^8 - H$ duality.

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

One can fairly say, that number theoretical compactification is responsible for most of the understanding of quantum TGD that has emerged during last years. This includes the realization of Equivalence Principle at space-time level, dual formulations of TGD as Minkowskian and Euclidian string model type theories, the precise identification of preferred extremals of Kähler action as extremals for which second variation vanishes (at least for deformations representing dynamical symmetries) and thus providing space-time correlate for quantum criticality, the notion of number theoretic braid implied by the basic dynamics of Kähler action and crucial for precise construction of quantum TGD

as almost-topological QFT, the construction of configuration space metric and spinor structure in terms of second quantized induced spinor fields with modified Dirac action defined by Kähler action realizing automatically the notion of finite measurement resolution and a connection with inclusions of hyper-finite factors of type II_1 about which Clifford algebra of configuration space represents an example.

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

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

Infinite primes

The discovery of the hierarchy of infinite primes and their correspondence with a hierarchy defined by a repeatedly second quantized arithmetic quantum field theory gave a further boost for the speculations about TGD as a generalized number theory. The work with Riemann hypothesis led to further ideas.

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

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

1.3.3 Hierarchy of Planck constants and dark matter hierarchy

By quantum classical correspondence space-time sheets can be identified as quantum coherence regions. Hence the fact that they have all possible size scales more or less unavoidably implies that Planck constant must be quantized and have arbitrarily large values. If one accepts this then also the idea about dark matter as a macroscopic quantum phase characterized by an arbitrarily large value of

Planck constant emerges naturally as does also the interpretation for the long ranged classical electro-weak and color fields predicted by TGD. Rather seldom the evolution of ideas follows simple linear logic, and this was the case also now. In any case, this vision represents the fifth, relatively new thread in the evolution of TGD and the ideas involved are still evolving.

Dark matter as large \hbar phase

D. Da Rocha and Laurent Nottale [E7] 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 [K66].

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 [K66].

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

Hierarchy of Planck constants from the anomalies of neuroscience biology

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

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

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

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

This starting point led gradually to the recent picture in which the hierarchy of Planck constants is postulated to come as integer multiples of the standard value of Planck constant. Given integer multiple $\hbar = n\hbar_0$ of the ordinary Planck constant \hbar_0 is assigned with a multiple singular covering of the imbedding space [K20]. One ends up to an identification of dark matter as phases with non-standard value of Planck constant having geometric interpretation in terms of these coverings providing generalized imbedding space with a book like structure with pages labelled by Planck constants or integers characterizing Planck constant. The phase transitions changing the value of Planck constant would correspond to leakage between different sectors of the extended imbedding space. The question is whether these coverings must be postulated separately or whether they are only a convenient auxiliary tool.

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

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

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

1.3.4 TGD as a generalization of physics to a theory consciousness

General coordinate invariance forces the identification of quantum jump as quantum jump between entire deterministic quantum histories rather than time=constant snapshots of single history. The new view about quantum jump forces a generalization of quantum measurement theory such that observer becomes part of the physical system. Thus a general theory of consciousness is unavoidable outcome. This theory is developed in detail in the books [K75, K9, K53, K7, K29, K35, K39, K68] .

Quantum jump as a moment of consciousness

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

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

where U is informational "time development" operator, which is unitary like the S-matrix characterizing the unitary time evolution of quantum mechanics. U is however only formally analogous to Schrödinger time evolution of infinite duration although there is *no* real time evolution involved. It is not however clear whether one should regard U-matrix and S-matrix as two different things or not: U -matrix is a completely universal object characterizing the dynamics of evolution by self-organization

whereas S-matrix is a highly context dependent concept in wave mechanics and in quantum field theories where it at least formally represents unitary time translation operator at the limit of an infinitely long interaction time. The S-matrix understood in the spirit of superstring models is however something very different and could correspond to U-matrix.

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

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

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

The notion of self

The concept of self is absolutely essential for the understanding of the macroscopic and macro-temporal aspects of consciousness. Self corresponds to a subsystem able to remain un-entangled under the sequential informational 'time evolutions' U . Exactly vanishing entanglement is practically impossible in ordinary quantum mechanics and it might be that 'vanishing entanglement' in the condition for self-property should be replaced with 'subcritical entanglement'. On the other hand, if space-time decomposes into p-adic and real regions, and if entanglement between regions representing physics in different number fields vanishes, space-time indeed decomposes into selves in a natural manner.

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

An attractive possibility suggested by zero energy ontology is that the notions of self and quantum jump reduce to each other and that a fractal hierarchy of quantum jumps within quantum jumps is enough. CD s would serve as imbedding space correlates of selves and quantum jumps would be followed by cascades of state function reductions beginning from given CD and proceeding downwards to the smaller scales (smaller CD s). State function reduction cascades could also take place in parallel

branches of the quantum state. One ends up with concrete ideas about how the arrow of geometric time is induced from that of subjective time defined by the experiences induced by the sequences of quantum jumps for sub-selves of self. One ends also ends up with concrete ideas about how the localization of the contents of sensory experience and cognition to the upper boundaries of CD could take place.

Relationship to quantum measurement theory

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

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

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

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

Selves self-organize

The fourth basic element is quantum theory of self-organization based on the identification of quantum jump as the basic step of self-organization [K63]. Quantum entanglement gives rise to the generation of long range order and the emergence of longer p-adic length scales corresponds to the emergence of larger and larger coherent dynamical units and generation of a slaving hierarchy. Energy (and quantum entanglement) feed implying entropy feed is a necessary prerequisite for quantum self-organization.

Zero modes represent fundamental order parameters and localization in zero modes implies that the sequence of quantum jumps can be regarded as hopping in the zero modes so that Haken's classical theory of self organization applies almost as such. Spin glass analogy is a further important element: self-organization of self leads to some characteristic pattern selected by dissipation as some valley of the "energy" landscape.

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

Classical non-determinism of Kähler action

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

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

p-Adic physics as physics of cognition and intentionality

The sixth basic element adds a physical theory of cognition to this vision. TGD space-time decomposes into regions obeying real and p-adic topologies labelled by primes $p = 2, 3, 5, \dots$. p-Adic regions obey the same field equations as the real regions but are characterized by p-adic non-determinism since the functions having vanishing p-adic derivative are pseudo constants which are piecewise constant functions. Pseudo constants depend on a finite number of positive binary digits of arguments just like numerical predictions of any theory always involve decimal cutoff. This means that p-adic space-time regions are obtained by gluing together regions for which integration constants are genuine constants. The natural interpretation of the p-adic regions is as cognitive representations of real physics. The freedom of imagination is due to the p-adic non-determinism. p-Adic regions perform mimicry and make possible for the Universe to form cognitive representations about itself. p-Adic physics space-time sheets serve also as correlates for intentional action.

A more 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 [K72]. 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 binary digits a p -valued logic but as such this kind of logic does not have any reasonable identification. p-Adic length scale hypothesis suggest that the $p = 2^k - n$ binary digits represent a Boolean logic B^k with k elementary statements (the points of the k -element set in the set theoretic realization) with n taboos which are constrained to be identically true.

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

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

1. Macroscopic quantum coherence can be understood since a particle with a given mass can in principle appear as arbitrarily large scaled up copies (Compton length scales as \hbar). The phase transition to this kind of phase implies that space-time sheets of particles overlap and this makes possible macroscopic quantum coherence.
2. The space-time sheets with large Planck constant can be in thermal equilibrium with ordinary ones without the loss of quantum coherence. For instance, the cyclotron energy scale associated with EEG turns out to be above thermal energy at room temperature for the level of dark matter hierarchy corresponding to magnetic flux quanta of the Earth's magnetic field with the size scale of Earth and a successful quantitative model for EEG results [K17].

Dark matter hierarchy leads to detailed quantitative view about quantum biology with several testable predictions [K17]. 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 [K17]. Also a generalization of the notion of genetic code emerges resolving the paradoxes related to the standard dogma [K37, K17]. 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 [K17].

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 [K16, K17]. The larger the value of Planck constant, the longer the subjectively experienced duration and the average geometric duration $T(k) \propto \hbar$ of the quantum jump.

Quantum jumps form also a hierarchy with respect to p-adic and dark hierarchies and the geometric durations of quantum jumps scale like \hbar . Dark matter hierarchy suggests also a slight modification of

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

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

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

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

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

Dark matter hierarchy brings additional finesse. For the higher levels of dark matter hierarchy τ is scaled up by \hbar/\hbar_0 . One could understand evolutionary leaps as the emergence of higher levels at the level of individual organism making possible intentionality and memory in the time scale defined τ .

Higher levels of dark matter hierarchy provide a neat quantitative view about self hierarchy and its evolution. Various levels of dark matter hierarchy would naturally correspond to higher levels in the hierarchy of consciousness and the typical duration of life cycle would give an idea about the level in question. The level would determine also the time span of long term memories as discussed in [K17]. 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 [K37, K17]. 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.

The seven online books about TGD [K82, K61, K62, K70, K47, K45, K69] and eight online books about TGD inspired theory of consciousness and quantum biology [K75, K9, K53, K7, K29, K35, K39, K68] are warmly recommended for the reader willing to get overall view about what is involved.

1.4 The contents of the book

1.4.1 Topological Geometroynamics: Basic Visions

In this article I will discuss three basic visions about quantum Topological Geometroynamics (TGD). It is somewhat matter of taste which idea one should call a vision and the selection of these three in a special role is what I feel natural just now.

1. The first vision is generalization of Einstein's geometrization program based on the idea that the Kähler geometry of the world of classical worlds (WCW) with physical states identified as classical spinor fields on this space would provide the ultimate formulation of physics.
2. Second vision is number theoretical and involves three threads. The first thread relies on the idea that it should be possible to fuse real number based physics and physics associated with various p-adic number fields to single coherent whole by a proper generalization of number concept. Second thread is based on the hypothesis that classical number fields could allow to understand the fundamental symmetries of physics and and imply quantum TGD from purely number theoretical premises with associativity defining the fundamental dynamical principle both classically and quantum mechanically. The third thread relies on the notion of infinite primes whose construction has amazing structural similarities with second quantization of supersymmetric quantum field theories. In particular, the hierarchy of infinite primes and integers allows to generalize the notion of numbers so that given real number has infinitely rich number theoretic anatomy based on the existence of infinite number of real units.
3. The third vision is based on TGD inspired theory of consciousness, which can be regarded as an extension of quantum measurement theory to a theory of consciousness raising observer from an outsider to a key actor of quantum physics.

The basic aspects of quantum classical correspondence are discussed. Strong form of General Coordinate Invariance implies strong form of holography and effective 2-dimensionality. Weak form of electric magnetic duality and simple general condition on preferred extremals of Kähler action imply that TGD indeed reduces to almost topological QFT defined by Chern-Simons terms located at space-like at ends of CDs and light-like 3-surfaces defined by the orbits of partonic 2-surfaces defining wormhole throats at which the signature of induced metric changes. A further reduction of action to sum of areas of minimal surfaces is conjectured on basis of effective 2-dimensionality. Feynman diagrams have direct interpretation in terms of space-time topology and ZEO leads to a dramatic simplification of the Feynman diagrammatics and suggest a close connection with twistorial diagrams. Induced gauge field concept makes impossible the superposition of classical fields in TGD Universe. This is a grave objection circumvented by simple observation: only the superposition of their effects is observed and many-sheeted space-time implies it.

1.4.2 Quantum Mind in TGD Universe

The basic difficulties and challenges of Quantum Mind program are analyzed. The conclusion is that the recent form of quantum theory is not enough to overcome the challenges posed by the philosophical problems of quantum physics and quantum mind theories, and the puzzles of quantum biology and quantum neuroscience. Certain anomalies of recent day biology giving hints about how quantum theory should be generalized serve as an introduction to the summary of the aspects of quantum TGD especially relevant to the notion of Quantum Mind. These include the notions of many-sheeted space-time and field (magnetic) body, zero energy ontology, the identification dark matter as a hierarchy of phases with large value of Planck constant, and p-adic physics proposed to define physical correlates for cognition and intentionality.

Especially relevant is the number theoretic generalization of Shannon entropy: this entropy is well defined for rational or even algebraic entanglement probabilities and its minimum as a function of the prime defining p-adic norm appearing in the definition of the entropy is negative. Therefore the notion of negentropic entanglement makes sense in the intersection of real and p-adic worlds and is negative: this motivates the proposal that living matter resides in this intersection.

TGD inspired theory of consciousness is introduced as a generalization of quantum measurement theory. The notions of quantum jump and self defining the generalization of the notion of observer

are introduced and it is argued that the notion of self reduces to that for quantum jump. Negentropy Maximization Principle reproduces standard quantum measurement theory for ordinary entanglement but respects negentropic entanglement so that the outcome of state function reduction is not random for negentropic entanglement. The new view about the relationship of experienced time and geometric time combined with zero energy ontology is claimed to solve the basic philosophical difficulties of quantum measurement theory and consciousness theory. The identification of the quantum correlates of sensory qualia and Boolean cognition, emotions, cognition and intentionality and self-referentiality of consciousness is discussed.

1.4.3 Quantum Mind, Magnetic Body, and Biological Body

The chapter is devoted to some applications of TGD inspired view about Quantum Mind to biology. Magnetic body carrying dark matter and forming an onionlike structure with layers characterized by large values of Planck constant is the key concept. Magnetic body is identified as intentional agent using biological body as sensory receptor and motor instrument. EEG is identified as a communication and control tool of the magnetic body and a fractal hierarchy of analogs of EEG is predicted. Living system is identified as a kind of Indra's net with biomolecules representing the nodes of the net and magnetic flux tubes connections between them. The reconnection of magnetic flux tubes and phase transitions changing Planck constant and therefore the lengths of the magnetic flux tubes are identified as basic mechanisms behind DNA replication and analogous processes and also behind the phase transitions associated with the gel phase in cell interior. The braiding of magnetic flux makes possible universal memory representation recording the motions of the basic units connected by flux tubes. Braiding also defines topological quantum computer programs updated continually by the flows of the basic units. The model of DNA as topological quantum computer is discussed as an application.

A vision about quantum metabolism in TGD Universe is proposed. The new element is the idea that the presence of ATP at magnetic flux tube is a necessary prerequisite for negentropic entanglement between its ends. ATP could be seen as a molecule of consciousness in this picture. Also a possible modification of second law to take into account negentropic entanglement is discussed. TGD approach to living matter was strongly motivated by the findings about strange behavior of cell membrane and of cellular water, and gel behavior of cytoplasm. These findings are briefly discussed in TGD framework by bringing in magnetic flux tubes as a new element. Water is in key role in living matter and TGD inspired view about water and its anomalies is discussed.

1.4.4 Quantum Mind and Neuro Science

The article discusses some applications of TGD inspired view about Quantum Mind to neuroscience. Magnetic body carrying dark matter and forming an onionlike structure with layers characterized by large values of Planck constant is the key concept.

A general model for qualia is introduced. The identification of the correlates of the fundamental qualia as quantum number increments for a subsystem is in a complete analogy with the identification of quantum numbers as characterizers of physical states. A general classification of qualia based on thermodynamical notions is discussed and a mechanism generating sensory qualia is proposed. Also the question whether some qualia could correspond also to those of magnetic body is raised.

The interaction of subsystem S representing self with environment E is assumed to generate a negentropic entanglement between S and environment E . As long as this negentropic entanglement lasts, qualia are experienced. After the state function reduction eliminating this entanglement, there can be only a memory of qualia. There is clearly a resemblance with Orch OR of Penrose and Hameroff. During negentropic entanglement there is polarization in scale of $S \otimes E$ and S and E carry opposite quantum numbers. After the state function reduction negentropic entanglement and polarization prevail only in the scale S and S has vanishing net quantum numbers. "Quantum number increments ΔQ in quantum jump" therefore correspond to the reduction of charges of subsystem in the state function reduction process. The system is analogous to a capacitor whose size scale is that of $S \otimes E$ during the sensation of qualia and that of S after it. In ZEO one can consider states of S at both upper and lower boundaries of CD and assign ΔQ with this time evolution so that quantum classical correspondence is realized.

The capacitor model for sensory receptor based on the idea that sensory qualia are generated in the analog of di-electric breakdown introducing a flow of large number of particles with quantum numbers

characterizing the quale. A model for the cell membrane as sensory receptor and as qualia chart with lipids serving as its pixels is developed. Although sensory organs are assumed to define the seats of the fundamental qualia, also neurons would define sensory homunculi not necessarily responsible for sensory mental images at our level of self hierarchy. Cell membrane is assumed to be a quantum critical system taken to mean that it is near to a vacuum extremal of so called Kähler action. This explains large parity breaking in living matter (chiral selection) very difficult to understand in standard model. The model explains the peak frequencies of visible light for photoreceptors and predicts that biophotons and bunches of EEG photons result as decay products of same dark photons with energies mostly in visible range.

The model of nerve pulse relies on the hypothesis that axonal membrane defines a Josephson junction. The ground state of the axon corresponds to a propagating soliton sequence for the phase difference over the membrane mathematically analogous to a sequence of coupled gravitational penduli with a constant phase difference between neighboring penduli. Nerve pulse is generated as one kicks one of the oscillating penduli. The model of nerve pulse explains the generation of EEG. The resonance frequencies of EEG can be understood as sums and differences of the harmonics of cyclotron frequencies of biologically important dark ions and of Josephson frequency.

A model of bio-photons is discussed. The motivation comes from the observations that bio-photons could be interpreted as decay products of large \hbar EEG photons resulting in the energy conserving transformation to ordinary photons at visible and UV energies.

1.4.5 TGD inspired view about remote mental interactions and paranormal

I have proposed a general vision about what remote mental interactions and related phenomena could be in TGD Universe around 2003. A lot of progress that has taken place since then, and this motivates the reconsideration of this vision. The general vision is that both biology, consciousness, and remote mental interactions and related phenomena labelled as paranormal are predicted to share the same basic mechanisms, and that the proposed vision provides basic concepts and the language allowing to speculate and build simple models. One cannot of course take the proposed models too seriously at the level of details.

The new ideas that have emerged since 2003 are summarized and parapsychological phenomena are discussed at general level. Also some applications of the basic vision are discussed. The notion of conscious hologram is discussed from the point of view of remote mental interactions. The notion of magnetic body is in decisive role as it is also in the understanding of quantum biology in TGD framework. TGD inspired model for OBEs relying on the notion of magnetic body is summarized. The idea is that OBEs could correspond to sensory experiences assignable to magnetic body rather than real body. Also the connections with the work of other researchers, such as Shnoll, Persinger, and Tiller are discussed briefly. The challenge of testing the vision is also considered.

Mathematics

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Chapter 2

Topological Geometrodynamics: Basic Visions

2.1 Introduction

Originally Topological Geometrodynamics (TGD) was proposed as a solution of the problems related to the definition of conserved four-momentum in General Relativity. It was assumed that physical space-times are representable as 4-D surfaces in certain higher-dimensional space-time having symmetries of the empty Minkowski space of Special Relativity. This is guaranteed by the decomposition $H = M^4 \times S$, where S is some compact internal space. It turned out that the choice $S = CP_2$ is unique in the sense that it predicts the symmetries of the standard model and provides a realization for Einstein's dream of geometrizing of fundamental interactions at classical level. TGD can be also regarded as a generalization of super string models obtained by replacing strings with light-like 3-surfaces or equivalently with space-like 3-surfaces: the equivalence of these identification implies quantum holography.

The construction of quantum TGD turned out to be much more than mere technical problem of deriving S-matrix from path integral formalism. A new ontology of physics (many-sheeted space-time, zero energy ontology, generalization of the notion of number, and generalization of quantum theory based on spectrum of Planck constants giving hopes to understand what dark matter and dark energy are) and also a generalization of quantum measurement theory leading to a theory of consciousness and model for quantum biology providing new insights to the mysterious ability of living matter to circumvent the constraints posed by the second law of thermodynamics were needed. The construction of quantum TGD involves a handful of different approaches consistent with a similar overall view, and one can say that the construction of M-matrix, which generalizes the S-matrix of quantum field theories, is understood to a satisfactory degree although it is not possible to write even in principle explicit Feynman rules except at quantum field theory limit [K51, K22].

In this article I will discuss three basic visions about quantum Topological Geometrodynamics (TGD). It is somewhat matter of taste which idea one should call a vision and the selection of these three in a special role is what I feel natural just now.

1. The first vision is generalization of Einstein's geometrization program based on the idea that the Kähler geometry of the world of classical worlds (WCW) with physical states identified as classical spinor fields on this space would provide the ultimate formulation of physics [K61].
2. Second vision is number theoretical [K70] and involves three threads.
 - (a) The first thread [K72] relies on the idea that it should be possible to fuse real number based physics and physics associated with various p-adic number fields to single coherent whole by a proper generalization of number concept.
 - (b) Second thread [K73] is based on the hypothesis that classical number fields could allow to understand the fundamental symmetries of physics and and imply quantum TGD from purely number theoretical premises with associativity defining the fundamental dynamical principle both classically and quantum mechanically.

- (c) The third thread [K71] relies on the notion of infinite primes whose construction has amazing structural similarities with second quantization of super-symmetric quantum field theories. In particular, the hierarchy of infinite primes and integers allows to generalize the notion of numbers so that given real number has infinitely rich number theoretic anatomy based on the existence of infinite number of real units. This implies number theoretical Brahman=Atman identity or number theoretical holography when one consider hyper-octonionic infinite primes.
- (d) The third vision is based on TGD inspired theory of consciousness [K75], which can be regarded as an extension of quantum measurement theory to a theory of consciousness raising observer from an outsider to a key actor of quantum physics. The basic notions at quantum jump identified as as a moment of consciousness and self. Negentropy Maximization Principle (NMP) defines the fundamental variational principle and reproduces standard quantum measurement theory and predicts second law but also some totally new physics in the intersection of real and p-adic worlds where it is possible to define a hierarchy of number theoretical variants of Shannon entropy which can be also negative. In this case NMP favors the generation of entanglement and state function reduction does not mean generation of randomness anymore. This vision has obvious almost applications to biological self-organization.

My aim is to provide a bird's eye of view and my hope is that reader would take the attitude that details which cannot be explained in this kind of representation are not essential for the purpose of getting a feeling about the great dream behind TGD. I have also commented various ideas from the point of view of Quantum Mind program.

2.2 Quantum physics as infinite-dimensional geometry

The first vision in its original form is a the generalization of Einstein's program for the geometrization of physics by replacing space-time with the WCW identified roughly as the space of 4-surfaces in $H = M^4 \times CP_2$. Later generalization due to replacement of H with book like structures from by real and p-adic variants of H emerged. A further book like structure of imbedding space emerged via the introduction of the hierarchy of Planck constants. These generalizations do not however add anything new to the basic geometric vision.

2.2.1 World of the classical worlds as the arena of quantum physics

Physics as the classical spinor field geometry of WCW consisting of light-like 3-surfaces in 8-D imbedding space $H = M^4 \times CP_2$ (to be referred as configuration space CH or WCW in the sequel) is the oldest and best developed approach to TGD and means generalization of Einstein's program of geometrizing classical physics so that it applies to entire quantum physics [K61]. There are two natural identifications for the 3-surfaces.

1. By general coordinate invariance light-like 3-surfaces can be identified as wormhole throats at which the signature of the induced metric changes from a Minkowskian signature of space-time sheet to that of deformed CP_2 type vacuum extremal representing elementary particle. One can interpret so called CP_2 type vacuum extremals as lines of generalized Feynman diagrams so that geometrization and generalization of the notion of Feynman diagram emerges.
2. In zero energy ontology causal diamonds (CDs) of M^4 defined as intersection of future and past directed light-cones become define basic building bricks of WCW. The space-time surfaces belonging to CD having their 3-D future and past ends at the light-like boundaries of CD become the basic objects. The ends are 3-surfaces are space-like and come in pairs. WCW decomposes into a union over sub-WCWs associated with various CDs and their unions and the space-like ends of the space-time sheets at future and past boundaries of CD become very natural fundamental objects.

The condition that the two identifications of 3-surfaces are equivalent implies that all information about the geometry of WCW and quantum physics is coded by the 2-dimensional intersections of the

space-like and light-like 3-surfaces at the boundaries of CDs plus the information about the distribution of 4-D tangent spaces of the space-time sheet at these surfaces. I have christened partonic 2-surfaces since they are carriers of various quantum numbers. Therefore 4-D General Coordinate invariance implies effective 2-dimensionality and quantum holography. The effective two-dimensionality implies also by general consistency conditions related to conformal symmetries: this became obvious much before the emergence of zero energy ontology and led to interpretational difficulties at that time. The non-determinism of Kähler action defining space-time dynamics in the standard sense of the world implies that effective 2-dimensionality holds only locally.

WCW is endowed with Kähler metric guaranteeing the geometrization of hermitian conjugation of quantum theory.

1. The conjecture inspired by the geometry of loop spaces [A11] is that H is fixed from the mere requirement that the infinite-dimensional Kähler geometry exists. WCW must reduce to a union of symmetric spaces having infinite-dimensional isometry groups and labeled by zero modes having interpretation as classical dynamical variables. This requires infinite-dimensional symmetry groups. At space-time level super-conformal symmetries are possible only if the basic dynamical objects can be identified as light-like or space-like 3-surfaces. At imbedding space level there are extended super-conformal symmetries assignable to the light-cone of H if the Minkowski space factor is four-dimensional.

The recent progress in the understanding of the representations of super-conformal symmetries leads to a beautiful generalization of Equivalence Principle in terms of Super Virasoro conditions for the coset construction involving the super-symplectic algebras associated with conformal symmetries of the light-cone of Minkowski space and super Kac-Moody symmetries associated with light-like 3-surfaces [K15]. Einstein's equations result at long length scale limit [K78]. A string model type description emerges in a finite measurement resolution when light-like 3-surfaces are replaced by braids. This means also quantum holography. General Coordinate Invariance implies that classical space-time physics becomes an exact part of quantum theory in the sense that space-time sheets are analogous to Bohr orbits.

2. The condition that the symmetries of standard model are realized geometrically and that one can understand the known quantum numbers characterizing elementary particles in terms of the geometry of the imbedding space, leads to a unique choice for the imbedding space as $H = M^4 \times CP_2$. The challenge is to understand what makes this choice so special and number theoretic approach based on classical number fields allows to interpret this choice number theoretically so that the standard model symmetries find a number theoretical interpretation.

2.2.2 Geometrization of fermionic statistics in terms of configuration space spinor structure

The great vision has been that the second quantization of the induced spinor fields can be understood geometrically in terms of the configuration space spinor structure in the sense that the anti-commutation relations for configuration space gamma matrices require anti-commutation relations for the oscillator operators for free second quantized induced spinor fields defined at space-time surface.

1. One must identify the counterparts of second quantized fermion fields as objects closely related to the configuration space spinor structure. Ramond model [B12] has as its basic field the anti-commuting field $\Gamma^k(x)$, whose Fourier components are analogous to the gamma matrices of the configuration space and which behaves like a spin 3/2 fermionic field rather than a vector field. This suggests that they are analogous to spin 3/2 fields and therefore expressible in terms of the fermionic oscillator operators so that they naturally derive from the anti-commutativity of the fermionic oscillator operators.

Configuration space spinor fields can have arbitrary fermion number and there are good hopes of describing the whole physics in terms of configuration space spinor field. Clearly, fermionic oscillator operators would act in degrees of freedom analogous to the spin degrees of freedom of the ordinary spinor and bosonic oscillator operators would act in degrees of freedom analogous to the 'orbital' degrees of freedom of the ordinary spinor field. One non-trivial implication is bosonic emergence: elementary bosons correspond to fermion antifermion bound states associated with

the wormhole contacts (pieces of CP_2 type vacuum extremals) with throats carrying fermion and antifermion numbers. Fermions correspond to single throats associated with topologically condensed CP_2 type vacuum extremals.

2. The classical theory for the bosonic fields is an essential part of the configuration space geometry. It would be very nice if the classical theory for the spinor fields would be contained in the definition of the configuration space spinor structure somehow. The properties of the associated with the induced spinor structure are indeed very physical. The modified massless Dirac equation for the induced spinors predicts a separate conservation of baryon and lepton numbers. The differences between quarks and leptons result from the different couplings to the CP_2 Kähler potential. In fact, these properties are shared by the solutions of massless Dirac equation of the imbedding space.
3. Since TGD should have a close relationship to the ordinary quantum field theories it would be highly desirable that the second quantized free induced spinor field would somehow appear in the definition of the configuration space geometry. This is indeed true if the complexified configuration space gamma matrices are linearly related to the oscillator operators associated with the second quantized induced spinor field on the space-time surface and its boundaries. There is actually no deep reason forbidding the gamma matrices of the configuration space to be spin half odd-integer objects whereas in the finite-dimensional case this is not possible in general. In fact, in the finite-dimensional case the equivalence of the spinorial and vectorial vielbeins forces the spinor and vector representations of the vielbein group $SO(D)$ to have same dimension and this is possible for $D = 8$ -dimensional Euclidian space only. This coincidence might explain the success of 10-dimensional super string models for which the physical degrees of freedom effectively correspond to an 8-dimensional Euclidian space.
4. It took a long time to realize that the ordinary definition of the gamma matrix algebra in terms of the anti-commutators $\{\gamma_A, \gamma_B\} = 2g_{AB}$ must in TGD context be replaced with

$$\{\gamma_A^\dagger, \gamma_B\} = iJ_{AB} \ ,$$

where J_{AB} denotes the matrix elements of the Kähler form of the configuration space. The presence of the Hermitian conjugation is necessary because configuration space gamma matrices carry fermion number. This definition is numerically equivalent with the standard one in the complex coordinates. The realization of this delicacy is necessary in order to understand how the square of the configuration space Dirac operator comes out correctly.

2.2.3 Construction of the configuration space Clifford algebra in terms of second quantized induced spinor fields

The construction of WCW spinor structure must have a direct relationship to quantum physics as it is usually understood. The second quantization of the space-time spinor fields is needed to define the anticommutative gamma matrices of WCW: this means a geometrization of Fermi statistics [K13] in the sense that free fermionic quantum fields at space-time surface correspond to purely classical Clifford algebra of WCW. This is in accordance with the idea that physics at WCW level is purely classical apart from the notion of quantum jump.

The identification of the correct variational principle for the dynamics of space-time spinor fields identified as induced spinor fields has involved many trials. Ironically, the final outcome was almost the most obvious guess. The so called modified Dirac action (the obvious guess) with measurement interaction term (required by quantum classical correspondence) added defines the fundamental dynamics providing space-time representation of quantum physics via classical space-time physics [K21]. One can identify the vacuum functional -exponent of Kähler function of WCW- as a Dirac determinant. The conjecture is that Kähler function equals to Kähler action for a preferred extrema, which by internal consistency conditions must be critical in the sense that it allows infinite number of vanishing second variations. This realizes the notion of quantum criticality-one of guiding principles of quantum TGD-at space-time level.

Number theoretical approach in turn leads to the conclusion that space-time surfaces are either associative or co-associative in the sense that the modified gamma matrices at each point of space-time surface in their octonionic representation reduces to a quaternionic or co-quaternionic algebra and therefore have matrix representation. The conjecture is that these identifications of space-time dynamics are consistent or even equivalent.

The recent understanding of the modified Dirac action has emerged through a painful process and has strong physical implications.

1. Stringy propagators and emerge naturally thanks to the measurement interaction term in the modified Dirac action coupling to four-momentum and color hyper-charge and isospin.
2. The space-time super-symmetry generalizes to what might be called $\mathcal{N} = \infty$ supersymmetry which however effectively reduces to $\mathcal{N} = 1$ broken super-symmetry [K22]. The generators of the super-symmetry correspond to the modes of the induced spinor field at space-time sheet. Bosonic emergence means dramatic simplifications in the formulation of QFT limit of TGD. This formulation should generalize also to the level of the fundamental theory.
3. It is also possible to generalize the twistor program to TGD framework if one accepts the use of octonionic representation of the gamma matrices of imbedding space and hyper-quaternionicity of space-time surfaces [K84].

2.2.4 Zero energy ontology and WCW geometry

In the zero energy ontology quantum states have vanishing net values of conserved quantum numbers and decompose to superposition of pairs of positive and negative energy states defining counterparts of initial and final states of a physical event in standard ontology.

Zero energy ontology

Zero energy ontology was forced by the interpretational problems created by the vacuum extremal property of Robertson-Walker cosmologies imbedded as 4-surfaces in $M^4 \times CP_2$ meaning that the density of inertial mass (but not gravitational mass) for these cosmologies was vanishing meaning a conflict with Equivalence Principle. In zero energy ontology physical states are replaced by pairs of positive and negative energy states assigned to the past *resp.* future boundaries of causal diamonds defined as pairs of future and past directed light-cones ($\delta M_{\pm}^4 \times CP_2$). The net values of all conserved quantum numbers of zero energy states vanish. Zero energy states are interpreted as pairs of initial and final states of a physical event such as particle scattering so that only events appear in the new ontology. It is possible to speak about the energy of the system if one identifies it as the average positive energy for the positive energy part of the system. Same applies to other quantum numbers.

The matrix ("M-matrix") representing time-like entanglement coefficients between positive and negative energy states unifies the notions of S-matrix and density matrix since it can be regarded as a complex square root of density matrix expressible as a product of real squared of density matrix and unitary S-matrix. The system can be also in thermal equilibrium so that thermodynamics becomes a genuine part of quantum theory and thermodynamical ensembles cease to be practical fictions of the theorist. In this case M-matrix represents a superposition of zero energy states for which positive energy state has thermal density matrix.

Zero energy ontology combined with the notion of quantum jump resolves several problems. For instance, the troublesome questions about the initial state of universe and about the values of conserved quantum numbers of the Universe can be avoided since everything is in principle creatable from vacuum. Communication with the geometric past using negative energy signals and time-like entanglement are crucial for the TGD inspired quantum model of memory and both make sense in zero energy ontology. Zero energy ontology leads to a precise mathematical characterization of the finite resolution of both quantum measurement and sensory and cognitive representations in terms of inclusions of von Neumann algebras known as hyperfinite factors of type II_1 . The space-time correlate for the finite resolution is discretization which appears also in the formulation of quantum TGD.

Causal diamonds

The imbedding space correlates for zero energy ontology are causal diamonds (CD s) CD serves as the correlate zero energy state at imbedding space-level whereas space-time sheets having their ends at the light-like boundaries of CD are the correlates of the system at the level of 4-D space-time. Zero energy state can be regarded as a quantum superposition of space-time sheets with fermionic and other quantum numbers assignable to the partonic 2-surfaces at the ends of the space-time sheets.

1. The basic construct in the zero energy ontology is the space $CD \times CP_2$, where the causal diamond CD is defined as an intersection of future and past directed light-cones with time-like separation between their tips regarded as points of the underlying universal Minkowski space M^4 . In zero energy ontology physical states correspond to pairs of positive and negative energy states located at the boundaries of the future and past directed light-cones of a particular CD .
2. CD s form a fractal hierarchy and one can glue smaller CD s within larger CD s. Also unions of CD s are possible.
3. Without any restrictions CD s would be parametrized by the position of say lower tip of CD and by the relative M^4 coordinates of the upper tip with respect to the lower one so that the moduli space would be $M^4 \times M^4_+$. p-Adic length scale hypothesis follows if the values of temporal distance T between tips of CD come in powers of 2^n : $T = 2^n T_0$. This would reduce the future light-cone M^4_+ reduces to a union of hyperboloids with quantized value of light-cone proper time. A possible interpretation of this distance is as a quantized cosmic time. Also the quantization of the hyperboloids to a lattices of discrete points classified by discrete sub-groups of Lorentz group is an attractive proposal and the quantization of cosmic redshifts provides some support for it.

Zero energy ontology forces to replaced the original WCW by a union of WCWs associated with CD s and their unions. This does not however mean any problems of principle since Clifford algebras are simply tensor products of the Clifford algebras of CD s for the unions of CD s.

Generalization of S-matrix in ZEO

ZEO forces the generalization of S-matrix with a triplet formed by U-matrix, M-matrix, and S-matrix. The basic vision is that quantum theory is at mathematical level a complex square roots of thermodynamics. What happens in quantum jump was already discussed.

1. U-matrix as has its rows M-matrices, which are matrices between positive and negative energy parts of the zero energy state and correspond to the ordinary S-matrix. M-matrix is a product of a hermitian square root - call it H - of density matrix ρ and universal S-matrix S commuting with H : $[S, H] = 0$. There is infinite number of different Hermitian square roots H_i of density matrices which are assumed to define orthogonal matrices with respect to the inner product defined by the trace: $Tr(H_i H_j) = 0$. Also the columns of U-matrix are orthogonal. One can interpret square roots of the density matrices as a Lie algebra acting as symmetries of the S-matrix.
2. One can consider generalization of M-matrices so that they would be analogous to the elements of Kac-Moody algebra. These M-matrices would involve all powers of S .
 - (a) The orthogonality with respect to the inner product defined by $\langle A|B \rangle = Tr(AB)$ requires the conditions $Tr(H_1 H_2 S^n) = 0$ for $n \neq 0$ and H_i are Hermitian matrices appearing as square root of density matrix. $H_1 H_2$ is hermitian if the commutator $[H_1, H_2]$ vanishes. It would be natural to assign n :th power of S to the CD for which the scale is n times the CP_2 scale.
 - (b) Trace - possibly quantum trace for hyper-finite factors of type II_1 is the analog of integration and the formula would be a non-commutative analog of the identity $\int_{S^1} exp(in\phi) d\phi = 0$ and pose an additional condition to the algebra of M-matrices.

- (c) It might be that one must restrict M matrices to a Cartan algebra for a given U-matrix and also this choice would be a process analogous to state function reduction. Since density matrix becomes an observable in TGD Universe, this choice could be seen as a direct counterpart for the choice of a maximal number of commuting observables which would be now hermitian square roots of density matrices. Therefore ZEO gives good hopes of reducing basic quantum measurement theory to infinite-dimensional Lie-algebra.

1. *The first guess is wrong*

The definition of U-matrix elements as a matrix inducing a change of basis requires two natural state basis. The first guess is that the following two state basis are natural and unitarily related.

1. The pairs of positive and negative energy states with same quantum numbers.
2. The states obtained by entangling positive and negative energy states with various M-matrices.

If these state basics are in one-one correspondence then the orthogonality of the rows of U-matrix means that different M-matrices are orthogonal. The orthogonality of columns of U-matrix means that for the pair $|m_1\rangle_+|n_1\rangle_-$ and $|m_2\rangle_+|n_2\rangle_-$ of zero energy states gives

$$\sum_K M_{m_1 n_1}^K \overline{M}_{m_2 n_2}^K = \delta_{m_1, m_2} \delta_{n_1, n_2} .$$

The first guess is however not physically acceptable. The assumption that all pairs $|m_1\rangle_+|n_1\rangle_-$ are allowed as a complete set of states would mean complete non-determinism since correlations between the counterparts of initial and finals states would be absent apart from those induced by zero energy property.

2. *Second guess for the two state basis*

A better guess is that the collections of M-matrices defined as time reversals of each other define the sought for two natural state basis.

1. As for ordinary S-matrix, one can construct the states in such a manner that either positive or negative energy part of the state has well defined particle numbers, spin, etc... resulting in state function preparation. Therefore one has two kinds of M-matrices: M_K^\pm and for both of these the above orthogonality relations hold true. This implies also two kinds of U-matrices call them U^\pm . The natural assumption is that the two M-matrices differ only by Hermitian conjugation so that one would have $M_K^- = (M_K^+)^\dagger$.

One can assign opposite arrows of geometric time to these states and the proposal is that the arrow of time is a result of a process analogous to spontaneous magnetization. The possibility that the arrow of geometric time could change in quantum jump has been already discussed.

2. Unitary U-matrix U^\pm is induced from a projector to the zero energy state basis $|K^\pm\rangle$ acting on the state basis $|K^\mp\rangle$ and the matrix elements of U-matrix are obtained by acting with the representation of identity matrix in the space of zero energy states as $I = \sum_K |K^+\rangle\langle K^+|$ on the zero energy state $|K^-\rangle$ (the action on K^+ is trivial!) and gives

$$U_{KL}^+ = Tr(M_K^+ M_L^+) .$$

Note that finite measurement resolution requires that the trace operation is q-trace rather than ordinary trace.

3. As the detailed discussion of the anatomy of quantum jump demonstrated, the first step in state function reduction is the choice of M_K^\pm meaning the choice of the hermitian square root of a density matrix. A quantal selection of the measured observable takes place. This step is followed by a choice of "initial" state analogous to state function preparation and a choice of the "final state" analogous to state function reduction. The net outcome is the transition $|K^\pm\rangle \rightarrow |L^\pm\rangle$. It could also happen that instead of state function reduction as third step unitary process U^\mp (note the change of the sign factor!) takes place and induces the change of the arrow of geometric time.

4. As noticed, one can imagine even higher level choices and this would correspond to the choice of the commuting set of hermitian matrices H defining the allowed square roots of density matrices as a set of mutually commuting observables. This would fix the choices of U .

2.2.5 Hierarchy of Planck constants and WCW geometry

The motivations for introducing the hierarchy of Planck constants interpreted in terms of phases of dark matter came from astrophysics [E7] [K66, K49] and biology [K56] and led to a generalization of the imbedding space to a book like structure [K20]. This implies additional richness of structure at the level of geometry of WCW. In the following the recent view about structure of imbedding space forced by the quantization of Planck constant is summarized.

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 [K20, K52, K66].

1. The starting point was the proposal of Nottale [E7] 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 [K66] 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 [K67]. 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_l^3 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 [K77].
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 [K52]. 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 [E7] 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 Schwarzschild 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 [L9, K77].

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 . $\hat{M}^4 = M^4 \setminus M^2$ and $\hat{CP}_2 = CP_2 \setminus S^2$ 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 CD s 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 tetrahedral, 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 tetrahedron, 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 CD s 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 one could 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.

$$r = \frac{C - C}{n_a n_b} \quad \frac{F - C}{n_b} \quad \frac{C - F}{n_a} \quad \frac{F - F}{n_a n_b}$$

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 the powers of 2^{11} seem to be especially favored as values of n_a in living matter [K17].

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 [K20]. 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.

Implications for the construction WCW geometry

1. In the realization of the hierarchy of Planck constants $CD \times CP_2$ is replaced with a Cartesian product of book like structures formed by almost copies of CD s and CP_2 s defined by singular coverings and factors spaces of CD and CP_2 with singularities corresponding to intersection $M^2 \cap CD$ and homologically trivial geodesic sphere S^2 of CP_2 for which the induced Kähler form vanishes. The coverings and factor spaces of CD s are glued together along common $M^2 \cap CD$. The coverings and factors spaces of CP_2 are glued together along common homologically non-trivial geodesic sphere S^2 . The choice of preferred M^2 as subspace of tangent space of X^4 at all its points and interpreted as space of non-physical polarizations, brings M^2 into the theory also in different manner. S^2 in turn defines a subspace of the much larger space of vacuum extremals as surfaces inside $M^4 \times S^2$.
2. Configuration space (the world of classical worlds, WCW) decomposes into a union of sub-WCWs corresponding to different choices of M^2 and S^2 and also to different choices of the quantization axes of spin and energy, color isospin and hyper-charge for each choice of this kind. This means breaking down of the isometries to a subgroup. This can be compensated by the fact that the union can be taken over the different choices of this subgroup.
3. This means extension of the moduli space of CD s from $M^4 \times X$, where $X \subset M^4_+$ is suggested to be identifiable as a discrete lattice for the relative positions of the tips of CD . What is added is the space characterizing the choice of the quantization axes for energy and spin on one hand and color hypercharge and isospin on the other hand. This choice is part of a statefunction

reduction process and means localization in this space. In the case of color charges the moduli space is the flag-manifold $SU(3)/U(1) \times U(1)$.

2.2.6 Hyper-finite factors and the notion of measurement resolution

The work with TGD inspired model [K83, K19] for topological quantum computation [B9] led to the realization that von Neumann algebras [A9], in particular so called hyper-finite factors of type II_1 [A17], seem to provide the mathematics needed to develop a more explicit view about the construction of S-matrix. Later came the realization that the Clifford algebra of WCW defines a canonical representation of hyper-finite factors of type II_1 and that WCW spinor fields give rise to HFFs of type III_1 encountered also in relativistically invariant quantum field theories [K85].

Philosophical ideas behind von Neumann algebras

The goal of von Neumann was to generalize the algebra of quantum mechanical observables. The basic ideas behind the von Neumann algebra are dictated by physics. The algebra elements allow Hermitian conjugation $*$ and observables correspond to Hermitian operators. Any measurable function $f(A)$ of operator A belongs to the algebra and one can say that non-commutative measure theory is in question.

The predictions of quantum theory are expressible in terms of traces of observables. Density matrix defining expectations of observables in ensemble is the basic example. The highly non-trivial requirement of von Neumann was that identical a priori probabilities for a detection of states of infinite state system must make sense. Since quantum mechanical expectation values are expressible in terms of operator traces, this requires that unit operator has unit trace: $tr(Id) = 1$.

In the finite-dimensional case it is easy to build observables out of minimal projections to 1-dimensional eigen spaces of observables. For infinite-dimensional case the probability of projection to 1-dimensional sub-space vanishes if each state is equally probable. The notion of observable must thus be modified by excluding 1-dimensional minimal projections, and allow only projections for which the trace would be infinite using the straightforward generalization of the matrix algebra trace as the dimension of the projection.

The non-trivial implication of the fact that traces of projections are never larger than one is that the eigen spaces of the density matrix must be infinite-dimensional for non-vanishing projection probabilities. Quantum measurements can lead with a finite probability only to mixed states with a density matrix which is projection operator to infinite-dimensional subspace. The simple von Neumann algebras for which unit operator has unit trace are known as factors of type II_1 [A17].

The definitions adopted by von Neumann allow however more general algebras. Type I_n algebras correspond to finite-dimensional matrix algebras with finite traces whereas I_∞ associated with a separable infinite-dimensional Hilbert space does not allow bounded traces. For algebras of type III non-trivial traces are always infinite and the notion of trace becomes useless being replaced by the notion of state which is generalization of the notion of thermodynamical state. The fascinating feature of this notion of state is that it defines a unique modular automorphism of the factor defined apart from unitary inner automorphism and the question is whether this notion or its generalization might be relevant for the construction of M-matrix in TGD.

Von Neumann, Dirac, and Feynman

The association of algebras of type I with the standard quantum mechanics allowed to unify matrix mechanism with wave mechanics. Note however that the assumption about continuous momentum state basis is in conflict with separability but the particle-in-box idealization allows to circumvent this problem (the notion of space-time sheet brings the box in physics as something completely real).

Because of the finiteness of traces von Neumann regarded the factors of type II_1 as fundamental and factors of type III as pathological. The highly pragmatic and successful approach of Dirac [K21] based on the notion of delta function, plus the emergence of generalized Feynman graphs [K27], the possibility to formulate the notion of delta function rigorously in terms of distributions [A25, A16], and the emergence of path integral approach [A22] meant that von Neumann approach was forgotten by particle physicists.

Algebras of type II_1 have emerged only much later in conformal and topological quantum field theories [A32, A23] allowing to deduce invariants of knots, links and 3-manifolds. Also algebraic

structures known as bi-algebras, Hopf algebras, and ribbon algebras [A19, A18] relate closely to type II_1 factors. In topological quantum computation [B9] based on braid groups [A7] modular S-matrices they play an especially important role.

In algebraic quantum field theory [A13] defined in Minkowski space the algebras of observables associated with bounded space-time regions correspond quite generally to the type III_1 hyper-finite factor [A24, A5].

Hyper-finite factors in quantum TGD

The following argument suggests that von Neumann algebras known as hyper-finite factors (HFFs) of type II_1 and III_1 - the latter appearing in relativistic quantum field theories provide also the proper mathematical framework for quantum TGD.

1. The Clifford algebra of the infinite-dimensional Hilbert space is a von Neumann algebra known as HFF of type II_1 . There also the Clifford algebra at a given point (light-like 3-surface) of WCW is therefore HFF of type II_1 . If the fermionic Fock algebra defined by the fermionic oscillator operators assignable to the induced spinor fields (this is actually not obvious!) is infinite-dimensional it defines a representation for HFF of type II_1 . Super-conformal symmetry suggests that the extension of the Clifford algebra defining the fermionic part of a super-conformal algebra by adding bosonic super-generators representing symmetries of WCW respects the HFF property. It could however occur that HFF of type II_∞ results.
2. WCW is a union of sub-WCWs associated with causal diamonds (CD) defined as intersections of future and past directed light-cones. One can allow also unions of CD s and the proposal is that CD s within CD s are possible. Whether CD s can intersect is not clear.
3. The assumption that the M^4 proper distance a between the tips of CD is quantized in powers of 2 reproduces p-adic length scale hypothesis but one must also consider the possibility that a can have all possible values. Since $SO(3)$ is the isotropy group of CD , the CD s associated with a given value of a and with fixed lower tip are parameterized by the Lobatchevski space $L(a) = SO(3, 1)/SO(3)$. Therefore the CD s with a free position of lower tip are parameterized by $M^4 \times L(a)$. A possible interpretation is in terms of quantum cosmology with a identified as cosmic time [K67]. Since Lorentz boosts define a non-compact group, the generalization of so called crossed product construction strongly suggests that the local Clifford algebra of WCW is HFF of type III_1 . If one allows all values of a , one ends up with $M^4 \times M^4_+$ as the space of moduli for WCW.

Hyper-finite factors and M-matrix

HFFs of type III_1 provide a general vision about M-matrix [K85].

1. The factors of type III allow unique modular automorphism Δ^{it} (fixed apart from unitary inner automorphism). This raises the question whether the modular automorphism could be used to define the M-matrix of quantum TGD. This is not the case as is obvious already from the fact that unitary time evolution is not a sensible concept in zero energy ontology.
2. Concerning the identification of M-matrix the notion of state as it is used in theory of factors is a more appropriate starting point than the notion modular automorphism but as a generalization of thermodynamical state is certainly not enough for the purposes of quantum TGD and quantum field theories (algebraic quantum field theorists might disagree!). Zero energy ontology requires that the notion of thermodynamical state should be replaced with its "complex square root" abstracting the idea about M-matrix as a product of positive square root of a diagonal density matrix and a unitary S-matrix. This generalization of thermodynamical state -if it exists- would provide a firm mathematical basis for the notion of M-matrix and for the fuzzy notion of path integral.
3. The existence of the modular automorphisms relies on Tomita-Takesaki theorem [A29], which assumes that the Hilbert space in which HFF acts allows cyclic and separable vector serving as ground state for both HFF and its commutant. The translation to the language of physicists

states that the vacuum is a tensor product of two vacua annihilated by annihilation oscillator type algebra elements of HFF and creation operator type algebra elements of its commutant isomorphic to it. Note however that these algebras commute so that the two algebras are not hermitian conjugates of each other. This kind of situation is exactly what emerges in zero energy ontology: the two vacua can be assigned with the positive and negative energy parts of the zero energy states entangled by M-matrix.

4. There exists infinite number of thermodynamical states related by modular automorphisms. This must be true also for their possibly existing "complex square roots". Physically they would correspond to different measurement interactions giving rise to Kähler functions of WCW differing only by a real part of holomorphic function of complex coordinates of WCW and arbitrary function of zero mode coordinates and giving rise to the same Kähler metric of WCW.

The concrete construction of M-matrix utilizing the idea of bosonic emergence (bosons as fermion anti-fermion pairs at opposite throats of wormhole contact) meaning that bosonic propagators reduce to fermionic loops identifiable as wormhole contacts leads to generalized Feynman rules for M-matrix in which modified Dirac action containing measurement interaction term defines stringy propagators [K15]. This M-matrix should be consistent with the above proposal.

Connes tensor product as a realization of finite measurement resolution

The inclusions $\mathcal{N} \subset \mathcal{M}$ of factors allow an attractive mathematical description of finite measurement resolution in terms of Connes tensor product [A8] but do not fix M-matrix as was the original optimistic belief.

1. In zero energy ontology \mathcal{N} would create states experimentally indistinguishable from the original one. Therefore \mathcal{N} takes the role of complex numbers in non-commutative quantum theory. The space \mathcal{M}/\mathcal{N} would correspond to the operators creating physical states modulo measurement resolution and has typically fractal dimension given as the index of the inclusion. The corresponding spinor spaces have an identification as quantum spaces with non-commutative \mathcal{N} -valued coordinates.
2. This leads to an elegant description of finite measurement resolution. Suppose that a universal M-matrix describing the situation for an ideal measurement resolution exists as the idea about square root of state encourages to think. Finite measurement resolution forces to replace the probabilities defined by the M-matrix with their \mathcal{N} "averaged" counterparts. The "averaging" would be in terms of the complex square root of \mathcal{N} -state and a direct analog of functionally or path integral over the degrees of freedom below measurement resolution defined by (say) length scale cutoff.
3. One can construct also directly M-matrices satisfying the measurement resolution constraint. The condition that \mathcal{N} acts like complex numbers on M-matrix elements as far as \mathcal{N} -"averaged" probabilities are considered is satisfied if M-matrix is a tensor product of M-matrix in $\mathcal{M}(\mathcal{N}$ interpreted as finite-dimensional space with a projection operator to \mathcal{N}). The condition that \mathcal{N} averaging in terms of a complex square root of \mathcal{N} state produces this kind of M-matrix poses a very strong constraint on M-matrix if it is assumed to be universal (apart from variants corresponding to different measurement interactions).

Number theoretical braids as space-time correlates for finite measurement resolution

Finite measurement resolution has discretization as a space-time counterpart. In the intersection of real and p-adic worlds defines as partonic 2-surfaces with a mathematical representation allowing interpretation in terms of real or p-adic number fields one can identify points common to real and p-adic worlds as rational points and common algebraic points (in preferred coordinates dictated by symmetries of imbedding space). Quite generally, one can identify rational points and algebraic points in some extension of rationals as points defining the initial points of what might be called number theoretical braid beginning from the partonic 2-surface at the past boundary of CD and connecting it with the future boundary of CD . The detailed definition of the braid inside light-like 3-surface is not relevant if only the information at partonic 2-surface is relevant for quantum physics.

Number theoretical braids are especially relevant for topological QFT aspect of quantum TGD. The topological QFT associated with braids accompanying light-like 3-surfaces having interpretation as lines of generalised Feynman diagrams should be important part of the definition of amplitudes assigned to generalised Feynman diagrams. The number theoretic braids relate also closely to a symplectic variant of conformal field theory emerges very naturally in TGD framework (symplectic symmetries acting on $\delta M_{\pm}^4 \times CP_2$ are in question) and this leads to a concrete proposal for how to construct n-point functions needed to calculate M-matrix [K15]. The mechanism guaranteeing the predicted absence of divergences in M-matrix elements can be understood in terms of vanishing of symplectic invariants as two arguments of n-point function coincide.

Quantum spinors and fuzzy quantum mechanics

The notion of quantum spinor leads to a quantum mechanical description of fuzzy probabilities [K85]. For quantum spinors state function reduction to spin eigenstates cannot be performed unless quantum deformation parameter $q = \exp(i2\pi/n)$ equals to $q = 1$. The reason is that the components of quantum spinor do not commute: it is however possible to measure the commuting operators representing moduli squared of the components giving the probabilities associated with 'true' and 'false'. Therefore the probability for either spin state becomes a quantized observable. The universal eigenvalue spectrum for probabilities does not in general contain (1,0) so that quantum qbits are inherently fuzzy. State function reduction would occur only after a transition to $q=1$ phase and decoherence is not a problem as long as it does not induce this transition.

2.2.7 Twistor revolution and TGD

During last decade so called twistor revolution has revived theoretical physics and has also had strong impact on TGD.

Twistor revolution

There are classical papers by several authors such as Witten and Nima Arkani-Hamed who is one of the leading theoreticians driving the twistor revolution [B7, B11, B10, B6] .

1. The notion of twistor is due to Penrose and is very convenient notion in theories describing massless particles and therefore possessing conformal invariance extending Poincare symmetries by the inclusion of scalings and so called special conformal transformation which is analogous to reflections in spherical mirror.
2. Twistor kinematics means that one can express massless four-momentum and helicity in terms of two massless spinors combining to a twistor living in 4-D complex space which reduces to CP_3 because of projective invariance of the description. The beauty of the twistor kinematics is that non-linear action of special conformal transformations linearizes in CP_3 . What one does is to replace light-like geodesic in Minkowski space with points in the twistor space CP_3 whereas the complex lines of CP_3 correspond to points of Minkowski space. To be honest, complexified Minkowski space is in question and this is one of the technical difficulties involved.
3. Gauge theories without fermions and scalar fields are such theories and the applications of twistorial methods to $\mathcal{N} = 4$ super-symmetric Yang-Mills theory has produced amazingly strong results demonstrating that Feynman diagrams sum up to stunningly single twistorial expressions. The key idea is that four-dimensional integrals over loop momenta are interpreted as residue integrals in the complexified space of four-momenta so that they reduce to residues from poles. The surprising discovery is that using Yangian invariants one can express the planar loop amplitudes for given number of external states with given helicities and momenta in terms of on mass shell amplitudes for smaller number of particles and with smaller number of loops by using recursion formulas.
4. Twistor revolution has led to a discovery of what is known as dual twistors. The massless momenta associated with incoming states of twistor diagram and expressible in terms of ordinary twistors, can be also expressed as differences of so called region momenta propagating in the edges of polygon characterizing twistor diagram. The massless momenta correspond to intersections of

complex lines in what is called momentum twistor space so that one diagram has interpretation also as a diagram in momentum twistor space. The theory possesses conformal invariance also in the momentum twistor space and the two conformal symmetries combine to form a large infinite-dimensional symmetry known as Yangian symmetry [A3] associated with the conformal group of Minkowski space.

5. The work of Nima Arkani-Hamed and others [B6] has revealed that the integrands for the twistor amplitudes for planar diagrams can be expressed as residue integrals over Grassmannians $G(n, k)$ where n is the number of massless external particles (gluons or gluinos) and k is the number of negative (say) helicities. The integrands appearing in these integrals are Yangian invariants and there are recipes for their construction. The generalization of BCFW formula gives a recursion formula allowing to deduce the l-loop construction to the scattering of n particles with k negative helicities. The vision of Arkani-Hamed is that this approach allows to get rid of space-time altogether.

The impact of twistor approach on TGD

Twistor revolution has had also a strong impact on TGD [K84, K87, K28].

1. The study of the modified Dirac equations for induced spinors [K21] motivated the proposal that the fermions associated with the braid strands accompanying wormhole throats are massless and on mass shell always - even for the internal lines of generalized Feynman diagrams. Since the sign of the energy of internal line can be also negative, wormhole contacts identified as building bricks of virtual bosons can carry space-like virtual momentum. The condition that all wormhole throats appearing in the loops of generalized Feynman diagrams are on mass shell and massless poses enormously strong constraints on loops and with additional restrictions coming from the geometric picture and Uncertainty Principle one can expect that only finite number of diagrams contributes to a given scattering amplitude so that the diagrammatics should be extremely simple, perhaps much simpler than in twistorial diagrammatics involving infinite number of diagrams labelled by the number of loops.
2. The masslessness of all fermionic braid strands appearing in the diagram makes twistorial approach extremely natural. The problem is only the treatment of massive external particles expressible as bound states of massless fermions and antifermions at wormhole throats. The idea is that the vertices of generalized Feynman diagrams can be interpreted as 3-gons of twistorial diagrams with region momenta describing momentum exchanges between the throats of wormhole contacts. This picture allows to consider the possibility that 3-vertices could be expressible using the same general formulas as used in Grassmannian approach to $\mathcal{N} = 4$ SYM. Kinematical constraints would imply that only a finite number of diagrams would contribute to a give reaction meaning also upper bound on the number of loops.
3. One might of course argue that the massless propagators on mass shell braid strands make the amplitudes infinite. This is not the case since the momentum appearing in the propagators is M^2 projection of the momentum for a preferred $M^2 \subset M^4$.

Generalized Feynman diagrammatics - or rather given CD - involve however a selection of preferred $M^2 \subset M^4$. M^2 is forced by number theoretical vision as complex and thus commutative subspace of octonions. Physically M^2 is forced by the construction of massless states as the sub-space containing non-physical polarizations. M^2 fixes the quantization axes of energy and spin. In generalized Feynman diagrams the propagators for on mass shell states contain only the M^2 projection of four-momentum so that the propagators are finite. The modification of gauge conditions to statement that M^2 projection of momentum is orthogonal to polarization vector allows massive states for gauge bosons. Lorentz invariance is not broken since one must integrate over all the choices of M^2 .

Could TGD circumvent the difficulties of twistor approach?

The twistor approach has also some problems and TGD allows also to consider solutions to the difficulties of twistorial approach.

1. Twistor approach to $\mathcal{N} = 4$ SYM applies only to planar Feynman diagrams containing no intersecting lines and this restriction interpreted as approximation becomes exact only at the limit when the gauge group becomes infinite-dimensional. One could argue that in TGD string like objects defined by the Kähler magnetic flux tubes are the basic objects and the stringy character makes planar approximation exact. One could also argue that infinite-dimensional symplectic group takes the role of gauge group in TGD. A more convincing argument is that non-planar diagrams are possible but that generalized Feynman diagrams can be regarded as generalizations of knot diagrams. The crossings of the lines are the problem and for knot diagrams there is a recipe for removing the crossings gradually completely and in this manner obtain an expression for knot invariant. Similar un-knotting procedure could make sense also in TGD framework.
2. $\mathcal{N} = 4$ SYM is believed to be ultraviolet finite but twistor approach does not remove the infrared divergences. In TGD framework external particles are bound states of massless particles and this brings in IR cutoff naturally. The upper bound for the size for CDs brings this cutoff in the case of photons, gluons, and gravitons. One implication is that Higgs like states are not needed in TGD framework.

The recent considerations [K28] suggest a more refined view about particle masses. It seem that it is M^2 mass squared which is given by stringy mass formula fixed by conformal invariance. If so, p-adic thermodynamics allows to calculate thermal M^2 mass squared and this mass squared would define the observed mass of the elementary fermion. Fermionic braid strands would be massless in M^4 sense. The situation is obviously tricky and the understanding of the role of M^2 in TGD framework is one of the basic challenges of the theory.

3. In twistor approach there are also problems with the understanding of renormalization group, which involves momentum scale: this is understandable since conformal invariance does not allow a preferred scale. One should be able to bring in massive particles without losing the conformal invariance. The fractal hierarchy of CDs within CDs with quantized size scales leads to a detailed proposal for how the vision about p-adic coupling constant evolution is realized for generalized Feynman diagrams [K28].
4. The beauty of Feynman graphs is their ability to code unitarity in an elegant manner by using analyticity. Unitarity conditions are obtained simply by considering the discontinuities of the amplitude at cuts associated with on mass shell configurations of momenta. These discontinuities are expressible by putting internal lines on mass shell so that integral over intermediate on mass shell states is obtained. Unitarity is however not manifest in twistor approach.

The situation is more complex in TGD framework. M-matrices are not unitary and S-matrix is analogous to the phase of a complex number where as the hermitian square root of the density matrix is analogous to its modulus. Therefore unitarity is not required at this level. Different M-matrices (allowing also integer powers of S) must form an infinite-dimensional Kac Moody type algebra and this gives strong constraints on the amplitudes. How to take into account these constraints should be understood.

5. Locality is not manifest in twistor approach. In other words, for Grassmannian amplitudes the poles do not correspond to single particle propagator poles associated with internal lines as they do in Feynman graphs. TGD is manifestly non-local theory since zero energy states involve partonic 2-surfaces at both light-like boundaries of CD. Also partonic 2-surfaces and braids are non-local objects. Yangian symmetry is manifestly non-local since the generators are multilocal objects and in TGD framework this multilocality generalized since the n points of multilocal generator of Yangian algebra are replaced by n partonic 2-surfaces. Also this aspect should be understood in detail.

Twistor approach combined with the requirement of number theoretic universality realized in terms of quantum arithmetics leads to a rather detailed view about generalized Feynman diagrams [K28].

1. One can understand how p-adic length scale hypothesis (stating that primes near powers of two are physically preferred) emerges. This has been one of the main challenges of quantum TGD since 1995 when I performed p-adic mass calculations for the first time.

2. A deep connection with adeles used in Langlands program emerges since the amplitudes can be understood as having values in the tensor product of quantum rationals corresponding to various values of p-adic prime and real amplitudes are obtained by using canonical identification mapping powers of p with their inverses.
3. One implication is that for large primes assignable to elementary particles the convergence in powers of p is extremely fast (one has $p = M_{127} = 2^{127} - 1$ for electron and $p = M_{89}$ for weak gauge bosons!).

2.3 Physics as a generalized number theory

Physics as a generalized number theory vision involves actually three threads: p-adic ideas [K72], the ideas related to classical number fields [K73], and the ideas related to the notion of infinite prime [K71].

2.3.1 Fusion of real and p-adic physics to a coherent whole

p-Adic number fields were not present in the original approach to TGD. The success of the p-adic mass calculations (summarized in the first part of [K45]) made however clear that one must generalize the notion of topology also at the infinitesimal level from that defined by real numbers so that the attribute "topological" in TGD gains much more profound meaning than intended originally. It took a decade to get convinced that the identification of p-adic physics as a correlate of cognition and intentionality is the most plausible interpretation discovered hitherto [K46], and that p-adic topology of p-adic space-time sheets somehow induces the effective p-adic topology of real space-time sheets. The discovery of the properties of number theoretic variants of Shannon entropy led to the idea that living matter could be seen as something in the intersection of real and p-adic worlds and gave additional support for this interpretation. If even elementary particles reside in this intersection and effective p-adic topology applies for real partonic 2-surfaces, the success of p-adic mass calculations can be understood.

The original view about physics as the geometry of WCW is not enough to meet the challenge of unifying real and p-adic physics to a single coherent whole. This inspired "physics as a generalized number theory" approach [K70].

1. The first element is a generalization of the notion of number obtained by "gluing" reals and various p-adic number fields and their algebraic extensions along common rationals and algebraics to form a larger structure.
2. At the level of imbedding space this gluing corresponds to a gluing of real and p-adic variants of the imbedding space together along rational and common algebraic points (the number of which depends on algebraic extension of p-adic numbers used) to what could be seen as a book like structure. General Coordinate Invariance restricted to rationals or their extension requires preferred coordinates for $CD \times CP_2$ and this kind coordinates can be fixed by isometries of H . The coordinates are however not completely unique since non-rational isometries produce new equally good choices. Whether this can be seen as an objection against the approach is not clear.
3. The analogous gluing of real and various p-adic physics to a larger structure forces to ask what are the common points of WCWs associated with real and various p-adic worlds. What it is to be a partonic 2-surface belonging to the intersection of real and p-adic variants of WCW? The natural answer is that partonic 2-surfaces which have a mathematical representation making sense both for real numbers and p-adic numbers or their algebraic extensions can be regarded as "common points" or identifiable points of p-adicity and reality. This of course applies also to partonic 2-surfaces corresponding to two different p-adic number fields. This mathematical property means a representability in terms of ratios of polynomials with rational (or possibly even algebraic) coefficients in the preferred imbedding space coordinates.
4. The intersections of WCWs and partonic 2-surfaces in different number fields are involved. An attractive idea is that only the information about common points of surfaces belonging to different number fields code for physics so that number-theoretically universal part of physics is

number theoretical physics relying only on rationals and their algebraic extensions. For instance, the transition amplitudes between p-adic and real variants of partonic 2-surface can involve only the data at these points. This suggests the existence of what might be called number theoretical QFT. At space-time level this extension of introduce a discretization at space-time level in terms of rational and algebraic points common to real space-time sheets and their p-adic variants. The number of these points is in general finite for a given CD and the proposed interpretation is in terms of cognitive representations. The discrete intersections would define the initial and final points of number theoretical braids central for the formulation of the theory in finite measurement resolution.

5. Much later came the realization that living matter or what makes living matter living could be interpreted as something in this intersection of real and p-adic worlds so that number theoretic QFT might apply to crucial aspects of living matter.

The interpretation for discretization could be in terms of cognitive, sensory, and measurement resolutions rather than fundamental discreteness of the space-time. What looks rather counter intuitive first is that transcendental points of p-adic space-time sheets are at spatiotemporal infinity in real sense so that the correlates of cognition and intentionality cannot be localized to any finite spatiotemporal volume unlike those of sensory experience. The description of intentionality and cognition in this manner predicts p-adic fractality of real physics meaning chaos in short scales combined with long range correlations: p-adic mass calculations represent one example of p-adic fractality.

The realization of this program at the level of WCW is far from trivial. Modified Dirac equation and classical field equations make sense but quantities expressible as space-time integrals - in particular Kähler action- do not make sense p-adically. Therefore one can ask whether only the partonic surfaces in the intersection of real and p-adic worlds should be allowed. Also this restricted theory would be highly non-trivial physically.

2.3.2 Classical number fields and associativity and commutativity as fundamental law of physics

The dimensions of classical number fields appear as dimensions of basic objects in quantum TGD. Imbedding space has dimension 8, space-time has dimension 4, light-like 3-surfaces are orbits of 2-D partonic surfaces. If conformal QFT applies to 2-surfaces (this is questionable), one-dimensional structures would be the basic objects. The lowest level would correspond to discrete sets of points identifiable as intersections of real and p-adic space-time sheets. This suggests that besides p-adic number fields also classical number fields (reals, complex numbers, quaternions, octonions [A4]) are involved [K73] and the notion of geometry generalizes considerably. In the recent view about quantum TGD the dimensional hierarchy defined by classical number field indeed plays a key role. $H = M^4 \times CP_2$ has a number theoretic interpretation and standard model symmetries can be understood number theoretically as symmetries of hyper-quaternionic planes of hyper-octonionic space.

The associativity condition $A(BC) = (AB)C$ suggests itself as a fundamental physical law of both classical and quantum physics. Commutativity can be considered as an additional condition. In conformal field theories associativity condition indeed fixes the n-point functions of the theory. At the level of classical TGD space-time surfaces could be identified as maximal associative (hyper-quaternionic) submanifolds of the imbedding space whose points contain a preferred hyper-complex plane M^2 in their tangent space and the hierarchy finite fields-rationals-reals-complex numbers-quaternions-octonions could have direct quantum physical counterpart [K73]. This leads to the notion of number theoretic compactification analogous to the dualities of M-theory: one can interpret space-time surfaces either as hyper-quaternionic 4-surfaces of M^8 or as 4-surfaces in $M^4 \times CP_2$. As a matter fact, commutativity in number theoretic sense is a further natural condition and leads to the notion of number theoretic braid naturally as also to direct connection with super string models.

At the level of modified Dirac action the identification of space-time surface as a hyper-quaternionic submanifold of H means that the modified gamma matrices of the space-time surface defined in terms of canonical momentum currents of Kähler action using octonionic representation for the gamma matrices of H span a hyper-quaternionic sub-space of hyper-octonions at each point of space-time surface (hyper-octonions are the subspace of complexified octonions for which imaginary units are octonionic imaginary units multiplied by commuting imaginary unit). Hyper-octonionic representation leads to a proposal for how to extend twistor program to TGD framework [K21, K84].

2.3.3 Infinite primes and quantum physics

The hierarchy of infinite primes (and of integers and rationals) [K71] was the first mathematical notion stimulated by TGD inspired theory of consciousness. The construction recipe is equivalent with a repeated second quantization of a super-symmetric arithmetic quantum field theory with bosons and fermions labeled by primes such that the many-particle states of previous level become the elementary particles of new level. At a given level there are free many particle states plus counterparts of many particle states. There is strong structural analogy with polynomial primes. For polynomials with rational coefficients free many-particle states would correspond to products of first order polynomials and bound states to irreducible polynomials with non-rational roots.

The hierarchy of space-time sheets with many particle states of space-time sheet becoming elementary particles at the next level of hierarchy. For instance, the description of proton as an elementary fermion would be in a well defined sense exact in TGD Universe. Also the hierarchy of n :th order logics are possible correlates for this hierarchy.

This construction leads also to a number theoretic generalization of space-time point since a given real number has infinitely rich number theoretical structure not visible at the level of the real norm of the number a due to the existence of real units expressible in terms of ratios of infinite integers. This number theoretical anatomy suggest a kind of number theoretical Brahman=Atman identity stating that the set consisting of number theoretic variants of single point of the imbedding space (equivalent in real sense) is able to represent the points of WCW or maybe even quantum states assignable to causal diamond. One could also speak about algebraic holography.

The correspondence between the quantum states defined by WCW spinor fields and wave functions in the infinite-dimensional discrete space of hyper-octonionic units can be made more concrete [K71]. These wave functions must transform irreducibly under discrete subgroup $SU(3)$ of octonion automorphisms transforming ordinary hyper-octonionic prime to a new hyper-octonionic prime. $SU(3)$ has interpretation as color group. One can assign standard model quantum numbers to these wave functions and prime property in principle fixes the spectrum of possible quantum states- in particular the spectrum of masses. Therefore the extremely esoteric looking notion of infinite prime might turn out to be very practical calculational tool.

2.3.4 Quantum Mathematics and Quantum Mechanics

Quantum Mathematics replaces numbers with Hilbert spaces and arithmetic operations $+$ and \times with direct sum \oplus and tensor product \otimes .

1. The original motivation comes from quantum TGD where direct sum and tensor product are naturally assigned with the two basic vertices analogous to stringy 3-vertex and 3-vertex of Feynman graph. This suggests that generalized Feynman graphs could be analogous to sequences of arithmetic operations allowing also co-operations of \oplus and \otimes .
2. One can assign to natural numbers, integers, rationals, algebraic numbers, transcendentals and their p -adic counterparts for various prime p Hilbert spaces with formal dimension given by the number in question. Typically the dimension of these Hilbert spaces in the ordinary sense is infinite. Von Neuman algebras known as hyper-finite factors of type II_1 assume as a convention that the dimension of basic Hilbert space is one although it is infinite in the standard sense of the word. Therefore this Hilbert space has sub-spaces with dimension which can be any number in the unit interval. Now however also negative and even complex, quaternionic and octonionic values of Hilbert space dimension become possible.
3. The decomposition to a direct sum matters unlike for abstract Hilbert space as it does also in the case of physical systems where the decomposition to a direct sum of representations of symmetries is standard procedure with deep physical significance. Therefore abstract Hilbert space is replaced with a more structured objects. For instance, the expansion $\sum_n x_n p^n$ of a p -adic number in powers of p defines decomposition of infinite-dimensional Hilbert space to a direct sum $\oplus_n x_n \otimes p^n$ of the tensor products $x_n \otimes p^n$. It seems that one must modify the notion of General Coordinate Invariance since number theoretic anatomy distinguishes between the representations of space-time point in various coordinates. The interpretation would be in terms of cognition. For instance, the representation of Neper number requires infinite number

of binary digits whereas finite integer requires only a finite number of them so that at the level of cognitive representations general coordinate invariance is broken.

Note that the number of elements of the state basis in p^n factor is p^n and $m \in \{0, \dots, p-1\}$ in the factor x_n . Therefore the Hilbert space with dimension $p^n > x_n$ is analogous to the Hilbert space of a large effectively classical system entangled with the microscopic system characterized by x_n . p-Adicity of this Hilbert space in this example is for the purpose of simplicity but raises the question whether the state function reduction is directly related to cognition.

4. One can generalize the concept of real numbers, the notions of manifold, matrix group, etc... by replacing points with Hilbert spaces. For instance, the point (x_1, \dots, x_n) of E^n is replaced with Cartesian product of corresponding Hilbert spaces. What is of utmost importance for the idea about possible connection with the multiverse idea is that also this process can be also repeated indefinitely. This process is analogous to a repeated second quantization since intuitively the replacement means replacing Hilbert space with Hilbert space of wave functions in Hilbert space. The finite dimension and its continuity as function of space-time point must mean that there are strong constraints on these wave functions. What does this decomposition to a direct sum mean at the level of states? Does one have super-selection rules stating that quantum interference is possible only inside the direct summands?
5. Could one find a number theoretical counterpart for state function reduction and preparation and unitary time evolution? Could zero energy ontology have a formulation at the level of the number theory as earlier experience with infinite primes suggest? The proposal was that zero energy states correspond to ratios of infinite integers which as real numbers reduce to real unit. Could zero energy states correspond to states in the tensor product of Hilbert spaces for which formal dimensions are inverses of each other so that the total space has dimension 1?

The fractal character of the Quantum Mathematics is what makes it a good candidate for understanding the self-referentiality of consciousness. The replacement of the Hilbert space with the direct sum of Hilbert spaces defined by its points would be the basic step and could be repeated endlessly corresponding to a hierarchy of statements about statements or hierarchy of n^{th} order logics. The construction of infinite primes leads to a similar structure.

What about the step leading to a deeper level in hierarchy and involving the replacement of each point of Hilbert space with Hilbert space characterizing it number theoretically? What could it correspond at the level of states?

1. Suppose that state function reduction selects one point for each Hilbert space $x_n \times p^n$. The key step is to replace this direct sum of points of these Hilbert spaces with direct sum of Hilbert spaces defined by the points of these Hilbert spaces. After this one would select point from this very big Hilbert space. Could this point be in some sense the image of the Hilbert space state at previous level? Should one imbed Hilbert space $x_n \times p^n$ isometrically to the Hilbert space defined by the preferred state $x_n \times p^n$ so that one would have a realization of holography: part would represent the whole at the new level. It seems that there is a canonical manner to achieve this. The interpretation as the analog of second quantization suggest the identification of the imbedding map as the identification of the many particle states of previous level as single particle states of the new level.
2. Could topological condensation be the counterpart of this process in many-sheeted spacetime of TGD? The states of previous level would be assigned to the space-time sheets topologically condensed to a larger space-time sheet representing the new level and the many-particle states of previous level would be the elementary particles of the new level.
3. If this vision is correct, second quantization performed by theoreticians would not be a mere theoretical operation but a fundamental physical process necessary for cognition! The above proposed unitary imbedding would imbed the states of the previous level as single particle states to the new level. It would seem that the process of second quantization, which is indeed very much like self-reference, is completely independent from state function reduction and unitary process. This picture would conform with the fact that in TGD Universe the theory about the Universe is the Universe and mathematician is in the quantum jumps between different solutions of this theory.

Unitary process and state function reduction in ZEO

The minimal view about unitary process and state function reduction is provided by ZEO [K5].

1. Zero energy states correspond to a superposition of pairs of positive and negative energy states. The M-matrix defining the entanglement coefficients is product of Hermitian square root of density matrix and unitary S-matrix, and various M-matrices are orthogonal and form rows of a unitary U-matrix. Quantum theory is square root of thermodynamics. This is true even at single particle level. The square root of the density matrix could be also interpreted in terms of finite measurement resolution.
2. It is natural to assume that zero energy states have well-defined single particle quantum numbers at the either end of CD as in particle physics experiment. This means that state preparation has taken place and the prepared end represents the initial state of a physical event. Since either end of CD can be in question, both arrows of geometric time identifiable as the Minkowski time defined by the tips of CD are possible.
3. The simplest identification of the U-matrix is as the unitary U-matrix relating to each other the state basis for which M-matrices correspond to prepared states at two opposite ends of CD . Let us assume that the preparation has taken place at the "lower" end, the initial state. State function reduction for the final state means that one measures the single particle observables for the "upper" end of CD . This necessarily induces the loss of this property at the "lower" end. Next preparation in turn induces localization in the "lower" end. One has a kind of time flip-flop and the breaking of time reversal invariance would be absolutely essential for the non-triviality of the process.

The basic idea of Quantum Mathematics is that M-matrix is characterized by Feynman diagrams representing sequences of arithmetic operations and their co-arithmetic counterparts. The latter ones give rise to a superposition of pairs of direct summands (factors of tensor product) giving rise to same direct sum (tensor product). This vision would reduce quantum physics to generalized number theory. Universe would be calculating and the consciousness of the mathematician would be in the quantum jumps performing the state function reductions to which preparations reduce.

Note that direct sum, tensor product, and the counterpart of second quantization for Hilbert spaces in the proposed sense would be quantum mathematics counterpart for set theoretic operations, Cartesian product and formation of the power set in set theory.

ZEO, state function reduction, unitary process, and quantum mathematics

State function reduction acts in a tensor product of Hilbert spaces. In the p-adic context to be discussed in the following $x_n \otimes p^n$ is the natural candidate for this tensor product. One can assign a density matrix to a given entangled state of this system and calculate the Shannon entropy. One can also assign to it a number theoretical entropy if entanglement coefficients are rationals or even algebraic numbers, and this entropy can be negative. One can apply Negentropy Maximization Principle to identify the preferred states basis as eigenstates of the density matrix. For negentropic entanglement the quantum jump does not destroy the entanglement.

Could the state function reduction take place separately for each subspace $x_n \otimes p^n$ in the direct sum $\oplus_n x_n \otimes p^n$ so that one would have quantum parallel state function reductions? This is an old proposal motivated by the many-sheeted space-time. The direct summands in this case would correspond to the contributions to the states localizable at various space-time sheets assigned to different powers of p defining a scale hierarchy. The powers p^n would be associated with zero modes by the previous argument so that the assumption about independent reduction would reflect the super-selection rule for zero modes. Also different values of p-adic prime are present and tensor product between them is possible if the entanglement coefficients are rationals or even algebraics. In the formulation using adeles the needed generalization could be formulated in a straightforward manner.

How can one select the entangled states in the summands $x_n \otimes p^n$? Is there some unique choice? How do unitary process and state function reduction relate to this choice? Could the dynamics of Quantum Mathematics be a structural analog for a sequence of state function reductions taking place at the opposite ends of CD with unitary matrix U relating the state basis for which single particle states have well defined quantum numbers either at the upper or lower end of CD ? Could the unitary

process and state function reduction be identified solely from the requirement that zero energy states correspond to tensor products Hilbert spaces, which correspond to inverses of each other as numbers? Could the extension of arithmetics to include co-arithmetics make the dynamics in question unique?

2.4 Physics as extension of quantum measurement theory to a theory of consciousness

TGD inspired theory of consciousness could be seen as a generalization of quantum measurement theory to make observer, which in standard quantum measurement theory remains an outsider, a genuine part of physical system subject to laws of quantum physics. The basic notions are quantum jump identified as moment of consciousness and the notion of self [K40]: in zero energy ontology these notions might however reduce to each other. Negentropy Maximization Principle [K42] defines the dynamics of consciousness and as a special case reproduces standard quantum measurement theory.

2.4.1 Quantum jump as moment of consciousness

TGD suggests that the quantum jump between quantum histories could be identified as moment of consciousness and could therefore be for consciousness theory what elementary particle is for physics [K40].

This means that subjective time evolution corresponds to the sequence of quantum jumps $\Psi_i \rightarrow U\Psi_i \rightarrow \Psi_f$ consisting of unitary process followed by state function process. Originally U was thought to be the TGD counterpart of the unitary time evolution operator $U(-t, t)$, $t \rightarrow \infty$, associated with the scattering solutions of Schrödinger equation. It seems however impossible to assign any real Schrödinger time evolution with U . In zero energy ontology U defines a unitary matrix between zero energy states and is naturally assignable to intentional actions whereas the ordinary S-matrix telling what happens in particle physics experiment (for instance) generalizes to M-matrix defining time-like entanglement between positive and negative energy parts of zero energy states. One might say that U process corresponds to a fundamental act of creation creating a quantum superposition of possibilities and the remaining steps generalizing state function reduction process select between them.

2.4.2 Negentropy Maximization Principle and the notion of self

U -process is followed by a sequence of state function reductions. Negentropy Maximization Principle (NMP [K42]) states that in a given quantum state the most quantum entangled subsystem-complement pair can perform the quantum jump. More precisely: the reduction of the entanglement entropy in the quantum jump is as large as possible. This selects the pair in question and in case of ordinary entanglement entropy leads the selected pair to a product state. The interpretation of the reduction of the entanglement entropy as conscious information gain makes sense. The sequence of state function reductions decomposes at first step the entire system to two parts in such a manner that the reduction entanglement entropy is maximal. This process repeats itself for subsystems. If the subsystem in question cannot be divided into a pair of entangled free system the process stops since energy conservation does not allow it to occur (binding energy).

The original definition of self was as a subsystem able to remain unentangled under state function reductions associated with subsequent quantum jumps. Everything is consciousness but consciousness can be lost if self develops bound state entanglement during U process so that state function reduction to smaller un-entangled pieces is impossible.

The existence of number theoretical entanglement entropies in the intersection of real and various p-adic worlds force to modify this picture. The reduction process can stop also if the self in question allows only decompositions to pairs systems with negentropic entanglement. This does not require that the system forms a bound state for any pair of subsystems so that the systems decomposing it can be free (no binding energy). This defines a new kind of bound state not describable as a jail defined by the bottom of a potential well. Subsystems are free but remain correlated by negentropic entanglement.

The ordinary state function reductions imply dissipation crucial for self organization and quantum jump could be regarded as the basic step of an iteration like process leading to the asymptotic self-organization patterns. One could regard dissipation as a Darwinian selector as in standard theories of

self-organization. NMP thus predicts that self organization and hence presumably also fractalization can occur inside selves. NMP would favor the generation of negentropic entanglement. This notion is highly attractive since it could allow to understand how quantum selforganization generates larger coherent structures. Note that state function reduction for negentropic entanglement is highly deterministic since the number of degenerate states with same negative entanglement entropy is expected to be small. This could allow to understand how living matter is able to develop almost deterministic cellular automaton like behaviors.

2.4.3 Life as islands of rational/algebraic numbers in the seas of real and p-adic continua?

The observation that Shannon entropy allows an infinite number of number theoretic variants for which the entropy can be negative in the case that probabilities are algebraic numbers leads to the idea that living matter in a well-defined sense corresponds to the intersection of real and p-adic worlds. This would mean that the mathematical expressions for the space-time surfaces (or at least 3-surfaces or partonic 2-surfaces and their 4-D tangent planes) make sense in both real and p-adic sense for some primes p . Same would apply to the expressions defining quantum states. In particular, entanglement probabilities would be rationals or algebraic numbers so that entanglement can be negentropic and the formation of bound states in the intersection of real and p-adic worlds generates information and is thus favored by NMP.

This picture has also a direct connection with consciousness [K42].

1. Algebraic entanglement is a prerequisite for the realization of intentions as transformations of p-adic space-time sheets to real space-time sheets representing actions. Essentially a leakage between p-adic and real worlds is in question and makes sense only in zero energy ontology. Since various quantum numbers in real and p-adic sectors are not in general comparable in positive energy ontology so that conservation laws would be broken in positive energy ontology. Algebraic entanglement could be also called cognitive since it is something between real and p-adic worlds. The transformation can occur if the partonic 2-surfaces and their 4-D tangent space-distributions are representable using rational functions with rational coefficients in preferred coordinates for the imbedding space dictated by symmetry considerations. Intentional systems must live in the intersection of real and p-adic worlds. For the minimal option life would be also effectively 2-dimensional phenomenon and essentially a boundary phenomenon as also number theoretical criticality suggests.
2. What happens that the Universe corresponding to given CD decomposes to two un-entangled subsystems, which in turn decompose, and the process continues until all subsystems have only entropic bound state entanglement or negentropic algebraic entanglement with the external world. If the sub-system generates entropic bound state entanglement in the process, it loses consciousness. The generation of negentropic entanglement means expansion of consciousness.
3. One can ask whether the entanglement entropy of the sub-system should be defined as a sum over entanglement entropies over all subsystems involved or whether the levels are independent. This hierarchy of subsystems corresponds to the hierarchy of sub- CD s so that for the first option the survival without a loss of consciousness depends on what happens at all levels below the highest level for a given self is this is assumed. In more concrete terms, ability to stay conscious depends on what happens at cellular level too. For the first option the stable evolution of systems having algebraic entanglement is expected to be a process proceeding from short to long length scales as the evolution of life indeed is.
4. U -process generates a superposition of states in which any sub-system can have both real and algebraic entanglement with the external world. This would suggest that the choice of the type of entanglement is a volitional selection. A possible interpretation is as a choice between good and evil. The hedonistic complete freedom resulting as the entanglement entropy is reduced to zero on one hand, and the algebraic bound state entanglement implying correlations with the external world and meaning giving up the maximal freedom on the other hand. The hedonistic option is risky since it can lead to non-algebraic bound state entanglement implying a loss of consciousness. The second option means expansion of consciousness - a fusion to the ocean of consciousness as described by spiritual practices.

5. This formulation means a sharpening of the earlier statement "Everything is conscious and consciousness can be only lost" with the additional statement "This happens when non-algebraic bound state entanglement is generated". Clearly, the quantum criticality of TGD Universe seems to have many aspects and life as a critical phenomenon in the number theoretical sense is only one of them besides the criticality of the space-time dynamics and the criticality with respect to phase transitions changing the value of Planck constant and other more familiar criticalities. How closely these criticalities relate remains an open question [K63].

A good guess is that algebraic entanglement is essential for quantum computation, which therefore might correspond to a conscious process. Hence cognition could be seen as a quantum computation like process, a more appropriate term being quantum problem solving. Living-dead dichotomy could correspond to rational-irrational or to algebraic-transcendental dichotomy: this at least when life is interpreted as intelligent life. Life would in a well defined sense correspond to islands of rationality/algebraicity in the seas of real and p-adic continua.

The view about the crucial role of rational and algebraic numbers as far as intelligent life is considered, could have been guessed on very general grounds from the analogy with the orbits of a dynamical system. Rational numbers allow a predictable periodic decimal/pinary expansion and are analogous to one-dimensional periodic orbits. Algebraic numbers are related to rationals by a finite number of algebraic operations and are intermediate between periodic and chaotic orbits allowing an interpretation as an element in an algebraic extension of any p-adic number field. The projections of the orbit to various coordinate directions of the algebraic extension represent now periodic orbits. The decimal/pinary expansions of transcendentals are un-predictable being analogous to chaotic orbits. The special role of rational and algebraic numbers was realized already by Pythagoras, and the fact that the ratios for the frequencies of the musical scale are rationals supports the special nature of rational and algebraic numbers. The special nature of the Golden Mean, which involves $\sqrt{5}$, conforms the view that algebraic numbers rather than only rationals are essential for life.

2.4.4 Two times

The basic implication of the proposed view is that subjective time and geometric time of physicist are not the same [K40]. This is not a news actually. Geometric time is reversible, subjective time irreversible. Geometric future and past are in completely democratic position, subject future does not exist at all yet. One can say that the non-determinism of quantum jump is completely outside space-time and Hilbert space since quantum jumps replaces entire 4-D time evolution (or rather, their quantum superposition) with a new one, re-creates it. Also conscious existence defies any geometric description. This new view resolves the basic problem of quantum measurement theory due to the conflict between determinism of Schrödinger equation and randomness of quantum jump. The challenge is to understand how these two times correlate so closely as to lead to their erratic identification.

With respect to geometric time the contents of conscious experience is naturally determined by the space-time region inside CD in zero energy ontology. This geometro-temporal integration should have subjecto-temporal counterpart. The experiences of self are determined by the mental images assignable to subselves (having sub- CD s as imbedding space correlates) and the quantum jump sequences associated with sub-selves define a sequence of mental images. The hypothesis is that self experiences these sequences of mental images as a continuous time flow. In absence of mental images self would have experience of "timelessness" in accordance with the reports of practitioners of various spiritual practices. Self would lose consciousness in quantum jump generating entropic entanglement and experience expansion of consciousness if the resulting entanglement is negentropic. The assumption that the integration of experiences of self involves a kind of averaging over sub-selves of sub-selves guarantees that the sensory experiences are reliable despite the fact that quantum nondeterminism is involved with each quantum jump.

Thus the measurement of density matrix defined by the MM^\dagger , where M is the M-matrix between positive and negative energy parts of the zero energy state would correspond to the passive aspects of consciousness such as sensory experiencing. U would represent at the fundamental level volition as a creation of a quantum superposition of possibilities. What follows it would be a selection between them. The volitional choice between macroscopically differing space-time sheets representing different maxima of Kähler function could be basically responsible for the active aspect of consciousness. The fundamental perception-reaction feedback loop of biosystems would result from the combination of

the active and passive aspects of consciousness represented by U and M .

2.4.5 General view about psychological time and intentionality

The recent TGD inspired attempts to understand the arrow of psychological time and the localization of the contents of conscious sensory experience and experienced volition to a rather narrow time interval of .1 seconds rely on zero energy ontology. The most argument below summarizes the most recent view [K5].

Why sensory experience is about so short time interval?

The picture based on CD s implies automatically the 4-D character of conscious experience and memories form part of conscious experience even at elementary particle level. Amazingly, the secondary p-adic time scale of electron characterizing the time scale of electronic CD is $T = 0.1$ seconds defining a fundamental time scale in living matter. The problem is to understand why the sensory experience is about a short time interval of geometric time rather than about the entire personal CD with temporal size of order life-time. The explanation would be that sensory input corresponds to subselves (mental images) with $T \simeq .1$ s at the upper light-like boundary of CD in question. This requires a strong asymmetry between upper and lower light-like boundaries of CD s.

The localization of the contents of the sensory experience to the upper light-cone boundary and local arrow of time could emerge as a consequence of self-organization process involving conscious intentional action. Sub- CD s would be in the interior of CD and self-organization process would lead to a distribution of CD s concentrated near the upper or lower boundary of CD . The local arrow of geometric time would depend on CD and even differ for CD and sub- CD s.

1. The localization of contents of sensory experience to a narrow time interval would be due to the concentration of sub- CD s representing mental images near the either boundary of CD representing self.
2. Phase conjugate signals identifiable as negative energy signals to geometric past are important when the arrow of time differs from the standard one in some time scale. If the arrow of time establishes itself as a phase transition, this kind of situations are rare. Negative energy signals as a basic mechanism of intentional action and transfer of metabolic energy would explain why living matter is so special.
3. Geometric memories would correspond to subselves in the interior of CD , the oldest of them to the regions near "lower" boundaries of CD . Since the density of sub- CD s is small there geometric memories would be rare and not sharp. A temporal sequence of mental images, say the sequence of digits of a phone number, would correspond to a temporal sequence of sub- CD s.
4. Sharing of mental images corresponds to a fusion of sub-selves/mental images to single sub-self by quantum entanglement: the space-time correlate could be flux tubes connecting space-time sheets associated with sub-selves represented also by space-time sheets inside their CD s.

Arrow of time

TGD forces a new view about the relationship between experienced and geometric time. Although the basic paradox of quantum measurement theory disappears the question about the arrow of geometric time remains. There are actually two times involved. The geometric time assignable to the space-time sheets and the M^4 time assignable to the imbedding space.

Consider first the the geometric time assignable to the space-time sheets.

1. Selves correspond to CD s. The CD s and their projections to the imbedding space do not move anywhere. Therefore the standard explanation for the arrow of geometric time cannot work.
2. The only plausible interpretation at classical level relies on quantum classical correspondence and the fact that space-times are 4-surfaces of the imbedding space. If quantum jump corresponds to a shift for a quantum superposition of space-time sheets towards geometric past in the first approximation (as quantum classical correspondence suggests), one can understand the arrow

of time. Space-time surfaces simply shift backwards with respect to the geometric time of the imbedding space and therefore to the 8-D perceptive field defined by the CD . This creates in the materialistic mind a temporal variant of train illusion. Space-time as 4-surface and macroscopic and macro-temporal quantum coherence are absolutely essential for this interpretation to make sense.

Why this shifting should always take place to the direction of geometric past of the imbedding space? Does it so always? The proposed mechanism for the localization of sensory experience to a short time interval suggests an explanation in terms of intentional action.

1. CD defines the perceptive field for self. Selves are curious about the space-time sheets outside their perceptive field and perform quantum jumps tending to shift the superposition of the space-time sheets so that unknown regions of space-time sheets emerge to the perceptive field. Either the upper or lower boundary of CD wins in the competition and the arrow of time results as a spontaneous symmetry breaking. The arrow of time can depend on CD but tends to be the same for CD and its sub- CD s. Global arrow of time could establish itself by a phase transitions establishing the same arrow of time globally by a mechanism analogous to percolation phase transition.
2. Since the news come from the upper boundary of CD , self concentrates its attention to this region and improves the resolution of sensory experience. The sub- CD s generated in this manner correspond to mental images with contents about this region. Hence the contents of conscious experience, in particular sensory experience, tends to be about the region near the upper boundary.

The emergence of the arrow of time at the level of imbedding space reduces to a modification of the oldest TGD based argument for the arrow of time which is wrong as such. If physical objects correspond to 3-surfaces inside future directed light-cone then the sequence of quantum jumps implies a diffusion to the direction of increasing value of light-cone proper time. The modification of the argument goes as follows.

1. CD s are characterized by their moduli. In particular, the relative coordinate for the tips of CD has values in past light cone M^4 if the future tip is taken as the reference point. An attractive interpretation for the proper time of M^4 is as cosmic time having quantized values. Quantum states correspond to wave functions in the modular degrees of freedom and each U process creates a non-localized wave function of this kind. Suppose that state function reduction implies a localization in the modular degrees of freedom so that CD is fixed completely apart from its center of mass position to which zero four-momentum constant plane wave is assigned. One can expect that in average sense diffraction occurs in M^4 so that the size of CD tends to increase and that the most distant geometric past defined by the past boundary of CD recedes. This is nothing but cosmic expansion. This provides a formulation for the flow of time in terms of a cosmic redshift. This argument applies also to the positions of the sub- CD s inside CD . Also their proper time distance from the tip of CD is expected to increase.
2. One can argue that one ends up with contradiction by changing the roles of upper and lower tips. In the case of CD itself is only the proper time distance between the tips which increases and speaking about "future" and "past" tips is only a convention. For sub- CD s of CD the argument would imply that the sub- CD s drifting from the opposite tips tend to concentrate in the middle region of CD unless either tip is in a preferred position. This requires a spontaneous selection of the arrow of time. One could say that the cosmic expansion implied by the drift in M^4 "draws" the space-time sheet with it to the geometric past. The spontaneous generation of the asymmetry between the tips might require the "curious" conscious entities.

2.4.6 T-duality and life

The usual view about emergences teaches that life as something macroscopic is totally separated from the physics in elementary particle length scales. This need not be the case in TGD Universe where p-adic length scale hierarchy, the length scale hierarchy associated with dark matter, and the length scale hierarchy associated with CD s give rise to fractality. For instance, dark nucleons realize genetic

code suggesting that deepest information processing level is at the level of dark nuclear physics, and the fundamental 10 Hz biorhythm appears as secondary p-adic time scale for electron. Canonical identification mapping p-adic physics to real physics long real scales to short real scales. Therefore one ends up with a suggestion that the generalization of T-duality of string models to a symmetry relating long and short scales could allow to relate life as macroscopic phenomenon to physics in CP_2 scale. What could be the counterpart of T-duality in TGD framework?.

T-duality [A2] is formulated for strings in space $M^d \times S^1$ or its generalization replacing S^1 with higher-dimensional torus and generalized to fractal strings. Duality states that the transformation $R \rightarrow 1/R$ with suitable unit for R defined by string tension is a duality: the physics for these different values of R is same. Intuitively this is due to the fact that the contributions of the string modes representing n -fold winding and those representing vibrations labelled by integer n are transformed to each other in the transformation $R \rightarrow 1/R$.

For a physicist like me it is extremely painful to type the equation $R \rightarrow 1/R$ without explicitly explaining that it should actually read as $R \rightarrow R_0^2/R$, where R_0 is length unit, which must represent fundamental length scale remaining invariant under the duality transformation. Only after this physicist could reluctantly put $R_0 = 1$ but still would feel himself guilty of unforgivable sloppiness. $R_0 = 1$ simplifies the formulas but one must not forget that there are three scales involved rather than only two. The question inspired by this nitpicking is how the physics in the length scales R_1 and R relates to the physics in length scale R . Are dualities - or perhaps holography like relations in question- so that T-duality would follow from these dualities?

Could one replace winding number with magnetic charge and T-duality with canonical identification?

How could one generalize T-duality to TGD framework? One should identify the counterpart of the winding number, the three fundamental scales, and say something about the duality transformation itself.

1. In TGD Universe partonic 2-surfaces are the basic object. Partonic 2-surface is not strings and the only reasonable generalization for winding number is as Kähler magnetic charge representing the analog of winding of the partonic 2-surface around magnetically charged 2-sphere of CP_2 . Magnetic charge tells how many times partonic 2-surface wraps around the homologically non-trivial geodesic sphere with unit magnetic charge. If the generalization of T-duality holds true, one would expect that the contributions of the oscillations and windings of the partonic two-surface to ground state energy must be transformable to each other by the counterpart of the transformation $R \rightarrow R_0^2/R$ - or something akin to that. Also less concrete and more general interpretations are possible, and below the most plausible interpretation will be considered.
2. The duality $R \rightarrow R_0^2/R = R_1$ gives R_0 as a geometric mean $R_0 = \sqrt{RR_1}$ of the scales R and R_1 . What are these three length scales in TGD Universe? The obvious candidate for R is CP_2 size scale. p-Adic mass calculations [K38] imply that the primary p-adic length scale $L_{p,1} = \sqrt{p}R$ is of order of Compton length of the elementary particle characterized by the p-adic prime p . The secondary p-adic length scale $L_{p,2} = pR$ in turn defines the size scale of causal diamond (CD) assignable to the magnetic body of the elementary particle characterized by prime p . For instance, for electron this scale corresponds to .1 seconds, a fundamental biological time scale.

One indeed has $L_{p,1} = \sqrt{L_{p,2}R}$, and CP_2 scale and CD length scale are dual to each other if T-duality holds true. Therefore the duality would relate physics at CP_2 scale - counterpart of Planck length in TGD framework - and in biological scales and would have direct relevance to quantum biology. One has an infinite hierarchy of p-adic length scales and each of them would give rise to one particular instance of the T-duality. Adeles [K90] would provide appropriate formulation of T-duality in TGD framework. The corresponding mass scales would be \hbar/R , $\hbar/\sqrt{p}R$ and \hbar/pR . The third scale corresponds to a scale, which for electron corresponds to the 10 Hz frequency in the case of photons. The duality would suggest that the physics associated with the frequencies in EEG scale related to the communications from the biological body to magnetic body is dual to the physics in CP_2 scale.

Note that one cannot exclude alternative variants of T-duality. In particular, Planck scale and CP_2 length scale as candidates R_1 and R could be considered.

3. What is the interpretation of these three length scales? CP_2 length scale corresponds naturally to the size scale of wormhole contacts. They are Euclidian regions of space-time surface and represent lines of generalized Feynman graphs. Both general arguments and the construction of elementary bosons forces [K43] to assign to these regions braid strands playing a role of Euclidian strings. Parallel translation along the strands is essential in the construction of fermionic bilinears as invariant under general coordinate transformations and gauge transformations [K43]. The ends of these strands carry fermion and anti-fermion numbers. The counterpart of string tension involved appearing in stringy mass formula implied by super-conformal invariance is indeed determined by R and p-adic thermodynamics [K38] leads to a detailed and successful calculations for elementary particle masses using only p-adic thermodynamics, super-conformal invariance, and p-adic length scale hypothesis as basic assumptions.
4. The wormhole throats carrying fermion number are Kähler magnetic monopoles and the wormhole must be accompanied by a second wormhole throat carrying opposite magnetic charge and also a neutrino pair neutralizing the weak isospin so that weak massivation takes place. The end of the flux tube containing the neutrino pair is virtually non-existent at low energies. The length scale for this string must correspond to Compton length for elementary particle given essentially by primary p-adic length scale $L_{p,1}$. The more restrictive assumption that this length scale corresponds to the Compton length of weak bosons looks un-necessarily restrictive and looks also un-natural.
5. The excitations with mass scale \hbar/pR would correspond to excitations assignable to entire CD , maybe assignable to the flux tubes of the magnetic bodies of elementary particles defining also string like objects but in macroscopic scales. For electron the scale is of order of the circumference of Earth. This dynamics would naturally correspond to the dynamics in Minkowskian space-time regions. The dynamics at intermediate length scale would be intermediate between the Euclidian and Minkowskian dynamics and reduce to that for light-like orbits of partonic 2-surfaces with metric intermediate between Minkowskian and Euclidian.
6. A natural interpretation for T-duality in this sense is in terms of strong form of holography. The interior dynamics at length scale R resp. pR assigned to Euclidian resp. Minkowskian regions of space-time surface corresponds by holography to the dynamics of light-like orbits of partonic 2-surfaces identified as wormhole throats. Therefore the dynamics in Euclidian and Minkowskian regions are dual to each other. Therefore T-duality in TGD sense would follow from the possibility of having both Euclidian and Minkowskian holography. Strong form of holography in turn reduces to strong form of General Coordinate Invariance, which has turned out to be extremely powerful principle in TGD framework.

Is the physics of life dual to the physics in CP_2 scale?

The duality of life with elementary particle physics at CP_2 length scale - the TGD counterpart of Planck scale - looks rather far-fetched idea. There is however already earlier support for this idea.

1. p-Adic physics is physics of cognition, and one can say that living systems are in the algebraic intersection of real and p-adic worlds: the intersection of cognition and matter. Canonical identification maps p-adic physics to real physics. This map takes p-adic integers which are small in p-adic sense to larger integers in real sense and thus maps long real scales to short real scales. Clearly this map is highly analogous to the T-duality. p-Adic length scales are indeed explicitly related with the above identification of the T-duality so that canonical identification might be involved with T-duality.

If this interpretation is correct, cognitive p-adic representations in long real length scales would give representations for the physics in short length scales. EEG range of frequencies allowing communication to the magnetic bodies is absolutely essential for brain function. CDs would correspond to the real physics scale associated with the cognitive representations. These cognitive representations are indeed exactly what our science is building so that T-duality would make also scientist as a part of the big vision!

2. The model for dark nucleons as three quark states led to one of the greatest surprises of my professional life [L9, K31]. Under rather general conditions the three quark states for nucleon are

in one-one correspondence with the DNA, RNA, tRNA codons, and aminoacids for vertebrate genetic code and there is natural physical correspondence between DNA triplets and aminoacids. This suggests that genetic code is realized at the level of hadrons and that living matter is a kind of emulation for it, or that living matter is representation for matter at hadron level. This leads to rather far reaching speculations about biological evolution - not as random process - but a process analogous R&D applied in industry [K31]. New genes would be continually tested at the level of dark matter and the modifications of genome could be carried out if there is a transcription process transforming dark DNA to ordinary DNA.

3. The secondary p-adic mass scale of electron corresponds to the 10 Hz frequency, which defines a fundamental biorhythm. Also to current quark masses, which are actually not so well-known but are in MeV range, one can assign biologically interesting time scales in millisecond range. This suggests that all elementary particles induce physics in macroscopic time scales via their CD :s containing their magnetic bodies.

The unavoidable and completely crazy looking question raised by T-duality is whether there is intelligent life in the Euclidian realm below the CP_2 length scale - inside the lines of generalized Feynman graphs. This kind of possibility cannot be avoided if one takes holography absolutely seriously. In purely mathematical sense TGD suggests even stronger form of holography based on the notion of infinite primes [K71]. In this holography the number theoretic anatomy of given space-time point is infinitely complex and evolves. The notion of quantum mathematics replacing numbers by Hilbert spaces representing ordinary arithmetics in terms of direct sum and tensor product suggest the same [K90]. Space-time point would be in this picture its own infinitely complex Universe - the Platonia.

2.5 Implications of Quantum Classical Correspondence

Quantum Classical Correspondence has been of the guiding principles in the construction of Quantum TGD. Recall that at the level of WCW Quantum TGD is a theory of purely classical spinor fields. In ZEO the modes of sub-WCW spinor fields associated with a given CD have by effective 2-dimensionality as their arguments collections of partonic 2-surfaces and their 4-D tangent space data. U-matrix, M-matrices, and S-matrix are in principle reducible to the properties of the basis of WCW spinor fields.

Quantum classical correspondence assumes that classical dynamics defined by the preferred extremals of Kähler action define an exact part of Quantum TGD. More generally, all quantum notions - even the quantum jump sequence characterizing contents of consciousness - must have space-time counterpart: this representation is analogous to written language.

The notion of WCW Kähler geometry combined with GCI allows to identify classical space-time surfaces as analogs of Bohr orbits as preferred extremals of Kähler action. What "preferred" means is of course a highly non-trivial question. Assuming that light-like 3-surfaces and space-like 3-surfaces at the ends of CD s give rise to same theory implies effective 2-dimensionality and strong form of holography having dramatic implications for the theory.

2.5.1 Strong form of holography and effective 2-dimensionality

Strong form of holography reduces to strong form of General Coordinate Invariance.

1. The starting point is the vision about geometrization of quantum physics in terms of the geometry of WCW, the space of 3-surfaces of H . Quantum states correspond to classical WCW spinor fields and WCW spinors (spinor field at given point of WVV, which is 3-surface!). No quantization occurs at WCW level: spinor fields are classical. WCW spinor corresponds to fermionic Fock states with fermionic oscillator operators associated with free second quantized induced spinor fields (spinor fields of H) at 3-surfaces and extended to 4-surfaces. This "second quantization" has purely geometric meaning and makes possible WCW spinor geometry.
2. General Coordinate Invariance is one of the fundamental symmetries and states that 4-D general coordinate transformations act as gauge symmetries. This requires that the definition of WCW

metric assigns to 3-D surface a 4-D space-time surface. This space-time surface is analogous to Bohr orbit and defines the "classical physics" associated with the 3-surface but satisfying the analogs of Bohr quantization rules. This space-time surface is a preferred extremal of Kähler action and the value of Kähler action for the Euclidian regions of space-time surface defines Kähler function defining the Kähler metric of WCW.

The value of Kähler action for Minkowskian regions of space-time surface defines a complex phase in vacuum functional and plays a role of Morse function and is also analogous to the action in ordinary quantum field theory: in particular it makes possible interference effects at the level of vacuum functional central in quantum field theories.

Obviously the effective reduction of 4-D theory to 3-D theory corresponds to holography. In ordinary QFT approach to TGD this would not take place since one performs path integral over all space-time surfaces. In fact, the total failure of this approach led to the generalization of Einstein's geometrization program of classical physics to a geometrization of quantum physics in terms of WCW geometry.

Characterizing the mathematical conditions satisfied by the preferred extremals of Kähler action precisely is still one of the basic mathematical challenges and several conjectures have been made during years.

3. GCI makes possible to fix the gauge by choosing the 3-surfaces in some especially convenient manner. One choice is as unions of space-like 3-surfaces at the light-like boundaries of CDs . Second choice is as wormhole throats which are light-like 3-surfaces at which the signature of the induced metric changes from Euclidian to Minkowskian and behaving in many respects like causal horizons and black hole horizons. Which of the choices is correct or are both correct? If both choices are correct one ends up with the strong form of GCI: the intersections of 3-D light-like wormhole throats with the 3-D space-like ends of space-time surface defining partonic 2-surfaces and their 4-D tangent space data carry information about quantum states.

Strong form of GCI implies strong form of holography. Already partonic 2-surfaces and their 4-D tangent space data are enough. This does not mean genuine 2-dimensionality and reduction to a string theory since tangent space data are needed. Also the breaking of strict determinism for Kähler action implies that the effective 2-dimensionality is true only in some length scales.

2.5.2 Weak form of electric magnetic duality

The notion of electric-magnetic duality [B2] was proposed first by Olive and Montonen and is central in $\mathcal{N} = 4$ supersymmetric gauge theories. It states that magnetic monopoles and ordinary particles are two different phases of theory and that the description in terms of monopoles can be applied at the limit when the running gauge coupling constant becomes very large and perturbation theory fails to converge. The notion of electric-magnetic self-duality is more natural since for CP_2 geometry Kähler form is self-dual and Kähler magnetic monopoles are also Kähler electric monopoles and Kähler coupling strength is by quantum criticality renormalization group invariant rather than running coupling constant. The notion of electric-magnetic (self-)duality emerged already two decades ago in the attempts to formulate the Kähler geometric of WCW. Quite recently a considerable step of progress took place in the understanding of this notion [K14]. What seems to be essential is that one adopts a weaker form of the self-duality applying at partonic 2-surfaces [K15].

Every new idea must be of course taken with a grain of salt but the good sign is that this concept leads to precise predictions. The point is that elementary particles do not generate monopole fields in macroscopic length scales: at least when one considers visible matter. The first question is whether elementary particles could have vanishing magnetic charges: this turns out to be impossible. The next question is how the screening of the magnetic charges could take place and leads to an identification of the physical particles as string like objects identified as pairs magnetic charged wormhole throats connected by magnetic flux tubes.

1. The first implication is a new view about electro-weak massivation reducing it to weak confinement in TGD framework. The second end of the string contains particle having electroweak isospin neutralizing that of elementary fermion and the size scale of the string is electro-weak scale would be in question. Hence the screening of electro-weak force takes place via weak confinement realized in terms of magnetic confinement.

2. This picture generalizes to the case of color confinement. Also quarks correspond to pairs of magnetic monopoles but the charges need not vanish now. Rather, valence quarks would be connected by flux tubes of length of order hadron size such that magnetic charges sum up to zero. For instance, for baryonic valence quarks these charges could be $(2, -1, -1)$ and could be proportional to color hyper charge.
3. The highly non-trivial prediction making more precise the earlier stringy vision is that elementary particles are string like objects in the length scale defined by their Compton length. Since the other end of flux tube carries neutrino pair it is however essentially invisible at low energies so that there is no obvious conflict with experimental facts.

The hierarchy of Planck constants means that the Compton lengths of dark elementary particles can be macroscopic so that their character as magnetic flux tubes with monopoles at ends could make itself manifest in condensed and living matter.

2.5.3 TGD as almost topological QFT

TGD as almost topological QFT is one of those idea that one cannot be sure of. I think it emerged around 2005. I have been even ready to give it up but it experienced re-incarnation as I discovered the weak form of electric-magnetic duality.

1. Holography in the sense that data at 3-D surfaces code for the quantum state is an idea which emerged already at 1990 or so since 3-surfaces are indeed basic objects in quantum TGD. General Coordinate Invariance indeed implies this and the highly non-trivial implication is that space-time surface associated with a given 3-surface is analogous to Bohr orbit. Therefore semiclassical quantization is an exact part of quantum TGD.
2. The question is whether it is light-like 3-surfaces or space-like 3-surfaces at the ends of space-time sheet defined by CD can be identified as the 3-surfaces that carry the data. Strong form of General Coordinate Invariance states that both choices are equally good. Only the intersections of these surfaces at the boundaries of CDs and their 4-D tangent spaces carry the data. This implies effective 2-dimensionality and strongly suggests conformal invariance and coset representation meaning that the actions of conformal generators of light-like 3-surface and those associated with the boundary of CD cancel each other. This implies EP in generalized form.
3. Already effective 3-dimensionality suggests but does not imply that the Kähler action reduces to 3-D Chern-Simons term. If this occurs, the theory simplifies enormously computationally and there are good hopes of calculating even without knowing details about preferred extremals. Chern-Simons action defines a topological QFT for braids and braids indeed replaced the 3-D light-like orbits of partonic 2-surfaces in TGD Universe in finite measurement resolution.

The reduction of Kähler action to 3-D integrals

To achieve reduction to Chern-Simons term the Kähler action for preferred extremals must reduce to a total divergence. This is achieved if in the decomposition of action to a total divergence and term $j \cdot A$, where j is Kähler current the latter term vanishes: $j \cdot A = 0$. This takes place in the following situations.

1. Empty space Maxwell equations $j = 0$ stating the vanishing of Kähler current hold true.
2. j and A are light-like and in the same direction so that their product vanishes. This is true for so called "massless extremals" (topological light rays).
3. j is proportional to the instanton current $j = \Phi j_I$, $j_I = \epsilon^{\alpha\beta\gamma\delta} A_\beta J_{\gamma\delta}$ so that $j \cdot A$ vanishes identically. Conservation of the Kähler current requires that the proportional factor Φ must satisfy $d\Phi \cdot j_I + \Phi I = 0$ where I is instanton density. $d\Phi$ is either orthogonal to j_I or both $d\Phi$ and j_I are light-like and have same direction.

This kind of proportionality might hold true also for other isometry currents and would mean "topologicalization" of conserved currents in accordance with the idea about almost topological QFT.

One also ends up with the proposal that preferred extremals are such that the flow lines of isometry currents integrate to coordinate lines globally. This kind of flow is known as Beltrami flow. This would mean that they define the analog of hydrodynamic flow in which the orbits of particles do not cross each other and there are no collisions. The analog of quantum flow (no collisions - no dissipation) would be in question and one could assign to the flow an order parameter of a supra phase varying only along the flow lines. The basic condition for a flow J to define Beltrami flow read as $J \wedge dJ = 0$, where J is the 1-form defined by the current (covariant form of current depending on induced metric).

Reduction to Chern-Simons term by the weak form of electric-magnetic duality

The proportionality of Kähler current to instanton current implies the reduction of action to 3-D terms but not yet a reduction to Chern-Simons terms implying almost topological QFT property.

1. This is guaranteed if one assumed what I have called weak form of electric-magnetic duality. This duality generalizes the Montonen-Olive electric-magnetic duality and would hold at wormhole throats and space-like 3-surfaces at the ends of space-time sheets but not necessarily elsewhere. It would imply that Kähler flux equals to magnetic flux so that Kähler electric charge is quantized. There are good reasons to assume that this charge corresponds to fermion number so that all wormhole throats carrying fermion number would be magnetic monopoles carrying Kähler magnetic charge equal to fermion number. Physical particles would correspond to multi-monopole states with vanishing total Kähler magnetic charge.
2. It is important to notice that the weak form of electric-magnetic duality at the space-like 3-surfaces and wormhole throats involves the induced metric of the space-time sheet so that metric does not disappear from the theory although Kähler action reduces to Chern-Simons term. This gives a precise content to the attribute "almost". The reduction to Chern-Simons terms would mean enormous calculational simplification of the theory and raises the hope that the theory could be calculable.
3. This also fixes to a high degree the view about leptons and hadrons. For instance, leptons should be string like objects formed by Kähler magnetically charged wormhole throats connected by magnetic flux tubes. Analogous picture applies to gauge bosons consisting of wormhole contacts with throats carrying fermion and antifermion numbers respectively. Hadrons could correspond multimonopole states.

Morse, Kähler, and me

First year physics student would immediately say that $\sqrt{g_4}$ is imaginary in the space-time regions with Minkowskian signature of the induced metric and real otherwise. For me it took 33 years to finally accept this trivial fact as a fact but finally I had to give up! This simple fact implies that Minkowskian regions give imaginary exponent of Chern-Simons term and Euclidian regions real exponent of Chern-Simons term [K88]. Under rather natural assumptions the two Chern-Simons terms are identical and would be obtained as an exponent of Chern-Simons term multiplied by complex number.

The imaginary exponent gives rise to interference effects typical for gauge theories and defining the core mechanism of quantum field theories and implies that stationary phase approximation makes sense. Stationary phase approximation is important also in topological QFTs and Chern-Simons term plays the role of Morse function in topological QFTs classifying the topological of 4-manifolds. The real exponent defines Kähler function and guarantees the convergence of the functional integral and guarantees that it exists as a genuine mathematical object.

Could Kähler action reduce to a 2-D integral?

Effective 2-dimensionality suggests a further dimensional reduction in the sense that Chern-Simons terms might allow expression as 2-dimensional integrals. If this idea is accepted, the only natural option is a reduction to a sum of areas of string world sheets with dynamical string tension. I have indeed developed a detailed proposal concerning the identification of this string world sheet [K87]. String world sheets indeed emerge naturally in quantum TGD and have as their boundary the space-like braid strands at the ends of space-time surfaces and light-like braid strands at the light-like 3-surfaces. Knotting of string world sheets is possible in 4-D space-time whereas braid strands link

and knot at 3-surfaces so that quantum TGD would provide a theory of ordinary knots and 2-knots. This adds additional aspect to the statement that TGD is almost topological QFT.

2.5.4 Generalized Feynman diagrams and braids

The notion of generalized Feynman diagram [K32, K28] has been developing rapidly during last five years. This progress has been boosted by several developments. The basic observation is that the regions of space-time surface with Euclidian signature of induced metric can be identified as generalized Feynman diagrams. Same interpretation applies by holography also to the light-like 3-surfaces at which the signature of the induced metric changes from Euclidian to Minkowskian. Additional boosts are due to ZEO allowing to interpret the Feynman diagrams as a characterization of zero energy states. Also strong form of holography, bosonic emergence, finite measurement resolution realized as discretization allows to replaced space-time sheets with string world sheets with the ends of string world sheets realized as braid strands, the realization that knotting of these strings is possible and could play a key role, and the connection with twistor approach have been important stimuli. The special role of 10 Hz frequency assignable to electron suggests that generalized Feynman diagrams could be relevant also for TGD inspired biology.

ZEO together with the notion of bosonic emergence leads to a new view about Feynman diagrams. The new element is that all physical states consist basically of wormhole throats which carry light-like four-momentum. Even virtual momenta are light-like and space-like four-momenta are obtained for wormhole contacts for which the energies of light-like states are of opposite sign. This leads to very powerful constraints on loop diagrams and there are good reasons to believe that both UV and IR divergences are absent.

Finite measurement resolution allows to assign braid strands to the light-like 3-surfaces and string world sheets to the 4-surfaces and one can also identify the braid strands as lines of generalized Feynman diagrams. It is possible to distinguish between light-like braids assignable to the light-like 3-surfaces and space-like braids connecting different partonic 2-surfaces at the ends of the space-time surface at the boundary of CD . Braids have also direct biological significance. DNA as topological quantum computer [K19] utilizes both kinds of braidings.

2.5.5 The superposition of classical fields in TGD Universe

Living system as conscious hologram is one of the basic visions. What one means with classical fields, their interference, and their interaction with elementary particles is an very essential aspect of what it is to be a hologram and a clarification to this issued emerged only during last year. As a matter fact, basic objection against TGD is that the interference of classical fields in the usual sense is not possible in TGD Universe!

In TGD Universe gauge fields are replaced with topological field quanta. Examples are topological light rays, magnetic/electric flux tubes and sheets, and flux quanta carrying both magnetic and electric fields. Flux quanta form a fractal hierarchy in the sense that there are flux quanta inside flux quanta. It is natural to assume quantization of Kähler magnetic flux. Braiding and reconnection are the basic topological operations for flux quanta.

The basic question is how the basic notions assigned with the classical gauge and gravitational fields understood in standard sense generalize in TGD framework.

1. Superposition and interference of the classical fields is very natural in Maxwell electrodynamics and certainly experimentally verified phenomena. Also the notion of hologram relies crucially on the notion of interference. How can one describe the effects explained in terms of superposition of fields in a situation in which the theory is extremely non-linear and all classical gauge fields are expressible in terms of CP_2 coordinates and their gradients? It is also rather clear that the preferred extremals for Kähler action decompose to space-time regions representing space-time correlates for quanta. The superposition of classical fields in Maxwellian sense is impossible.
2. How can one cope with this situation? The answer is based on simple observation: only the *effects* of the classical fields superpose. There is no need for the fields to superpose. Together with the notion of many-sheeted space-time this leads to elegant description of interference effects without any need to assume that linearization is a good approximation.

3. Topological quantization brings in also braiding and reconnection of magnetic flux tubes as basic operations for classical fields. These operations for flux tubes have also Maxwellian counterparts at the level of field lines. Braiding and reconnection are in a central role in TGD Universe and especially so in in TGD inspired theory of consciousness and quantum biology. The challenge is to build a coherent overall phenomenological view about the role of topologically quantized classical fields in biology and neuroscience. For instance, one can ask what is the precise formulation for the notion of conscious hologram and whether magnetic flux tubes could serve as correlates of entanglement (or at least negentropic entanglement suggested by the number theoretic vision and identified as a basic signature of living matter).
4. Topological quantization and the notion of magnetic body are especially important in TGD inspired model of EEG. The attempt to understand the findings of Persinger from the study of what is known as God helmet leads to a considerable progress in the understanding the possible role of topologically quantized classical fields in biology and neuro-science.

Mathematics

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Chapter 3

Quantum Mind in TGD Universe

3.1 Introduction

The notion of Quantum Mind [J40] has become a respected branch of science during thirty years since Esalen conference. The basic vision is that quantum superposition, quantum entanglement and state function reduction (or some of its interpretational equivalents) are somehow highly relevant for the understanding of consciousness. Whether quantum entanglement or quantum jump or something else is identified as a correlate for consciousness depends on theorist.

The basic objections against Quantum Mind is that standard quantum physics - at least wave mechanics- leaves no room for quantum mind. Decoherence leading to a loss of entanglement is the basic enemy of quantum mind [J64]. Experimental work however suggests that macroscopic quantum coherence prevails in cell length scale: the findings about photosynthesis provide an example of this [I14]. There is also a growing evidence for macro-entanglement between different brains correlating closely with electromagnetic fields [J55, J68].

Of course, the idea that wave mechanics is enough to describe living matter and also the belief that quantum theory - as we know it - is something final are only beliefs. There are many other similar beliefs: the belief on reductionism coded to the statement that everything above intermediate boson length scale is understood in recent day physics; the belief that living matter differs from inanimate matter only because it is very complex; the belief that experienced time and the geometric time of physicist are one and the same thing; the pragmatic belief that the problems of quantum measurement theory can be forgotten by saying that quantum theory is just a calculational recipe;...

One could add one further not quite obvious item to the list. Dark matter and dark energy are one of the most notorious problems of recent day physics and it is just a belief that dark matter is nothing but some exotic X-ino having very weak interactions with visible matter and therefore does not have any relevance for the understanding of living matter.

The basic message of this article is that standard quantum theory is not enough if one wants to construct a theory of Quantum Mind. A profound re-evaluation of the belief system underlying the ontology of the recent day quantum physics is needed. My own proposal is following.

- The reductionistic dogma is replaced with fractality meaning infinite hierarcies both at the level of matter and mind. Consciousness is everywhere in a form of self hierarchy so that Quantum Mind involves more than brain. Biological bodies, cells, biomolecules, and even elementary particles correspond to the levels of the self hierarchy. Also higher collective levels are present.
- Topological field structures implied by the new fractal view about space-time - I speak about many-sheeted space-time- are essential parts of this hierarchy. The notion of field (or magnetic) body is one aspect of the many-sheeted space-time and one could even say that magnetic body is the intentional agent using biological body as a motor instrument and sensory receptor. EEG and its various fractal analogs can be seen as communication and control tools of of the magnetic body in this conceptual framework. The explanation for the strange time delays associated the the passive aspects of consciousness discovered by Libet [J34] and the good hopes about understanding of fundamental biorhythms in terms of cyclotron frequencies of biologically important and Josephson frequencies assignable to cell membrane Josephson junctions [K17]

provide support for this vision. This conforms with the proposals that spin and more generally angular momentum are central for understanding consciousness and living matter [J43, J55]. Biological evolution becomes evolution of consciousness and one cannot restrict Quantum Mind to microtubules, brain, or even biological body.

- Self hierarchy has two physical correlates: the hierarchy of p-adic length scales and the hierarchy of Planck constants: both hierarchies have experimental support. A number theoretical miracle occurs: the length scale range 10 nm-2.5 μm involves as many as four Gaussian Mersennes expected to define preferred p-adic length scales since this they do so in the case of elementary particles. The effects of ELF em fields on vertebrate brain [J19] and the strange behavior of cell membrane and cell interior suggesting strongly quantal ionic currents [I61] provide physical support for both the hierarchy of Planck constants and p-adic length scale hypothesis.
- In TGD Universe zero energy ontology (ZEO) replaces the positive energy ontology of standard physics. The motivation comes both certain philosophical dilemma which is very frustrating for a theoretician, and the crossing symmetry of quantum field theory justifies ZEO. ZEO assigns new macroscopic time scale to each elementary particle. For electron and quarks these time scale coincide with fundamental biological time scales (for instance, the .1 second time scale predicted for electron corresponds to 10 Hz fundamental biorhythm). Elementary particle physics and biology are therefore strongly interrelated in ZEO.
- The identification of quantum jump as moment of consciousness and the notion of self emerge from a generalization of quantum measurement theory to a theory of consciousness. In this framework the experienced time identified as a sequence of quantum jumps and the geometric time of physicist cannot be identified [?]

The fact that the contents of conscious experience is about a four-dimensional region of space-time implies a new interpretation of memories [K60]. Quantum jump replacing the entire geometric future and past with a new one: Libet's strange findings about active aspects of consciousness [J46] forcing in positive energy ontology the conclusion that free will is illusion provide support for this view. The challenge is to understand the arrow of time and why the contents of sensory experience is localized to a rather short time interval of about .1 second: this suggests a rather dramatic radical idea about how the arrow of subjective time emerges as a consequence of Negentropy Maximization Principle [K42] defining the basic variational principle of TGD inspired theory of consciousness.

- p-Adic physics extending reality to include also various p-adic levels is highly relevant for the understanding of the difference between living and inanimate matter. Negentropic entanglement is possible for p-adic variant of Shannon entropy making sense if entanglement probabilities are algebraic. One can say that this entanglement is possible in the intersection of real and p-adic worlds in which intentions could transform to actions by quantum jumps replacing p-adic space-time sheets with real ones (this makes sense only in ZEO!). Maybe this is the mathematical and information theoretical quintessence of life.

Before continuing a comment about the notion of consciousness is in order. This notion as also the notion of awareness implicitly codes for the assumption that consciousness is a property of a physical system- something mathematically analogous to mass or charge. The greek word "nous" and finnish word "tajunta" refer to activity rather than property and this meaning is more appropriate in TGD framework. Since it would sound rather artificial to talk about "TGD inspired theory of nous" I will use the standard term in the sequel although it is misleading. It should be also emphasize that I represent only those aspects of a rather extensive work documented in the books at my homepage, which seem to be especially interesting just now. In the following representation I am forced to leave out all details. They can be found in the books about TGD inspired theory of consciousness at my homepage [K75, K9, K53, K29, K8, K35, K39, K68]. I have also summarized TGD inspired theory of consciousness in an issue of JCER [L19, L17, L18] but from different view point.

3.2 What are the problems of quantum mind theories?

In the following I list briefly the basic problems of physics and quantum mind theories using a classification which is rather natural from the point of view of physics.

3.2.1 Some philosophical problems of quantum physics

- "Monism, dualism, or something else?" is the first basic question. Monism appears as two variants which are mirror images. Materialism has the problem that consciousness becomes something totally reducible to the state of material system so that free will must be an illusion if one believes in the deterministic laws of physics. This is in a sharp contrast to what we directly experience. In the idealistic framework one loses completely physics. The difficulty of dualism - pointed out very clearly by Chalmers [J25] - is that it is very difficult to achieve consistency with the basic laws of physics which do not allow free will. It seems that one must have something new allowing to achieve consistency of the determinism of field equations with (partially) free will.
- "Reductionism or not?" is second key question. For me personally the realization that reductionism is a mere dogma was a painful process although it was from the beginning clear that TGD based view about space-time forces to challenge this belief. It was especially painful to take seriously the fact that even the reduction of chemical bond to wave mechanics alone is nothing but a belief since it is not yet testable by performing numerical calculations. Gradually I became conscious about the many non-existing bridges of reductionism: the bridge from quarks and gluons to hadrons; the bridge from nucleons to nuclei; the bridge from atoms to molecules; the bridges from inorganic chemistry to organic chemistry to biochemistry: all these bridges are just figments of wishful thinking and implications of the reductionistic dogma rather than support for it. Also the widely accepted argument about living matter as something which is just complex fails to be distinguishable from a rhetoric trick.
- "Determinism or not?" is the third question. Also here it took time to realize that the belief that free will is an illusion does not reflect the reality but our limited tools for describing it. The physicists of previous centuries did not have any conceptual and mathematical tools to describe free will without giving up the idea about laws of physics. Most importantly, they did not know anything about quantum non-determinism. Perhaps it is some kind of cognitive inertia that physicists have been ready to give up even the very notion of objective reality instead of accepting the fact that non-determinism is real and concluding that one should find an ontology consistent with both quantum non-determinism and Schrödinger equation.
- The notion of time is highly problematic.
 - The relationship between experienced time and the geometric time of physicist is poorly understood. Subjective time is irreversible and has only recent moment and past, geometric time is reversible and spans entire eternity. The assignment of experienced time with a 3-D wave front shifting in the direction of geometric time direction is in conflict with Lorentz symmetry and general coordinate invariance, which do not allow to identify a unique time coordinate as the subjective time. The natural basic object in general relativity is 4-dimensional space-time region, not time=constant snapshot.
 - In physics conceptual difficulties are encountered already in the phenomenological description of dissipation by adding to the reversible field equations phenomenological dissipation terms. Rather remarkably, the quantum mechanical formulas for the reaction rates in terms used to calculate dissipation coefficients involve integral over entire space-time so that quantum events have at least formally an infinite duration. Finite duration is certainly necessary by Uncertainty Principle. Somehow quantum jump seems to involve entire geometric eternity: as if it would take place between two geometric eternities.
 - There is also the problem of initial state. If the dynamics is deterministic and conservation laws hold, only a single solution of field equations is realized in classical physics and theoretical physics becomes useless waste of time since it cannot be tested. If quantum non-determinism is allowed, conservation laws still restrict the physical states to those

having fixed net values. "What was the initial state at the moment of Big Bang?" is the question which cannot be answered in the framework of physics alone and one ends up doing metaphysics. Indeed, the recent crisis of M-theory- meant to be the final jewel in the crown of materialistic and reductionistic science- has led to the landscape problem, and many colleagues have given up the hope that ultimate theory could predict anything so that anthropic principle would be the only manner to connect theory with experiment.

3.2.2 Basic philosophical problems of quantum mind theories

At least the following problems could be seen as basic philosophical problems of quantum mind theories.

- What are the quantum correlates for consciousness? Entanglement has been proposed as a correlate of consciousness. For instance, in the orchestrated reduction approach of Hameroff and Penrose the period of consciousness ends with a state function reduction and quantum gravitation is believed to play a fundamental role in the understanding of consciousness. The believer in free will could see state function reduction or its generalization as a natural quantum correlate for a moment of consciousness. The basic objection is that the randomness of state function reduction does not allow genuine goal directed free will. One could also argue that state function reduction generates entropy at least at the level of ensemble whereas intentional action should do just the opposite. Here one must however remember that entropy generation at the level of aspect need not mean entropy generation at the level of the member of ensemble.
- How the determinism of field equations and Schrödinger equation can be consistent with the non-determinism of the state function reduction? This question must be answered unless one is ready to give up the notion of objective reality completely or to believe in multiverse interpretation. These manners to circumvent the basic problem do not however leave much room for quantum consciousness theorizing. The closely related question about the relationship between experienced time and time of physicist has been already mentioned.
- What is the quantum correlate for the notion of self? The quantum notion of self should be a generalization of the notion of observer which in quantum measurement theory still remains a structureless outsider.
- What conscious information is? Can one give it a mathematical measure? Can one measure physically the amount of conscious information? Unfortunately the recent day physics can only provide measure for dis-information as Shannon entropy and the best that subsystem can achieve is no information at all if this picture is accepted.
- There is a bundle of questions about the quantum correlates of various aspects of conscious experience. For instance, what is the quantum correlate of mental image, and what are the quantum correlates of cognition and intentionality, Boolean mind, sensory qualia, memory, and of emotions?
- An especially challenging question relates to the quantum correlate for the self referentiality of consciousness making possible reflective levels of consciousness. What it means physically to be conscious about what one is (or perhaps only "was") conscious? Jack Sarfatti was well aware about this problem and in his dualistic approach talked about feedback loop but still used a trick in which one divides various fields to matter-like and mind-like.

3.2.3 Basic problems of quantum biology and quantum neuroscience

The basic problems of quantum biology and neuroscience are closely related unless one is ready to believe that consciousness reduces to one particular function assignable to some particular part of brain ("consciousness module"). This kind of assignment can be imagined in engineerish neuroscience identifying brain as electric circuitry but does not have much sense in quantum mind approach.

The first list of first principle questions includes at least the following ones.

- What distinguishes between living and dead matter is certainly the fundamental question. In standard biology based on materialistic philosophy one tries to reduce the distinction to a list of properties which as such can be possessed by inanimate matter. Ability to replicate, to process information, to communicate, to form representations about the external world, the ability to self-organize to increasingly complex configurations, intentional behavior, ability to co-operate,.... could be properties of this kind. Up to self-organization the reduction seems plausible. It is easy to model self-organization (by say cell automata) but its dynamics is like the dynamics of traffic rules and neither classical nor quantum dynamics resembles it. Intentional behavior is impossible to understand in classical physics unless one claims that it is a mere illusion. This is the case also in quantum physics as we understand it since the randomness of the outcome of state function reduction seems to be in conflict with intentional behavior. Here one must however keep in mind that the individual subsystem performing a state function reduction could quite well experience it as an intentional action. In any case, standard view about state function reduction makes it difficult to co-operative behavior.
- What distinguishes between biochemistry and organic chemistry? For instance, how biomolecules can find themselves in the dense soup of biomolecules and how can one understand the effectiveness of bio-catalysts? One might think that these problems are well-understood since we have learned what happens in DNA replication, transcription, and translation and we know the complex reaction pathways. The dynamics involved is very much like the symbolic dynamics of society (one can predict the day of practicing professional from knowing his profession but not from the knowledge of initial data of every possible elementary particle in his body). But what makes the soup of biomolecules a molecular society obeying a dynamics based on symbols? The description of biochemistry in terms of kinematics allows to construct complex reaction pathways based on the idea that each step of the reaction pathway requires a key which fits to a lock of a room containing a key to the lock to the next room [166] but can one really deduce this kind of kinematics from standard quantum theory?
- Both biology and neuroscience characterizes subsystems of biological systems and brain in terms of functions they possess and one should also understand whether and how the quantum counterparts of functions emerge. The identification of various functions as time evolution of standard self-organization patterns is certainly a part of the answer. But what self-organization means? Conscious information is certainly the key notion but is the existing quantum theory able to characterize it?
- At the level of brain one of the key questions concerns EEG. Since EEG correlates strongly with the contents of consciousness it is difficult to believe that it is random side product of neural activity. What is then the real role of neuronal activity and EEG and its variants? Why EEG is needed? Signaling related to communication and control is what comes first in mind. But why this kind of signaling would be needed. Brain sends (receives) information but who receives (sends) it?
- How macroscopic quantum coherence is achieved allowing quantum super-positions in long time scales? How stable quantum entanglement is achieved? These are difficult problems if one wants to understand quantum mind without generalizing quantum theory itself. Planck constant is simply too small so that dissipation rates are too high and coherence times and lengths are too short. Should physicists adopt a humbler attitude and consider seriously the possibility that the existing physics is not enough and try to learn from biology instead of saying that living systems are just complex?

3.2.4 Could anomalies help?

Anomalies are the best way to end up with a discovery of something new. Of course, living matter as such is a gigantic anomaly but this does not help much. One should pick up the anomalies which are in sharp conflict with the existing physics and give a clear hint about what is wrong with our cherished assumptions.

- In quantum mind approach EEG should be a quantal phenomenon since it correlates with consciousness. From the basic formula $E = hf$ of quantum mechanics the energies of EEG

photons are however ridiculously small as compared to the thermal energy at physiological temperatures. The strange quantal looking effects of ELF photons on vertebrate (why just vertebrate?!) brain at frequencies which correspond to cyclotron frequencies of biologically important ions such as Ca^{++} are however an experimental fact (see for instance [J19]). The effects of magnetic field patterns on brain studied by Persinger and collaborators represent also an example of this kind of strange effects [J54]. The strange findings about the behavior of cell membrane [I61] suggest that ionic currents do not dissipate much. The recently discovered burning of water when irradiated by radiowave photons [D11, D1] suggests that energetically these photons behave like photons of visible light. The recent findings about photosynthesis [I14] suggest quantum coherence in cellular length scale.

Is standard quantum theory able to explain these findings? Should one challenge the belief that Planck constant is just a conversion factor between units which can be put equal one with a suitable choice of units? Could Planck constant have a spectrum of discrete values? This would explain the strange findings since by $E = hf$ relation low frequencies could correspond to high energies and dissipation rates -in the first guess inversely proportional to \hbar - could be very small. Large values of Planck constant would also increase the spatial and time scales of quantum coherence and might solve the basic technical problem of quantum consciousness theories.

- Also biophotons [I26] correlate with the state of living system but are poorly understood in the existing theoretical framework.
- Libet's findings about strange time delays associated with the passive aspects of consciousness serve also as a hint. Our sensory data has age which is a fraction of second and corresponds to a photon wavelength $\lambda = cT$ to a length scale, which is of order of Earth size. As if sensory data would be communicated somewhere. Where?
- Cyclotron frequencies of biologically important ions in a magnetic field .2 Gauss (smaller than the nominal value of .5 Gauss of the Earth's magnetic field) are involved with the effects of ELF radiation on vertebrate brain. Also Schumann resonances are reported to have effects on brain. Are some kind of magnetic field structures involved? Earth's magnetic field and perhaps also the magnetic field patterns associated with biological system itself with $B = 2B_E/5$ for one important level in the hierarchy? As noticed in [J55], the cyclotron energy scale of electron in pT range is in EEG range and pT range indeed characterizes the magnetic field associated with brain activity. Do also these magnetic structures carry Cooper pairs of electrons?
- ADP-ATP machinery is the core of energy metabolism and its description involves the problematic notion of high energy phosphate bond [I7]. Does this notion really reduce to standard quantum theory?
- The chiral selection of biomolecules in living matter [I2, I56] means a large parity breaking. This is a complete mystery in standard model which predicts extremely small parity breaking effects. Therefore chiral selection is extremely valuable anomaly helping to guess what kind of new physics might be involved with living matter. Somehow it seems that the parity breaking effects which are large in electro-weak scale appear in immensely zoomed up scales (scaling factors of order 10^{10} would be involved)

3.3 Some aspects of quantum TGD

In the following I summarize very briefly those basic notions of TGD which are especially relevant for TGD inspired consciousness theory and quantum biology. The representation will be practically formula free. The article series published in Prespacetime Journal [L11, L12, L15, L16, L13, L10, L14, L20] describes the mathematical theory behind TGD. The seven books about TGD [K82, K61, K47, K45, K70, K62, K69] provide a detailed summary about the recent state of TGD.

3.3.1 New space-time concept

The physical motivation for TGD was what I have christened the energy problem of General Relativity. The notion of energy is ill-defined because the basic symmetries of empty space-time are lost in the

presence of gravity. The way out is based on assumption that space-times are imbeddable as 4-surfaces to certain 8-dimensional space by replacing the points of 4-D empty Minkowski space with 4-D very small internal space. This space -call it S - is unique from the requirement that the theory has the symmetries of standard model: $S = CP_2$, where CP_2 is complex projective space with 4 real dimensions [L20], is the unique choice.

The replacement of the abstract manifold geometry of general relativity with the geometry of surfaces brings the shape of surface as seen from the perspective of 8-D space-time and this means additional degrees of freedom giving excellent hopes of realizing the dream of Einstein about geometrization of fundamental interactions.

The work with the generic solutions of the field equations assignable to almost any general coordinate invariant variational principle led soon to the realization that the space-time in this framework is much more richer than in general relativity.

1. Space-time decomposes into space-time sheets with finite size: this lead to the identification of physical objects that we perceive around us as space-time sheets. For instance, the outer boundary of the table is where that particular space-time sheet ends. Besides sheets also string like objects and elementary particle like objects appear so that TGD can be regarded also as a generalization of string models obtained by replacing strings with 3-D surfaces.
2. Elementary particles are identified as topological inhomogenities glued to these space-time sheets. In this conceptual framework material structures and shapes are not due to some mysterious substance in slightly curved space-time but reduce to space-time topology just as energy-momentum currents reduce to space-time curvature in general relativity.
3. Also the view about classical fields changes. One can assign to each material system a field identity since electromagnetic and other fields decompose to topological field quanta. Examples are magnetic and electric flux tubes and flux sheets and topological light rays representing light propagating along tube like structure without dispersion and dissipation making em ideal tool for communications [K48]. One can speak about field body or magnetic body of the system.

Field body indeed becomes the key notion distinguishing TGD inspired model of quantum biology from competitors. The magnetic body inherits from the biological body an onionlike fractal structure. Each part of the magnetic body can be seen as an intentional agent using the corresponding part of the biological body as a motor instrument and sensory receptor. The size scale of the magnetic body is in general much larger than that of biological body. Cyclotron frequency identified as frequency of photons able to exist as oscillations at magnetic body gives an estimate for the size of the magnetic body corresponding to a particular magnetic field strength. For 10 Hz frequency the size scale is of order Earth size. In this framework a fractal generalization of EEG and its variants provides a communication and control tool for magnetic body. The findings of Libet about time delays associated with the passive aspects and meaning that sensory data is a fraction of second old [J34] could be understood as delays due to the finite velocity of light: it takes finite time for the signal to propagate from biological body to the magnetic body.

This obviously means a profound modification of the views about what we are. The identification with the biological body could be understood as an illusion: a child looking a movie assimilates completely with the hero. There is a rich variety of illusions related to this identification of observer with the region of space from which the dominating contribution to consciousness comes from.

3.3.2 Zero energy ontology

In standard ontology of quantum physics physical states are assumed to have positive energy. In zero energy ontology physical states decompose to pairs of positive and negative energy states such that all net values of the conserved quantum numbers vanish. The interpretation of these states in ordinary ontology would be as transitions between initial and final states, physical events. By quantum classical correspondences zero energy states must have space-time and imbedding space correlates.

1. Positive and negative energy parts reside at future and past light-like boundaries of causal diamond (CD) defined as intersection of future and past directed light-cones and visualizable as double cone. The analog of CD in cosmology is big bang followed by big crunch. CD s for

a fractal hierarchy containing CDs within CDs . Disjoint CDs are possible and CDs can also intersect.

2. p-Adic length scale hypothesis [?] motivates the hypothesis that the temporal distances between the tips of the intersecting light-cones come as octaves $T = 2^n T_0$ of a fundamental time scale T_0 defined by CP_2 size R as $T_0 = R/c$. One prediction is that in the case of electron this time scale is .1 seconds defining the fundamental biorhythm. Also in the case u and d quarks the time scales correspond to biologically important time scales given by 10 ms for u quark and by 2.5 ms for d quark [K6]. This means a direct coupling between microscopic and macroscopic scales.

Zero energy ontology conforms with the crossing symmetry of quantum field theories meaning that the final states of the quantum scattering event are effectively negative energy states. As long as one can restrict the consideration to either positive or negative energy part of the state ZEO is consistent with positive energy ontology. This is the case when the observer characterized by a particular CD studies the physics in the time scale of much larger CD containing observer's CD as a sub- CD . When the time scale sub- CD of the studied system is much shorter than the time scale of sub- CD characterizing the observer, the interpretation of states associated with sub- CD is in terms of quantum fluctuations.

ZEO solves the problem of initial state since in principle any zero energy state is obtained from any other state by a sequence of quantum jumps without breaking of conservation laws. The fact that energy is not conserved in general relativity based cosmologies can be also understood since each CD is characterized by its own conserved quantities. As a matter of fact, one must speak about average values of conserved quantities since one can have a quantum superposition of zero energy states with the quantum numbers of the positive energy part varying over some range.

For thermodynamical states this is indeed the case and this leads to the idea that quantum theory in ZEO can be regarded as a "complex square root" of thermodynamics obtained as a product of positive diagonal square root of density matrix and unitary S -matrix. M -matrix defines time-like entanglement coefficients between positive and negative energy parts of the zero energy state and replaces S -matrix as the fundamental observable. In standard quantum measurement theory this time-like entanglement would be reduced in quantum measurement and regenerated in the next quantum jump if one accepts Negentropy Maximization Principle (NMP) [K42] as the fundamental variational principle. Various M -matrices define the rows of the unitary U matrix characterizing the unitary process part of quantum jump. From the point of view of consciousness theory the importance of ZEO is that conservation laws in principle pose no restrictions for the new realities created in quantum jumps: free will is maximal.

3.3.3 The hierarchy of Planck constants

The motivations for the hierarchy of Planck constants come from both astrophysics and biology. The biological motivations have been already discussed. In astrophysics the observation of Nottale [E7] that planetary orbits in solar system seem to correspond to Bohr orbits with a gigantic gravitational Planck constant motivated the proposal that Planck constant might not be constant after all [K66, K49].

This led to the introduction of the quantization of Planck constant as an independent postulate. It has however turned that quantized Planck constant in effective sense could emerge from the basic structure of TGD alone. Canonical momentum densities and time derivatives of the imbedding space coordinates are the field theory analogs of momenta and velocities in classical mechanics. The extreme non-linearity and vacuum degeneracy of Kähler action imply that the correspondence between canonical momentum densities and time derivatives of the imbedding space coordinates is 1-to-many: for vacuum extremals themselves 1-to-infinite.

A convenient technical manner to treat the situation is to replace imbedding space with its n -fold singular covering. Canonical momentum densities to which conserved quantities are proportional would be same at the sheets corresponding to different values of the time derivatives. At each sheet of the covering Planck constant is effectively $\hbar = n\hbar_0$. This splitting to multisheeted structure can be seen as a phase transition reducing the densities of various charges by factor $1/n$ and making it possible to have perturbative phase at each sheet (gauge coupling strengths are proportional to $1/\hbar$ and scaled down by $1/n$). The connection with fractional quantum Hall effect [D2] is almost obvious. At the more detailed level one finds that the spectrum of Planck constants would be given by $\hbar = n_a n_b \hbar_0$.

This has many profound implications, which are wellcome from Quantum Mind perspective.

1. Quantum coherence and quantum superposition become possible in arbitrary long length scales. One can speak about zoomed up variants of elementary particles and zoomed up sizes make it possible to satisfy the overlap condition for quantum length parameters used as a criterion for the presence of macroscopic quantum phases. In the case of quantum gravitation the length scale involved are astrophysical. This would conform with Penrose's intuition that quantum gravity is fundamental for the understanding of consciousness and also with the idea that consciousness cannot be localized to brain.
2. Photons with given frequency can in principle have arbitrarily high energies by $E = hf$ formula, and this would explain the strange anomalies associated with the interaction of ELF em fields with living matter [J19]. Quite generally the cyclotron frequencies which correspond to energies much below the thermal energy for ordinary value of Planck constant could correspond to energies above thermal threshold.
3. The value of Planck constant is a natural characterizer of the evolutionary level and biological evolution would mean a gradual increase of the largest Planck constant in the hierarchy characterizing given quantum system. Evolutionary leaps would have interpretation as phase transitions increasing the maximal value of Planck constant for evolving species. The space-time correlate would be the increase of both the number and the size of the sheets of the covering associated with the system so that its complexity would increase.
4. The phase transitions changing Planck constant change also the length of the magnetic flux tubes. The natural conjecture is that biomolecules form a kind of Indra's net connected by the flux tubes and \hbar changing phase transitions are at the core of the quantum bio-dynamics. The contraction of the magnetic flux tube connecting distant biomolecules would force them near to each other making possible for the bio-catalysis to proceed. This mechanism could be central for DNA replication and other basic biological processes. Magnetic Indra's net could be also responsible for the coherence of gel phase and the phase transitions affecting flux tube lengths could induce the contractions and expansions of the intracellular gel phase. The reconnection of flux tubes would allow the restructuring of the signal pathways between biomolecules and other subsystems and would be also involved with ADP-ATP transformation inducing a transfer of negentropic entanglement [K23]. The braiding of the magnetic flux tubes could make possible topological quantum computation like processes and analog of computer memory realized in terms of braiding patterns [K19].
5. p-Adic length scale hypothesis and hierarchy of Planck constants suggest entire hierarchy of zoomed up copies of standard model physics with range of weak interactions and color forces scaling like \hbar . This is not conflict with the known physics for the simple reason that we know very little about dark matter (partly because we might be making misleading assumptions about its nature).

Dark matter would make possible the large parity breaking effects manifested as chiral selection of bio-molecules [I2]. What is required is that classical Z^0 and W fields responsible for parity breaking effects are present in cellular length scale. If the value of Planck constant is so large that weak scale is some biological length scale, weak fields are effectively massless below this scale and large parity breaking effects become possible.

For the solutions of field equations which are almost vacuum extremals Z^0 field is non-vanishing and proportional to electromagnetic field. The hypothesis that cell membrane corresponds to a space-time sheet near a vacuum extremal (this corresponds to criticality very natural if the cell membrane is to serve as an ideal sensory receptor) leads to a rather successful model for cell membrane as sensory receptor with lipids representing the pixels of sensory qualia chart. The surprising prediction is that bio-photons [I26] and bundles of EEG photons can be identified as different decay products of dark photons with energies of visible photons. Also the peak frequencies of sensitivity for photoreceptors are predicted correctly [K56].

3.3.4 p-Adic physics and number theoretic universality

p-Adic physics [K73, K45] has become gradually a key piece of TGD inspired biophysics. Basic quantitative predictions relate to p-adic length scale hypothesis and to the notion of number theoretic entropy. Basic ontological ideas are that life resides in the intersection of real and p-adic worlds and that p-adic space-time sheets serve as correlates for cognition and intentionality.

p-Adic number fields

p-Adic number fields Q_p [A6] -one for each prime p - are analogous to reals in the sense that one can speak about p-adic continuum and that also p-adic numbers are obtained as completions of the field of rational numbers. One can say that rational numbers belong to the intersection of real and p-adic numbers. p-Adic number field Q_p allows also an infinite number of its algebraic extensions. Also transcendental extensions are possible. For reals the only extension is complex numbers.

p-Adic topology defining the notions of nearness and continuity differs dramatically from the real topology. An integer which is infinite as a real number can be completely well defined and finite as a p-adic number. In particular, powers p^n of prime p have p-adic norm (magnitude) equal to p^{-n} in Q_p so that at the limit of very large n real magnitude becomes infinite and p-adic magnitude vanishes.

p-Adic topology is rough since p-adic distance $d(x, y) = d(x - y)$ depends on the lowest binary digit of $x - y$ only and is analogous to the distance between real points when approximated by taking into account only the lowest digit in the decimal expansion of $x - y$. A possible interpretation is in terms of a finite measurement resolution and resolution of sensory perception. p-Adic topology looks somewhat strange. For instance, p-adic spherical surface is not infinitely thin but has a finite thickness and p-adic surfaces possess no boundary in the topological sense. Ultrametricity is the technical term characterizing the basic properties of p-adic topology and is coded by the inequality $d(x - y) \leq \text{Min}\{d(x), d(y)\}$. p-Adic topology brings in mind the decomposition of perceptive field to objects.

Physical and biological motivations for p-adic number fields

The physical motivations for p-adic physics came from the observation that p-adic thermodynamics -not for energy but infinitesimal scaling generator of so called super-conformal algebra [A1] acting as symmetries of quantum TGD [K61]- predicts elementary particle mass scales and also masses correctly under very general assumptions [K45]. In particular, the ratio of proton mass to Planck mass, the basic mystery number of physics, is predicted correctly. The basic assumption is that the preferred primes characterizing the p-adic number fields involved are near powers of two: $p \simeq 2^k$, k positive integer. Those nearest to power of two correspond to Mersenne primes $M_n = 2^n - 1$. One can also consider complex primes known as Gaussian primes, in particular Gaussian Mersennes $M_{G,n} = (1 + i)^n - 1$.

It turns out that Mersennes and Gaussian Mersennes are in a preferred position physically in TGD based world order. What is especially interesting that the length scale range 10 nm-2.5 μ assignable to DNA contains as many as 4 Gaussian Mersennes corresponding to $n = 151, 157, 163, 167$ [K56]. This number theoretical miracle supports the view that p-adic physics is especially important for the understanding of living matter.

p-Adic length scale hypothesis suggests the identification of metabolic energy currencies as energy quanta liberated as particle drops from space-time sheet to a larger one. These energy quanta correspond to increments of zero point kinetic energy. Metabolic energy currencies would be completely universal and exist already during the prebiotic era so that metabolic machinery would build up around this pre-existing structure. A simple (and also rough) model based on p-adic length scale hypothesis allows to estimate the increments of zero point kinetic energy. The quantum corresponding to about .5 eV has place in this hierarchy for which basic energies (those for which larger space-time sheet is very large) come as octaves of basic energy quantum [K6, K33]. These energy quanta do not have interpretation in terms of molecular transitions and there exist anomalous lines of radiation from interstellar space both in IR, visible, and UV region [K6].

p-Adic physics as correlate for cognition and intentionality

The philosophical for p-adic numbers fields come from the question about the possible physical correlates of cognition and intention [K46]. Cognition forms representations of the external world which

have finite cognitive resolution and the decomposition of the perceptive field to objects is an essential element of these representations. Therefore p-adic space-time sheets could be seen as candidates of thought bubbles, the mind stuff of Descartes. One can also consider p-adic space-time sheets as correlates of intentions. The quantum jump in which p-adic space-time sheet is replaced with a real one could serve as a quantum correlate of intentional action. This process is forbidden by conservation laws in standard ontology: one cannot even compare real and p-adic variants of the conserved quantities like energy in the general case. In zero energy ontology the net values of conserved quantities for zero energy states vanish so that conservation laws allow these transitions.

Life as something in the intersection of real and p-adic worlds

Rational numbers belong to the intersection of real and p-adic continua. An obvious generalization of this statement applies to real manifolds and their p-adic variants. When extensions of p-adic numbers are allowed, also some algebraic numbers can belong to the intersection of p-adic and real worlds. The notion of intersection of real and p-adic worlds has actually two meanings.

1. The intersection could consist of the rational and possibly some algebraic points in the intersection of real and p-adic partonic 2-surfaces at the ends of CD . This set is in general discrete. The interpretation could be as discrete cognitive representations.
2. The intersection could also have a more abstract meaning. For instance, the surfaces defined by rational functions with rational coefficients have a well-defined meaning in both real and p-adic context and could be interpreted as belonging to this intersection. There is strong temptation to assume that intentions are transformed to actions only in this intersection. One could say that life resides in the intersection of real and p-adic worlds in this abstract sense.

Additional support for the idea comes from the observation that Shannon entropy $S = -\sum p_n \log(p_n)$ allows a p-adic generalization if the probabilities are rational numbers by replacing $\log(p_n)$ with $-\log(|p_n|_p)$, where $|x|_p$ is p-adic norm. Also algebraic numbers in some extension of p-adic numbers can be allowed. The unexpected property of the number theoretic Shannon entropy is that it can be negative and its unique minimum value as a function of the p-adic prime p it is always negative. Entropy transforms to information!

In the case of number theoretic entanglement entropy there is a natural interpretation for this. Number theoretic entanglement entropy would measure the information carried by the entanglement whereas ordinary entanglement entropy would characterize the uncertainty about the state of either entangled system. For instance, for p maximally entangled states both ordinary entanglement entropy and number theoretic entanglement negentropy are maximal with respect to R_p norm. Entanglement carries maximal information. The information would be about the relationship between the systems, a rule. Schrödinger cat would be dead enough to know that it is better to not open the bottle completely.

Negentropy Maximization Principle [K42] coding the basic rules of quantum measurement theory implies that negentropic entanglement can be stable against the effects of quantum jumps unlike entropic entanglement. Therefore living matter could be distinguished from inanimate matter also by negentropic entanglement possible in the intersection of real and p-adic worlds. In consciousness theory negentropic entanglement could be seen as a correlate for the experience of understanding or any other positively colored experience, say love.

Negentropically entangled states are stable but binding energy and effective loss of relative translational degrees of freedom is not responsible for the stability. Therefore bound states are not in question. The distinction between negentropic and bound state entanglement could be compared to the difference between unhappy and happy marriage. The first one is a social jail but in the latter case both parties are free to leave but do not want to. The special characteristics of negentropic entanglement raise the question whether the problematic notion of high energy phosphate bond citebbioHEP central for metabolism could be understood in terms of negentropic entanglement. This would also allow an information theoretic interpretation of metabolism since the transfer of metabolic energy would mean a transfer of negentropy [K23].

3.4 Consciousness theory as extension of quantum measurement theory

TGD inspired theory of consciousness [K40] could be seen as a generalization of quantum measurement theory. The notions of quantum jump and self self are the key notions. Negentropy Maximization Principle (NMP) [K42] is the basic dynamical principle. NMP is mirror image for the second law of thermodynamics and states that the amount of conscious information gain in quantum jump is maximal. NMP reproduces standard quantum measurement theory for entropic entanglement and is in this case consistent with the second law since the non-determinism of state function reductions implies the increase of ensemble entropy.

3.4.1 Quantum jumps as moment of consciousness

The starting point of TGD inspired theory of consciousness was the identification of quantum jump as a moment of consciousness [K40].

1. Quantum jump has a complex anatomy which however simplifies in ZEO. Quantum jump involves unitary time evolution leading from a state resulting in state function reduction to a quantum superposition of states: one could speak of multiverse. This step is described by the counterpart of the unitary process of Penrose and is coded by a unitary matrix U in the state space formed by zero energy states. U is therefore not identifiable directly as S -matrix of quantum field theories but contains as its rows all possible M -matrices which are what particle physicist tries to measure in laboratory. State function reduction and state preparation can be assigned to the opposite light-like boundaries of CD .

A good metaphor is Djinn in the bottle. In U -process bottle is opened and Djinn comes out and creates a quantum superposition of all possible worlds. The wish of the observer is fulfilled and leads to a state function reduction. Actually there is an entire cascade of state function reductions starting from the level of the entire universe which splits the entanglement sub-systems already obtained in a step-wise manner to pairs un-entangled sub-systems. The splitting for a given sub-system occurs only if it is consistent with NMP.

For the ordinary definition of entanglement entropy the process would lead to a completely unentangled situation. If the number theoretic entanglement entropy making sense for rational (and even algebraic) entanglement probabilities is allowed, the process stops unless the reduction of entanglement reduces the entanglement entropy. Therefore the number theoretic entanglement possible in the intersection of real and p -adic worlds can be stable and living systems are able to preserve their coherence.

2. Since the reduction cascade proceeds from top to bottom, one can speak about fractal formed by quantum jumps within quantum jumps. One cannot assign to the steps of this sequence any duration of geometric time. One can however associate to it an experienced duration and it is very tempting to assume that the experienced duration increases as one climbs up in the self hierarchy.
3. Quantum jump replaces the quantum superposition of classical histories (space-time surfaces, classical worlds) with a new one whereas ordinary state function reduction would do this for time=constant snapshot of Schrödinger evolution. Quantum jump does not spoil the determinism of classical dynamics or of Dirac equation since it occurs entirely outside space-time and Hilbert space. In quantum jump both the geometric future and past (defined only within measurement resolution) are replaced with new ones. The mysterious finding of Libet [J46] that intentional action is preceded by neural activity can be interpreted in this framework without giving up the notion of free will. This raises a fascinating question about time scales in which the geometric past can be affected in quantum jump. Also memories stored in the geometric past can be affected in quantum jumps and the fact that memories are highly unstable suggest that the time scale is measured in years.

It must be added that the notion of classical determinism in its standard form fails due to the special properties of Kähler action (vacuum degeneracy mathematically analogous to a gauge

degeneracy but physically analogous to 4-D spin glass degeneracy). This failure provides a space-time correlate for the non-determinism of the quantum jump sequence.

3.4.2 The notion of self

The notion of self is second basic notion introduced originally as a notion independent from quantum jump. It however seems that the notion of self could be reduced to that of quantum jump.

1. The notion of self can be seen as a generalization of the notion of observer. The natural first guess inspired by the standard notion of entanglement entropy was that self is a subsystem able to remain unentangled during a sequence of quantum jumps. Self would be a system able to preserve its quantum identity. In the case of negentropic entanglement a more natural interpretation is that expansion of consciousness rather than loss of it is experienced as self entangles with second system negentropically. Only entropic entanglement would lead to a loss of consciousness. Second condition would be that self is stable against splitting to unentangled subsystems. This criterion is satisfied if self corresponds to a system for which the entanglement between its subsystems is negentropic.

Self experiences its sub-selves as mental images and even we would represent mental images of some higher collective self. Everything would be conscious but consciousness could be lost. The flow of consciousness for a given self could be due to the quantum jump sequences performed by its sub-selves giving rise to mental images.

2. The fractal structure of quantum jump suggests that the notions of self and quantum jump are one and same thing. The fractal hierarchy of quantum jumps would correspond to fractal hierarchy of selves. This fractal hierarchy is very much analogous and closely related to the hierarchy formed by physical systems extending from elementary particle level to arbitrary long astrophysical scales. The hierarchy of Planck constants and NMP with number theoretic entanglement entropy predicts that particle like entities are possible in all length scales.
3. By quantum classical correspondence self has also space-time correlates. One can visualize subself as a space-time sheet "glued" by topological sum to the space-time sheet of self. Subsystem is not described as a tensor factor as in the standard description of subsystems. Also subselves of selves can entangle negentropically and this gives rise to a sharing of mental images about which stereo vision would be basic example. Quite generally, one could speak of stereo consciousness. Also the experiences of sensed presence [J55] could be understood as a sharing of mental images between brain hemispheres which are not themselves entangled. This is possible also between different brains. In the normal situation brain hemispheres are entangled.
4. At the level of 8-dimensional imbedding space the natural correlate of self would be CD (causal diamond). At the level of space-time the correlate would be space-time sheet or light-like 3-surface. The contents of consciousness of self would be determined by the space-time sheets in the interior of CD . Without further restrictions the experience of self would be essentially four-dimensional. Memories would be like sensory experiences except that they would be about the geometric past and for some reason are not usually colored by sensory qualia. As already noticed, .1 second time scale defining the duration of moment for sensory experience corresponds to that of electron's CD which suggests that Cooper pairs of electrons are essential for the sensory qualia.

3.4.3 How experienced time and the geometric time of physicist relate to each other?

The relationship between experienced time and time of physics is one of the basic puzzles of modern physics. In the proposed framework they are certainly two different things and the challenge is to understand why the correlation between them is so strong that it has led to their identification. One can imagine several alternative views explaining this correlation [K80, K81, K5] and it is better to keep mind open.

Basic questions

The flow of subjective time corresponds to quantum jump sequences for sub-selves of self having interpretation as mental images. If mind is completely empty of mental images subjectively experienced time ceases to exist. This leaves however several questions to be answered.

1. Why the contents of conscious of self comes from a finite space-time region looks like an easy question. If the contents of consciousness for subselves representing mental images is localized to the sub- CD s with indeed have defined temporal position inside CD assigned with the self the contents of consciousness is indeed from a finite space-time volume. This implies a new view about memory. There is no need to store again and again memories to the "brain now" since the communications with the geometric past by negative energy signals and also time-like negentropic quantum entanglement allow the sharing of the mental images of the geometric past.
2. There are also more difficult questions. Subjective time has arrow and has only the recent and possibly also past. The subjective past could in principle reduce to subjective now if conscious experience is about 4-D space-time region so that memories would be always geometric memories. How these properties of subjective time are transferred to apparent properties of geometric time? How the arrow of geometric time is induced? How it is possible that the locus for the contents of conscious experience shifts or at least seems to be shifted quantum jump by quantum jump to the direction of geometric future? Why the sensory mental images are located in a narrow time interval of about .1 seconds in the usual states of consciousness (not that sensory memories are possible: scent memories and phantom pain in leg could be seen as examples of vivid sensory memory)?

Just to make illustrate how many different aspects are involved and in the hope that various constraints would allow to select among many alternatives that one can imagine (and have imagined!), let us first try to list basic questions in the framework provided by ZEO.

1. ZEO forces the arrow of geometric time to become a property of zero energy states. What does this mean concretely? Could the observed arrow of time reduce solely to this arrow?
2. Do sub- CD s drift in preferred time direction inside CD ? Or do space-time sheets drift inside CD to preferred direction. Or is there a phase transition proceeding in the direction of geometric time of CD associated with the entire CD and inducing state function reduction for sub- CD s: it would not matter what boundary of sub- CD is selected if sub- CD would be effectively point-like. The quantum arrow of time for zero energy state should force preferred direction of this phase transition.
3. Does the U process as a cascade proceeding from long scales of CD s to short ones involve explicitly the arrow of geometric time. For instance, could state function reduction cascade for sub- CD s with a given scale correspond to a process analogous to burning proceeding towards geometric future? Or could a phase transition transforming p-adic space-time sheets to real ones as a realization of intentional action proceed in this manner?
4. Do space-time sheets possess an arrow of geometric time coming from the failure of strict determinism (shock waves in hydrodynamics) and giving space-time correlate for the quantum arrow of time? In hydrodynamics second law allows to select between alternative developments in multi-furcation. Could second law or NMP be involved also now?
5. What is the role of the fractal hierarchy of CD ? Also entanglement between sub- CD s carrying zero energy states is possible. Could the state function reductions occurring for sub- CD s give rise to the experience of flow of time at the level of CD . Do these quantum jumps occur for some reason in a time ordered manner (light-cone proper time defines a unique Lorentz invariant time ordering). Could the entanglement anatomy of zero energy states force this automatically? The process would be analogous to burning.
6. Suppose that the idea about time flip-flop meaning that unitary process reduces to a base change between basis with opposite arrows of geometric time. Doesn't this imply that the arrow of geometric time changes its direction alternately or is there a manner to avoid this conclusion?

7. State function reduction involves a reduction of entanglement between quantum variables and classical variables represented by zero modes in TGD Universe. Does this reduction play a key role in the generation of the arrow of time. What is the role of negentropic entanglement? For instance, could it be that the generation of negentropic entanglement at second end of the CD stabilizes the states with respect to state function reduction leading to counterpart of Orch OR?
8. The geometry of light-cone has intrinsic arrow of time. The question is how this arrow induces the arrow of experienced geometric arrow of time with minimal assumption (from structure of zero energy states).
9. The localization of sensory experience to short time interval does not define so strong constraint as one might think since if sensory mental images correspond to small enough sub- CD s, the localization inside sub- CD is enough. For CD itself the localization to either boundary looks natural since state function reduction takes place at the boundary.

First trial

Possible answers to these questions could rely on NMP if understood as a sufficiently general principle. Suppose that NMP translates to the statement that selves are eager to gain conscious information. The mere assumption that selves are curious leaves a lot of room for alternatives and one can imagine several models. Note also that geometric time can correspond to the local time assignable to space-time sheet or to the cosmic time assignable to the CD or to 8-D imbedding space.

1. The space-time in the geometric future above the "upper" light-like boundary of CD represents the unknown where the news come from. Negentropic self has to some extent free will and can perform quantum jumps inducing effectively the shift of the quantum superposition of the space-time surfaces towards geometric past. The news come from the future and represent sensory input and induce subelves as mental images. The population of sensory subelves would tend to be created near the "upper" boundary of CD . This would induce a breaking of time reversal invariance and spontaneous arrow of geometric time. Self would be like a person in movie theater. Self would not move anywhere, space-time surfaces -the film- would move with respect to self.
2. One can consider also alternative view analogous to the standard view if one assumes that the CD s representing subelves can shift towards geometric future in the sequence of quantum jumps. Suppose that U process creates a quantum superposition over temporal positions of CD and that temporal localization takes place during the state function reduction process. Also now the strong form of NMP could force a drift of the sub-self population towards unknown defining the geometric future. The geometric time would be assignable to the larger CD . Also the first option allows drifting of subelves to the upper boundary of CS as a consequence of strong form of NMP.

One might hope that spontaneous breaking of time reversal invariance alone could explain the induced arrow of geometric time so that the arrow of time would not be a result of intentional action. Following options represent attempts to understand the arrow of cosmic time as something analogous to diffusion in half-space.

1. Self is a subself of larger self and the corresponding CD could induce a breaking of time reversal invariance since the proper time coordinate for CD has only positive values so that a diffusion and even drift towards geometric future could result. If subself is nearer to the lower boundary of the larger CD it tends to diffuse upwards and vice versa. In the middle of the larger CD , where the analog of cosmic expansion changes to contraction geometric time would stop.
2. Second option is based on the observation that the size scale of given CD must increase on the average during quantum jump sequence. These events correspond to phase transitions increasing the size scale of CD by a factor of two and could serve as correlate for cosmic expansion. When one fixes either tip of CD , the second tip moves towards future with respect to it in discrete phase transition like steps. This discrete time evolution might define a quantum correlate for the flow of cosmic time at imbedding space level [K67].

More detailed discussions of the problem can be found in [K5]. In any case, it must be admitted that something important piece of understanding is still lacking. The following represents one of the many attempts to identify this piece and relies on single new input: zero energy states possess quantum arrow of time.

Second trial

ZEO allows to assign to zero energy states an arrow of time naturally since one can require that states have well defined single particle quantum numbers at either upper or lower boundary of CD . Also the spontaneous change of the arrow of geometric time is possible. The simplest possible description for U-process is that U-matrix relates to each other these two kinds of states and state function reductions occur alternately at upper and lower boundaries of CD meaning reduction to single particle states with well defined quantum numbers. The localization of sensory experience to short time interval could also correspond to mental images with size scale of CD being about .1 seconds so that the assumption that localization inside CD to either boundary takes place is not absolutely necessary.

It is unclear whether this identification of the unitary process allows a generation of a universal arrow of geometric time. It would seem that the arrow of time as a property of zero energy states must alternate for the proposed mechanism. But is this really the case? To answer this question one must try to understand how the observer concludes that there is geometric arrow of time.

1. This situation could correspond to single arrow of geometric time for a conscious entity if it resides permanently at either boundary of CD : does this mean a sleep-awake cycle of consciousness as a basic attribute of conscious experience? The hierarchy of CD s allows however to think that the scale in which the arrow of time as deduced from cosmology alternates in time scale of lifetime of the Universe so that unique arrow of time would be observed. In time scales shorter than that assignable to the CD of observer the arrow of time would vary periodically (generalized sleep-wake cycle).
2. Does the time flip-flop between upper and lower boundaries of CD really give rise to a variation of perceived arrow of geometric time? Suppose that quantum arrow of time has a direct counterpart in the time evolution of preferred extremals (dissipative processes). The direction of classical dissipation changes as the quantum arrow of time changes. Space-time evolution with a fixed geometric arrow of time would be effectively folded forth and back.

If this were the case, it seems that self has no means of detecting this change in the classical dynamics of preferred extremals assignable to its own CD . This if only the information about space-time sheet is used. The only manner to detect the change of the arrow of time would be by looking the classical dynamics of larger CD s.

If the arrow for the larger C remains the same when the arrow of geometric time for CD changes, self could detect the change of its own geometric arrow of time. For instance, self would experience dissipation inside its own CD to take place in opposite direction compared to that in larger scales. Here one however encounters a problem since in living systems the dissipation indeed could take place in wrong direction: this has even inspired the introduction of the notion of syntropy [J38, J28]. Self should however observe that the clocks defined by larger scale system run in wrong direction. But if the single half-period in the reduction cycle corresponds to life-cycle then also this is possible only after what we would call biological death!

Suppose that one just for a moment accepts this picture in absence of anything better. One can argue that there must exist concrete correlates for the flow of time experienced by self in terms of quantum dynamics of sub-selves. One should understand what the fractal hierarchy of selves really means at the level of conscious experience and of its physical correlates. Several mechanisms at space-time level for the generation of arrow of time have been discussed but the really satisfactory mechanism remains to be identified.

Is there a phase transition proceeding in the direction of geometric time of CD associated with the entire CD and inducing state function reduction for sub- CD s: it would not matter what is boundary of sub- CD is selected if sub- CD would be effectively point-like. The quantum arrow of time for zero energy state should force preferred direction of this phase transition.

1. Could it be that this phase transition like process corresponds to a sequence of state function reductions for sub-*CD*s of given size proceeding to the future. Could the fractal structure of zero energy states give rise to this structure? Ordinary Feynman diagrams would describe only single level in this hierarchy and state function reductions selecting subset of diagrams with given incoming and outgoing states are not possible. Suppose that zero energy states satisfy in very symbolic sense the recursion relation

$$\Psi_n = \Psi_{n,0} + \sum_{0 < k < n} \Psi_{n-k} \circ \Psi_k .$$

Here n corresponds to the size scale of *CD*. $\Psi_{n,0}$ corresponds an irreducible contribution corresponding to the ordinary Feynman diagrams for which no state function reduction in intermediate states is possible: this would be like dropping out subset of Feynman diagrams. The second term corresponds to splitting two two sub-*CD*s and is possible only in ZEO. We of course do physics in various scales without formal theoretical justification. For instance, we calculate QCD type process we can restrict the consideration to corresponding time scales. The decomposition would express this fact as a law of physics.

For these lower level contributions similar equation can be applied and one repeat the recursion down to the lowest level. \circ symbolizes entanglement between the zero energy states Ψ_{n-k} and Ψ_k .

2. Suppose that at the first step state function reduction has led to prepared states at -say- upper end (corresponding to Ψ_k). This is nothing but the basic assumption about zero energy states. At the next step the reduction reduces the entanglement between Ψ_{n-k} and Ψ_k : essentially the sum defining an element for a product AB of matrices reduces to a product of two elements: $\sum_j A_{ij} B_{jk} \rightarrow A_{ij} B_{jk}$. Time ordering of the reductions is unavoidable at this level since sub-*CD*s are in question. This process would continue fractally downwards to shorter scales. Complete time ordering results if the reduction for Ψ_k proceeds to the short scales first and only then for Ψ_{n-k} . Otherwise reduction sequences would occur for sub-*CD*s at different temporal positions simultaneously.
3. There is also entanglement with zero modes at each level but it seems that this entanglement is not relevant for this argument reducing the arrow to recursive property of states and to the factorization of two entangled zero energy states at given level of recursion.
4. This view about unitary process would explain the arrow of geometric time, explain why self experiences lower level state functions as time flow, and would also allow to understand the localization of sensory and various other kinds of experiences and also intentional action to short time interval.

3.4.4 Quantum correlates of for various aspects of conscious experience

The identification of quantum correlates of cognition and intentionality, of sensory qualia, Boolean mind, and of emotions [K26] represents one challenge for Quantum Mind theories. As already explained, p-adic physics, the vision about life as something residing in the intersection of real and p-adic worlds, and the notion of number theoretic entropy provide a plausible starting point when one tries to say something about the geometric and quantum correlates of cognition and intentionality. Zero energy ontology makes possible the transitions transforming p-adic zero energy states to their real counterparts and having interpretation in terms of intentional action.

1. Quantum numbers characterize quantum states. Therefore the increments ΔQ of quantum numbers for a subsystem should characterize quantum jumps and it is attractive to assign classify fundamental qualia in terms of quantum number increments. "The increments of quantum numbers for a sub-system representing self" looks innocent but what it really means is surprisingly difficult to make precise. The following attempt relies on ZEO.

- (a) For the positive energy part of state located at "lower" boundary of *CD* self - subsystem S - and environment E are un-entangled. At the "upper" boundary there is entanglement

between S and E , and it should be able to assign qualia as quantum number increments to this entanglement.

- (b) Consider increments of color quantum numbers identified in terms of visual colors as an example. In the positive energy state color quantum numbers for an unentangled subsystem S vanish by color confinement. In negative energy state they can be non-vanishing for S but vanish for $S \otimes E$. The experienced qualia for S are determined as quantum averages of color quantum numbers in the entangled state and expressible in terms of the sub-system density matrix. One can indeed assign to the zero energy state increments ΔQ_{ZEO} of color quantum numbers as difference of color quantum numbers for S at "upper" and "lower" boundaries of C . These increments characterize zero energy state rather than quantum jump.
- (c) In state function reduction the entanglement at upper boundary is reduced if the entanglement is entropic whereas negentropic entanglement can be stable. Quale is experienced sensorily as long as quantum jumps preserve negentropic entanglement. When entanglement is eventually reduced, the experience can be only a memory about the experienced quale. The increments ΔQ of color quantum numbers in quantum jump can be identified as $\Delta Q = \Delta Q_{ZEO}$. Hence this notion is indeed well-defined.
- (d) This interpretation allows to assign to the quantum jump also space-time evolution changing the quantum numbers in the same manner as they change in quantum jump. This is what quantum-classical correspondence indeed requires.

One application is the identification of basic colors in terms of color quantum number increments of quantum states [K26]. This identification makes sense if one accepts the fractal hierarchy of QCD like dynamics allowed by p-adic length scale hierarchy and by the hierarchy of Planck constants. The original concrete model was provided by the capacitor model of sensory qualia in which a large number of particles which same quantum numbers flows to a subsystem during quantum jump inducing the analog of di-electric breakdown (note the analogy with nerve pulse). Bose-Einstein condensation provides one possible realization. In this case one can say that the quantum numbers of the particle in question represent the basic quale which is amplified.

The above picture forces to modify this view by replacing a color capacitor with a fixed size with that of a variable size corresponding to the size of system S and $S \otimes E$: the second plate of capacitor either in S or environment. The flow of charges associated with the transition generating quale still makes sense and generates strong color polarization in the scale $S \otimes E$. In the model the increase of the size of the color capacitor means a formation of flux tubes between the sensory receptor and environment such that net color is non-vanishing only for these flux tubes. In state function reduction reducing entanglement the flux tubes are split and S become color neutral but can represent a memory about the quale as negentropic color neutral entanglement in the scale of S : some sub-system of S can now experience the color quale. This suggests a holographic memory in which quale eventually is represented in very small scale in terms of negentropic entanglement.

The argument involves assumption about color confinement. In the case of qualia assignable to electromagnetic charges, spin, etc... similar assumption makes sense. Even in case of momentum and angular momentum this assumption makes sense and means that subsystem in the state of experiencing momentum or angular momentum increment as quale is in a real accelerated motion in the scale of CD . As a matter fact, the vanishing of quantum numbers of S in absence of entanglement might not be necessary for the interpretation.

2. One could also speak about Boolean qualia and fermions provide possible correlates for them. The 2^N many-fermion states of fermionic Fock space for N fermionic qubits define a basis of Boolean algebra. The entangled pairs of fermionic states associated with the positive and negative energy parts of zero energy states define quantal Boolean functions as sums over entangled pairs of many fermion states. Negentropic entanglement could define a representation of a rule with entangled pairs representing various instances of the rule. Time-like entanglement would define a representation for a "law of physics" and M -matrices would be fundamental representations of this kind. The increments of the fermionic quantum numbers could define Boolean

qualia and one can imagine Boolean capacitor mechanism allowing to amplify a given Boolean statement.

One should be also able to say something about the quantum correlates of emotions. Here the notion of negentropic entanglement might be the key concept.

1. Emotions have a quale like character. For instance, psychological pleasure and pain resemble their physiological counterparts- and quite generally there is a tendency to assign to emotions the attributes of sensory experience. It would be attractive to assign this positive/negative dichotomy to the increase/reduction of entanglement negentropy. Emotion would represent Boolean bit as the sign of negentropy increment. The destruction of generation of negentropic entanglement would therefore be the core element of emotional quale. The character of entanglement involved would determine whether the emotion corresponds to pleasure or pain, joy or sorrow, pride or shame.

In the case of physiological pain or pleasure it is easy to imagine that the cause of pain destroys/creates negentropic entanglement. Pain and pleasure at this level relates directly to what happens to metabolism. This is easy to understand if the basic function of energy metabolism is to transfer negentropic entanglement. For higher level emotions the negentropy reduction or increase could be produced artificially to give an emotional content for something regarded as important.

2. Very often emotions are characterized by good-bad/right-wrong dichotomy characterizable by single binary digit. Perhaps emotions provide a representation of a high level summary about large amounts information, a kind of Boolean function of very many qubits. The function of neural transmitters can be often interpreted in terms of reward or punishment. Information and emotions seem to be closely related: peptides are often regarded as both information molecules and molecules of emotion [J56]. This can be understood if the function of information molecule is to induce emotional response representing the information.
3. Comparison to a standard -be it moral rule, expected or desired behavior, or something else- is rather often an essential aspect of emotion. Comparison can in principle be represented as a quantal Boolean function involving the standard (say moral rule) represented in terms of negentropic entanglement. If the Boolean instance compared with the rule corresponds to an instance allowed by the rule, positive emotion results. Otherwise the emotion is negatively colored. One might also think that there is expectation for the result of comparison. If the outcome differs from expected- which corresponds to a flip of bit, positive or negative emotion results but could do so as a secondary representation. The above argument suggests that the outcome of comparison does not represent the emotion as such but there is a neural circuitry encoding the outcome to reward or punishment.

3.4.5 Self referentiality of conscious experience

Self referentiality of consciousness is one of its most mysterious looking aspects. In a loose formulation one could say that system is able to be conscious what it *is* conscious of. This formulation however leads to an infinite hierarchy of reflective levels and therefore to a paradox. One can however milden the formulation by saying that self-referential system is able to be conscious about what it *was* conscious of (with respect to subjective time of course!)

In this formulation quantum classical correspondence gives hopes about the understanding of self-referentiality. Quantum classical correspondence means in TGD framework that not only quantum states but also quantum jump sequences have space-time correlates. The failure of classical determinism for Kähler action in standard sense of the word is responsible for this and relates directly to the basic properties distinguishing TGD Universe from that of standard model. This allows to imagine that quantum jump leading from a superposition of space-time surfaces to a new one also gives rise to a representation of the conscious experiences which preceded the last quantum jump at the level of space-time geometry. Reductio ad absurdum would transform to evolution of consciousness able to add to the existing hierarchy a new reflective level in each quantum jump.

I have proposed several correlates for the self-referentiality of consciousness. Many-sheeted space-time would provide the physical representation.

Many-sheeted space-time and self-referentiality

The fractal hierarchy of magnetic flux tubes giving rise to braids, which in turn make possible topological quantum computation would be a rather realization of this representation, A possible concrete physical realization of self-referentiality is suggested by DNA as quantum computer model [K19]. One assumes that DNA nucleotides and lipids are connected by magnetic flux tubes. Since the lipid layer of the cell membrane is 2-dimensional liquid crystal, the lipids are in continual hydrodynamical motion and this means in time direction entanglement of the orbits. The events in nearby environment and also nerve pulses affect this flow. This braiding in time direction defines a topological quantum computation. This motion entangles also the flux tubes connecting the lipids to DNA nucleotides so that when the topological quantum computation halts it becomes stored into memory as space-like entanglement. In TGD framework also the time-like braiding provides a space-time representation of the quantum computation which also gives to a conscious experience at some level of the hierarchy.

Infinite primes and self-referentiality

The hierarchy of infinite primes (and of integers and rationals) [K71] was the first mathematical notion stimulated by TGD inspired theory of consciousness. The construction recipe is equivalent with a repeated second quantization of a super-symmetric arithmetic quantum field theory with bosons and fermions labeled by primes such that the many-particle states of previous level become the elementary particles of new level. At a given level there are free many particle states plus counterparts of many particle states. There is strong structural analogy with polynomial primes. For polynomials with rational coefficients free many-particle states would correspond to products of first order polynomials and bound states to irreducible polynomials with non-rational roots.

The hierarchy of space-time sheets with many particle states of space-time sheet becoming elementary particles at the next level of hierarchy. For instance, the description of proton as an elementary fermion would be in a well defined sense exact in TGD Universe. Also the hierarchy of n:th order logics are possible correlates for this hierarchy.

This construction leads also to a number theoretic generalization of space-time point since a given real number has infinitely rich number theoretical structure not visible at the level of the real norm of the number a due to the existence of real units expressible in terms of ratios of infinite integers. This number theoretical anatomy suggest a kind of number theoretical Brahman=Atman identity stating that the set consisting of number theoretic variants of single point of the imbedding space (equivalent in real sense) is able to represent the points of WCW or maybe even quantum states assignable to causal diamond. One could also speak about algebraic holography.

The correspondence between the quantum states defined by WCW spinor fields and wave functions in the infinite-dimensional discrete space of hyper-octonionic units can be made more concrete [K71]. These wave functions must transforming irreducibly under discrete subgroup $SU(3)$ of octonion automorphisms transforming ordinary hyper-octonionic prime to a new hyper-octonionic prime. $SU(3)$ has interpretation as color group. One can assign standard model quantum numbers to these wave functions and prime property in principle fixes the spectrum of possible quantum states- in particular the spectrum of masses. Therefore the extremely esoteric looking notion of infinite prime might turn out to be very practical calculational tool.

Quantum Mathematics and self referentiality of consciousness

In Quantum Mathematics numbers are replaced with Hilbert spaces and the dimension of Hilbert space - in appropriately. generalized sense - characterizes the number.

1. This suggests a generalization of calculus for Hilbert spaces. Mathematical objects which are defined for numbers in various number fields become well defined when these numbers are replaced with Hilbert spaces. One can speak of the Hilbert space analogs of algebraic numbers, transcendentals, p-adic numbers and their extensions. Anything having as a building brick rationals, algebraic numbers, real or p-adic numbers or finite fields generalizes. Even the notions like matrix group, algebras, and ring generalize. Also the notion of manifold generalizes as well as the notion of calculus.
2. The Hilbert space in associated with the element of number field characterizes its number theoretic anatomy and therefore could be a correlate of cognition. The crucial step in the generaliza-

tion of this process to the level of the Hilbert space representing points. Points of Hilbert spaces can be replaced with Hilbert spaces and process can be repeated ad infinitum. This suggests that the self-referentiality at the deepest level corresponds to this fractal view about space-time based on assignment of quantum dynamics to numbers. Also a connection with the hierarchy of n :th order logics. A close relationship to infinite primes would not be surprising since in both cases one an infinite hierarchy of processes analogous to second quantization is involved. A natural question is whether many-sheeted space-time provides a dynamical representation in terms of space-time sheets for the number theoretic anatomy so that kind of Brahman=Atman identity or algebraic holography would hold true. This correspondence could be seen as a cognitive representation of external world and one could also see the external world as symbolic representation of the world of cognition.

3. A connection with generalized Feynman diagrams and hierarchy of Planck constants is suggestive and the idea was originally inspired by the observation that the two vertices of generalized Feynman diagrams identifiable as generalizations of the basic stringy 3-vertex for closed strings and basic 3-vertex for Feynman diagrams correspond naturally to direct sum and tensor product in turn having natural correspondence with $+$ and \times of the usual arithmetics. This correspondence motivates the introduction of co-operations of direct sum and tensor product meaning that quantum dynamics is brought into the game through these vertices. This suggests that Quantum Mathematics is actually Quantum dynamics in which generalized Feynman diagrams define sequences of arithmetic or even more general algebraic operations.

If so, the basic structures of Quantum Mechanics (QM) might reduce to fundamental mathematical and metamathematical structures, and that one even consider the possibility that Quantum Mechanics reduces to Quantum Mathematics with mathematician included or expressing it in a concise manner: QM=QM!

The fractal character of the Quantum Mathematics is what makes it a good candidate for understanding the self-referentiality of consciousness. The replacement of the Hilbert space with the direct sum of Hilbert spaces defined by its points would be the basic step and could be repeated endlessly corresponding to a hierarchy of statements about statements or hierarchy of n^{th} order logics. The construction of infinite primes leads to a similar structure.

What about the step leading to a deeper level in hierarchy and involving the replacement of each point of Hilbert space with Hilbert space characterizing it number theoretically? What could it correspond at the level of states?

1. Suppose that state function reduction selects one point for each Hilbert space $x_n \times p^n$. The key step is to replace this direct sum of points of these Hilbert spaces with direct sum of Hilbert spaces defined by the points of these Hilbert spaces. After this one would select point from this very big Hilbert space. Could this point be in some sense the image of the Hilbert space state at previous level? Should one imbed Hilbert space $x_n \times p^n$ isometrically to the Hilbert space defined by the preferred state $x_n \times p^n$ so that one would have a realization of holography: part would represent the whole at the new level. It seems that there is a canonical manner to achieve this. The interpretation as the analog of second quantization suggest the identification of the imbedding map as the identification of the many particle states of previous level as single particle states of the new level.
2. Could topological condensation be the counterpart of this process in many-sheeted spacetime of TGD? The states of previous level would be assigned to the space-time sheets topologically condensed to a larger space-time sheet representing the new level and the many-particle states of previous level would be the elementary particles of the new level.
3. If this vision is correct, second quantization performed by theoreticians would not be a mere theoretical operation but a fundamental physical process necessary for cognition! The above proposed unitary imbedding would imbed the states of the previous level as single particle states to the new level. It would seem that the process of second quantization, which is indeed very much like self-reference, is completely independent from state function reduction and unitary process. This picture would conform with the fact that in TGD Universe the theory about the Universe is the Universe and mathematician is in the quantum jumps between different solutions of this theory.

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Chapter 4

Quantum Mind, Magnetic Body, and Biological Body

4.1 Introduction

Quantum biology-rather than only quantum brain- is an essential element of Quantum Mind in TGD Universe. Cells, biomolecules, and even elementary particles are conscious entities and the biological evolution is evolution of consciousness so that it would be very artificial to restrict the discussion to brain, neurons, or microtubules. The basic new physics inspired ideas behind TGD inspired quantum biology have been discussed already in the first article but deserve to be listed.

The article is devoted to some applications of TGD inspired view about Quantum Mind to biology. Magnetic body carrying dark matter and forming an onion-like structure with layers characterized by large values of Planck constant is the key concept. Magnetic body is identified as intentional agent using biological body as sensory receptor and motor instrument. EEG and its fractal variants are identified as a communication and control tool of the magnetic body and a fractal hierarchy of analogs of EEG is predicted. Living system is identified as a kind of Indra's net with biomolecules representing the nodes of the net and magnetic flux tubes connections between them. The reconnection of magnetic flux tubes and phase transitions changing Planck constant and therefore the lengths of the magnetic flux tubes are identified as basic mechanisms behind DNA replication and analogous processes and also behind the phase transitions associated with the gel phase in cell interior. The braiding of magnetic flux makes possible universal memory representation recording the motions of the basic units connected by flux tubes. Braiding also defines topological quantum computer programs updated continually by the flows of the basic units. The model of DNA as topological quantum computer is discussed as an application.

In the following I briefly summarize some applications to quantum biology. I am of course forced to leave details to the books about TGD inspired theory of consciousness and quantum biology at my homepage [K75, K9, K53, K29, K8, K35, K39, K68].

1. A vision about relationship between information processing and metabolism in TGD Universe is represented.
 - (a) The already existing ideas include the notion of time mirror mechanism as a manner to realized intentional action, memory recall, and remote metabolism by sending negative energy photons to geometric past where some system able to absorb them exists. The proposal is that the utilization of ATP is also possible in this manner: this quantum credit card would make living matter extremely flexible since instantaneous reaction to changing circumstances would become possible. Many-sheeted space-time inspires the idea that the dropping of particles, in particular electrons and protons, to larger space-time sheets liberates metabolic energy. This mechanism would provide universal metabolic currencies and also ATP-ADP might be based on it.
 - (b) The new idea is that the presence of ATP at magnetic flux tube is a necessary prerequisite for negentropic entanglement between its ends. ATP could be seen as a molecule of consciousness in this picture and high energy phosphate bond would be replaced with a state

involving negentropic entanglement. There is also a connection with the model of living matter as quantum computer.

- (c) A possible modification of second law to take into account negentropic entanglement is discussed. The pessimistic modification states that genuine islands of negentropy can be generated rather than islands in which entropy is very small. The generation of negentropy is however always accompanied by compensating generation of entropy. A possible interpretation is that the eventual reduction of negentropic entanglement in state function reduction generates this entropy at ensemble level.
- 2. TGD approach to living matter was strongly motivated by the findings about strange behavior of cell membrane and of cellular water, and gel behavior of cytoplasm. These findings are briefly discussed in TGD framework by bringing in magnetic flux tubes as a new element.
- 3. Water is in key role in living matter and TGD inspired view about water and various anomalies related to the physics of water are also discussed.

4.2 Quantum mind and magnetic body

The notion of magnetic/field body is probably the feature of TGD inspired theory of quantum biology which probably creates strongest irritation in standard model physicist. A ridicule as some kind of Mesmerism might be the probable reaction. The notion of magnetic/field body has however gradually gained more and more support and it is now an essential element of TGD based view about living matter. In the following I discuss the basic applications in the hope that the overall coherency of the picture might force some readers to take this notion seriously. The notion of magnetic body leads to a dramatic modification of the views about functions of brain and biological systems in general. I will talk mostly about magnetic body although it is clear that field body has also electric parts (electric flux quanta with cell membrane and various electrets populating living matter) as well as radiative parts realized in terms of "massless extremals" or topological light rays [K48] providing correlates for EEG and its fractal analogs.

4.2.1 Living matter as ordinary matter controlled by dark matter at magnetic bodies

The notions of many-sheeted space-time, topological field quantization, and magnetic body were in a key role in the model of living matter as a macroscopic quantum system. It was assumed that space-time sheets are not at thermal equilibrium and that the space-time sheets responsible for the macroscopic quantum coherence are at very low temperature. See the article Biosystems as macroscopic quantum systems [L1].

- 1. 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 propagate to premotor cortex, supplementary motor cortex and to frontal lobes where the abstract plans about motor actions are generated.

- 2. The hierarchy of Planck constants and identification of dark matter as phases with non-standard value of Planck constant makes it possible to give up the assumption about low temperatures at

flux quanta. Dark matter becomes the key notion in the quantum controller of ordinary matter in living matter. The large value of Planck constant - integer multiple of standard value- scales up quantum lengths since typically they are proportional to \hbar and scales the quantum coherence lengths and times. This also scales the energy $E = hf$ associated with a photon with given frequency. This allows to understand the quantal effects of ELF em fields to vertebrate brain.

3. Large Planck constant means that quantum length scales such as Compton length are scaled up. This makes possible macroscopic quantum coherence and non-locality. Magnetic flux tubes are identified as carriers of dark matter with non-standard value of Planck constant.
4. The ideas about the role of magnetic flux quanta have evolved considerably. It is natural to assume that magnetic flux tubes carry macroscopic quantum phases of dark matter. The phase transitions changing Planck constant reduce or increase the length of the flux tube and could be responsible for the dramatic volume changes of cytoplasm. The reconnections of magnetic flux tubes make possible dynamics for the topology of the web formed by magnetic flux tubes. ATP-ADP process can be associated with this kind of reconnection process. The braiding of magnetic flux tubes makes possible topological quantum computations and DNA and lipid layers of cell membrane form an ideal hardware for topological quantum computer with braiding of flux tubes connecting lipid layers with DNA nucleotides defining the tqc programs. Braiding provides also a universal memory storage mechanism since liquid flow induces braiding of the particle in the flow. Lipid layers of cell membrane are indeed liquid crystals so that their flows update quantum computer programs coded by space-like braiding.
5. Living matter would be ordinary matter controlled by the dark manner at the "magnetic body" of the system and. magnetic flux tubes and sheetes act as carriers of dark matter. Phase transitions changing the value of Planck constant induce contractions or lengthenings of the flux tubes and would be key mechanism in the volume changing phase transitions in living matter. Reconnection process for the flux tubes is second mechanism and ATP-ADP mechanism would involve basically the reconnection which would in quantum computer inspired picture mean formation of a link to and address in memory. Braiding of flux tubes makes possible topological quantum computation. For details see the chapters Macroscopic quantum coherence and metabolism as different sides of the same coin [K33]. DNA as topological quantum computer [K19].

Dark Matter Hierarchy and Hierarchy of EEGs. [K17]. TGD Based View about Classical Fields in Relation to Consciousness Theory and Quantum Biology. Quantum model for bio-superconductivity. [K54] [K56].

4.2.2 Magnetic body as intentional agent and experiencer

In TGD Universe brain would be basically a builder of symbolic representations assigning a meaning to the sensory input by decomposing sensory field to objects and making possible effective motor control by magnetic body containing dark matter. A concrete model for how magnetic controls biological body and receives information from it is discussed in the model for the nerve pulse [K56] and for the hierarchy of EEGs [K17, K59].

Also magnetic body could have sensory qualia, which should be in a well-defined sense more refined than ordinary sensory qualia [K26]. The quantum number increments associated with cyclotron phase transitions of dark ion cyclotron condensates at magnetic body could relate to the cognitive and possibly also emotional content of sensory input and would indeed have interpretation as higher level sensory qualia. On the other hand, the positive/negative emotional coloring itself might be the core of what it is to be emotion and most naturally relates to the sign of negentropy increment in quantum jump so that it would not be a quale in the sense that visual colors are.

Right brain sings – left brain talks metaphor could characterize this emotional-cognitive (holistic-reductionistic) distinction for higher level qualia and would correspond to coding of sensory input from brain by frequency patterns *resp.* temporal patterns (analogs of phonemes). Fourier analysis indeed transforms local data into holistic data.

These qualia could be seen as somatosensory qualia at the level of magnetic body. One must be however cautious with interpretations. It is not all obvious whether the qualia should be assigned with body alone or magnetic body alone or both. Out of body experiences and various illusions such as train illusion and the disgusting sensation about falling when one is near the edge of cliff could be

virtual world experiences resulting from the relative motion of the magnetic body with respect to the biological body: the sensory sensation would correspond to the interference effects for dark photon radiation between the biological body and magnetic body [K74].

TGD framework fundamental qualia are associated with sensory receptors although also neuronal qualia are possible. The new view about time allows to overcome the arguments suggesting that qualia must be solely at the level of brain (say the pain in phantom limb).

Remote mental interactions between magnetic body and biological body are a key element of this picture. Remote mental interactions in the usual sense of the world would occur between magnetic body and some other, not necessary biological, body. This would include reception of sensory input from and motor control of other than own body. Also inanimate matter (no negentropic entanglement) possesses magnetic bodies (so that also psychokinesis could be based on the same mechanism). Magnetic body for which dissipation is much smaller than for ordinary matter (proportional to $1/\hbar$), could continue its conscious existence after biological death and find another biological body and use it as a tool of sensory perception and intentional action.

4.2.3 Time mirror mechanism can be seen as the basic mechanism of memory, intentional action, and metabolism

It means sending negative energy signal propagating backwards in time and ZEO gives precise meaning for this notion.

1. Memory recall in the case of symbolic memories would correspond to sending of negative energy signal to geometric past. The signal would be reflected as positive energy signal. An alternative possibility is that time-like entanglement is generated. This mechanism would make it unnecessary to store memories again and again. The proposed model for the recent finding that memory code with six bits might make sense suggests that metabolism is necessarily involved. The negative energy quantum absorbed in geometric past transforms ATP to ADP and deletes the conscious memory item but creates it again in the geometric now. This would conform with no-cloning theorem.
2. Sending of negative energy signals to a system serving as energy storage to generate metabolic energy as a recoil makes possible an extremely flexible quantum credit card in living matter. This kind of flexibility is extremely useful in circumstances requiring very rapid reactions.
3. Motor actions could be regarded as realizations of intentions using negative energy signals propagating to the direction of geometric past. This hypothesis would explain the strange finding of Libet that conscious decision in volitional action seems to occur later than the neural activity initiating the motor action. 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 [J33] . 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.

4.2.4 Biosystems as conscious holograms

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

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

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

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

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

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

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

4.2.5 High T_c superconductivity in living matter

The TGD inspired model for high T_c super-conductivity as quantum critical phenomenon is developed. The relies on the notions of quantum criticality, dynamical quantized Planck constant requiring a generalization of the 8-D imbedding space to a book like structure, and many-sheeted space-time. In particular, the notion of magnetic flux tube as a carrier of supra current of central concept.

The model of super-conductivity

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-conductivity 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 unnecessary. 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 $T_{c1} > T_c$ 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 at 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 with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μ m) 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 [?] 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.

The role of Josephson currents

The general vision is that Josephson currents of various ions generate Josephson photons having dual interpretations as bio-photons and EEG photons. Josephson photons can in principle regenerate the quale in the neurons of the sensory pathway. In the case of motor pathways the function would be different and the transfer of metabolic energy by quantum credit card mechanism using phase conjugate photons is suggested by the observation that basic metabolic quanta 2 eV *resp.* 4 eV are associated with smooth muscle cells *resp.* skeletal muscle cells.

As already found in the previous section, the energies of Josephson photons associated with the biologically important ions are in general in visible or UV range except when resting potential has the value of -40 mV which it has for photoreceptors. In this case also IR photons are present. Also the turning point value of membrane potential is +40 mV so that one expects the emission of IR photons.

Josephson photons could be used to communicate the qualia to the magnetic body.

1. If Josephson currents are present during the entire action potential, the entire range of Josephson photons down to frequencies of order 2 kHz range is emitted for the standard value of \hbar . The reason is that lower frequencies corresponds to cycles longer than the duration of the action potential. The continuum of Josephson frequencies during nerve pulse makes it possible to induce cyclotron transitions at the magnetic body of neuron or large structure. This would make possible to communicate information about spatial and temporal behavior of the nerve pulse pattern to the magnetic body and build by quantum entanglement a sensory map.
2. The frequencies below 2 kHz could be communicated as nerve pulse patterns. When the pulse rate is above $f = 28.57$ Hz the sequence of pulses is experienced as a continuous sound with pitch f . f defines the minimum frequency for which nerve pulses could represent the pitch and there remains a 9 Hz long range to be covered by some other communication method.
3. The cyclotron frequencies of quarks and possibly also of electron would make possible a selective reception of the frequencies emitted during nerve pulse. Same applies also to the Josephson frequencies of hair cell (, which does not fire). If the value of Planck constant is large this makes possible to communicate the entire range of audible frequencies to the magnetic body. Frequency would be coded by the magnetic field strength of the flux tube. Two options are available corresponding to the standard ground state for which Z^0 field is very weak and to almost vacuum extremals. For the first option one as ordinary cyclotron frequencies. The cyclotron frequency scales for them differ by a factor

$$r(q) = \frac{Q_{eff}(q)}{Q_{em}(q)} = \frac{\epsilon(q)}{2pQ_{em}(q)} + 1, \quad \epsilon(u) = -1, \quad \epsilon(d) = 1$$

from the standard one. For $p = .0295$ one obtains $(r(u), r(d), r(e)) = (24.42, 49.85, 15.95)$. The cyclotron frequencies for quarks and electron with masses $m(u)=2$ MeV, $m(d)=5$ MeV, and $m(e)=.5$ MeV are given the table below for the two options. If one assumes that B_{end} defines the upper bound for field strength then the standard option would require both d quark and electron. For dquark 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 CD s could be used and in case of musical sounds this looks a highly attractive option. In this case it is now however possible to select single harmonics as in the case of cyclotron transitions so that only the rate of nerve pulses can communicate single frequency.

Lorentz transform sub- CD scales up the frequency scale from the secondary p-adic time scale coming as octave of 10 Hz frequency. Also the scaling of \hbar scales this frequency scale.

4. What are the roles of Josephson and cyclotron photons?

The dual interpretation of Josephson radiation in terms of bio-photons and EEG photons seems to be very natural and also the role of Josephson radiation seems now relatively clear. The role of cyclotron radiation and its interaction with Josephson radiation are not so well understood.

1. At least cell membrane defines a Josephson junction (actually a collection of them idealizable as single junctions). DNA double strand could define a series of Josephson junctions possibly assignable with hydrogen bonds. This however requires that the strands carry some non-standard charge densities and currents- I do not know whether this possibility is excluded experimentally. Quarks and antiquarks assignable to the nucleotide and its conjugate have opposite charges at the two sheets of the wormhole flux tube connective nucleotide to a lipid. Hence one could consider the possibility that a connection generated between them by reconnection mechanism could create Josephson junction.
2. The model for the photoreceptors leads to the identification of biophotons as Josephson radiation and suggests that Josephson radiation propagates along flux tubes assignable to the cell membranes along sensory pathways up to sensory cortex and from there to motor cortex and back to the muscles and regenerates induced neuronal sensory experiences.
3. Josephson radiation could be used quite generally to communicate sensory data to/along the magnetic body: this would occur in the case of cell membrane magnetic body at least. The different resting voltages for various kinds of cells would select specific Josephson frequencies as communication channels.
4. If motor action indeed involves negative energy signals backwards in geometric time as Libet's findings suggest, then motor action would be very much like sensory perception in time reversed direction. The membrane resting potentials are different for various types of neurons and cells so that one could speak about pathways characterized by Josephson frequencies determined by the membrane potential. Each ion would have its own Josephson frequency characterizing the sensory or motor pathway.

The basic questions concern the function of cyclotron radiation and whether Josephson radiation induces resonantly cyclotron radiation or vice versa.

1. Cyclotron radiation would be naturally associated with the flux sheets and flux tubes. The simplest hypothesis is that at least the magnetic field $B_{end} = .2$ Gauss can be assigned with the some magnetic flux quanta at least. The model for hearing suggests that B_{end} is in this case quantized so that cyclotron frequencies provide a magnetic representation for audible frequencies. Flux quantization does not pose any conditions on the magnetic field strength if the above discussed general flux quantization condition involving charged currents at the boundary of the flux quantum are assumed. If these currents are not present, $1/\hbar$ scaling of B_{end} for flux tubes follows.
2. The assumption that cyclotron radiation is associated with the motor control via genome is not consistent with the vision that motor action is time reversed sensory perception. It would also create the unpleasant question about information processing of the magnetic body performed between the receipt of sensory data and motor action.
3. The notion of magnetic sensory canvas suggests a different picture. Josephson radiation induces resonant cyclotron transitions at the magnetic body and induces entanglement of the mental images in brain with the points of the magnetic body and in this manner creates sensory maps giving a third person perspective about the biological body. There would be two kind of sensory maps. Those assignable to the external world and those assignable to the body itself. The Josephson radiation would propagate along the flux tubes to the magnetic body.

4. There could be also flux tube connections to the outer magnetosphere of Earth. It would seem that the 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.

4.2.6 Possible roles of the magnetic body in living matter

An attractive working hypothesis is that dark matter and negentropic entanglement can be assigned to the magnetic bodies. For instance, the dark elementary particles at the ends of the magnetic flux tubes connecting (say) biomolecules could be entangled negentropically. Negentropic entanglement, which is not identifiable as ordinary bound state entanglement, can be applied to explain the stability of high energy phosphate bond in ADP and ATP and of DNA polymers, which are highly charged and thus expected to be unstable [K23]. This also allows to interpret metabolic energy transfer as a transfer of negentropic entanglement at the deeper level.

The anatomy of magnetic body

Consider first the anatomy of the magnetic body.

1. Magnetic body has a fractal onion like structure with decreasing magnetic field strengths and the highest layers can have astrophysical sizes. Cyclotron wave length gives an estimate for the size of particular layer of magnetic body. $B = .2$ Gauss is the field strength associated with a particular layer of the magnetic body assignable to vertebrates and EEG. This value is not the same as the nominal value of the Earth's magnetic field equal to .5 Gauss and follows from the TGD based explanation of the quantal effects of ELF em fields on vertebrate brain known for decades [J19]. It is quite possible that the flux quanta of the magnetic body correspond to those of wormhole magnetic field and thus consist of two parallel flux quanta which have opposite time orientation. This is true for flux tubes assigned to DNA in the model of DNA as a topological quantum computer [K19, K79].
2. The layers of the magnetic body are characterized by the values of Planck constant and the matter at the flux quanta can be interpreted as macroscopically quantum coherent dark matter. This picture makes sense only if one accepts the generalization of the notion of imbedding space [K16].
3. In the case of wormhole magnetic fields it is natural to assign a definite temporal duration to the flux quanta and the time scales defined by EEG frequencies are natural. Encouragingly, the inherent time scale .1 seconds assignable to electron as a duration of zero energy space-time sheet in zero energy ontology having positive and negative energy electron at its ends would correspond to 10 Hz cyclotron frequency for ordinary value of Planck constant. For larger values of Planck constants the time scale scales as \hbar . Quite generally, a connection between p-adic time scales of EEG and those of electron and lightest quarks is highly suggestive since light quarks play key role in the model of DNA as topological quantum computer.
4. TGD predicts also a fractal hierarchy of scaled variants of electro-weak and color physics so that ZXG, QXG, and GXG corresponding to Z^0 boson, W boson, and gluons appearing effectively as massless dark particles below some biologically relevant length scale suggest themselves. In this phase quarks and gluons are unconfined and electroweak symmetries are unbroken so that gluons, weak bosons, quarks and even neutrinos might be relevant to the understanding of living matter. In particular, long ranged entanglement in charge and color degrees of freedom becomes possible. For instance, TGD based model of atomic nucleus as nuclear string suggests that biologically important fermionic could be actually chemically equivalent bosons and form cyclotron Bose-Einstein condensates.

This picture would mean that dark matter -usually believed to interact extremely weakly with the ordinary matter- would become a key player in biology. The failure to observe dark matter would be the completely wrong view about its nature. In TGD framework dark matter would make itself visible both via classical em fields and via the phase transitions transforming dark photons to ordinary ones.

For instance, bunches of EEG photons and biophotons could be interpreted as decay products dark photons [K17].

What magnetic body looks like?

What magnetic body looks like has been a question that I have intentionally avoided as a question making sense only when more general questions have been answered. This question seems how unavoidable now. Some of the related questions are following. The magnetic flux lines along various parts of magnetic body must close: how does this happen? Magnetic body must have parts of size at least that defined by EEG wavelengths: how do these parts form closed structures? How the magnetic bodies assignable to biomolecules relate to the Earth sized parts of the magnetic body? How the personal magnetic body relates to the magnetic body of Earth?

1. The vision about genome as the brain of cell would suggest that active and passive DNA strands are analogous to motor and sensor areas of brain. This would suggest that sensory data should be communicated from the cell membrane along the passive DNA strand. The simplest hypothesis is that there is a pair of flux sheets going through the DNA strands. The flux sheet through the passive strand would be specialized to communicate sensory information to the magnetic body and the flux sheet through the active strand would generate motor action as DNA expression with transcription of RNA defining only one particular aspect of gene expression. Topological quantum computation assignable to introns and also electromagnetic gene expression would be possible.
2. The model for sensory receptor in terms of Josephson radiation suggests however that flux tubes assignable to axonal membranes carry Josephson radiation. Maybe the flux tube structures assigned to DNA define the magnetic analog of motor areas and flux tubes assigned with the axons that of sensory areas.
3. A complex structure of flux tubes and sheets is suggestive at the cellular level. The flux tubes assignable to the axons would be parallel to the sensory and motor pathways. Also microtubules would be accompanied by magnetic flux tubes. DNA as topological quantum computer model assumes and the proposed model of sensory perception and cell membrane level suggests transversal flux tubes between lipids and nucleotides. The general vision about DNA as brain of cell suggest flux sheets through DNA strands.

During sensory perception of cell and nerve pulse the wormhole flux tube connecting the passive DNA strand of the first cell to the inner lipid layer would recombine with the flux tube connecting outer lipid layer to some other cell to form single flux tube connecting two cells. In the case of sensory organs these other cells would be naturally other sensory receptors. This would give rise to a dynamical network of flux tubes and sheets and axonal sequences of genomes would be like lines of text at the page of book. This structure could have a fractal generalization and would give rise to an integration of genome to super-genome at the level of organelles, organs and organism and even hypergenome at the level of population. This would make possible a coherent gene expression.

4. This vision gives some idea about magnetic body in the scale of cell but does not say much about it in longer scales. The *CDs* of electrons and quarks could provide insights about the size scale for the most relevant parts of the magnetic body. Certainly the flux tubes should close even when they have the length scale defined by the size of Earth.

Additional ideas about the structure follow if one assumes that magnetic body acts a sensory canvas and that motor action can be regarded as time reversed sensory perception.

1. If the external world is represented at part of the magnetic body which is stationary, the rotation of head or body would not affect the sensory representation. This part of the magnetic body would be obviously analogous to the outer magnetosphere, which does not rotate with Earth.
2. The part of the magnetic body at which the sensory data about body (posture, head orientations and position, positions of body parts) is represented, should be fixed to body and change its orientation with it so that bodily motions would be represented as motions of the magnetic , which would be therefore analogous to the inner magnetosphere of rotating Earth.

3. The outer part of the personal magnetic body is fixed to the inner magnetosphere, which defines the reference frame. The outer part might be even identifiable as the inner magnetosphere receiving sensory input from the biosphere. This magnetic super-organism would have various life forms as its sensory receptors and muscle neurons. This would give quantitative ideas about cyclotron frequencies involved. The wavelengths assignable to the frequencies above 10 Hz would correspond to the size scale of the inner magnetosphere and those below to the outer magnetosphere. During sleep only the EEG communications with outer magnetic body would remain intact.
4. Flux quantization for large value of \hbar poses an additional constraint on the model.
 - (a) If Josephson photons are transformed to a bunch of ordinary small \hbar photons magnetic flux tubes can correspond to the ordinary value of Planck constant. If one assumes the quantization of the magnetic flux in the form

$$\int BdA = n\hbar$$

used in super-conductivity, the radius of the flux tube must increase as $\sqrt{\hbar}$ and if the Josephson frequency is reduced to the sound frequency, the value of \hbar codes for the sound frequency. This leads to problems since the transversal thickness of flux tubes becomes too large. This does not however mean that the condition might not make sense: for instance, in the case of flux sheets going through DNA strands the condition might apply.

- (b) The quantization of magnetic flux could be replaced by a more general condition

$$\oint (p - ZeA)dl = n\hbar , \quad (4.2.1)$$

where p represents momentum of particle of super-conducting phase at the boundary of flux tube. In this case also $n = 0$ is possible and poses no conditions on the thickness of the flux tube as a function of \hbar . This option looks reasonable since the charged particles at the boundary of flux tube would act as sources of the magnetic field.

- (c) Together with the Maxwell's equation giving $B = ZeNv$ in the case that there is only one kind of charge carrier this gives the expression

$$N = \frac{2m}{RZ^2e^2} \quad (4.2.2)$$

for the surface density N of charge carrier with charge Z . R denotes the radius of the flux tube. If several charge carriers are present one has $B = \sum_k N_k Z_k e v_k$, and the condition generalizes to

$$N_i = \frac{2m_i v_i}{RZ_i \sum_k Z_k v_k e^2} . \quad (4.2.3)$$

It seems that this condition is the most realistic one for the large \hbar flux sheets at which Josephson radiation induces cyclotron transitions.

Some functions of the magnetic body

The list of possible functions of the magnetic body is already now rather impressive.

1. Magnetic body controls biological body and receives sensory data from it. Together with zero energy ontology and new view about time explains Libet's strange findings about time lapses of consciousness [J34] in terms of time taken for the sensory signals from biological body to propagate to the appropriate layer of the magnetic body [K17]. EEG, or actually fractal hierarchy of EXGs assignable to various body parts makes possible communications to and control by the various layers of the magnetic body. WXG could induce charge density gradients by the exchange of W boson. Also the gluonic counterparts of EXG:s -QXG- are possible.

2. The flux sheets of the magnetic body traverse through DNA strands. The hierarchy of Planck constants and quantization of magnetic flux predicts that the flux sheets can have arbitrarily large width [K30]. This leads to the idea that there is hierarchy of genomes corresponding to ordinary genome, supergenome consisting of genomes of several cell nuclei arranged along flux sheet like lines of text, and hypergenomes involving genomes of several organisms arranged in a similar manner. The prediction is coherent gene expression at the level of organ, and even of population.

For instance, one could see the observed correlations between EEGs of two improvising musicians [J68], the findings of Germaine [J39] and also those of Persinger and colleagues about macro-entanglement [J55] as an experimental support for both macroscopic entanglement between brain and for the crucial role of magnetic body as a space-time correlate for this entanglement. In this picture the great leaps in evolution, in particular, the emergence of EEG, could be seen as the emergence of a new larger layer of magnetic body characterized by a larger value of Planck constant. For instance, this would allow to understand why the quantal effects of ELF em fields [J19] requiring so large a value of Planck constant that cyclotron energies are above thermal energy at body temperature are observed for vertebrates only.

3. Magnetic body makes possible information processing in a manner highly analogous to topological quantum computation [K19]. The model of DNA as topological quantum computer [K19] assumes that flux tubes of wormhole magnetic field connect DNA nucleotides with the lipids of the lipid layer of nuclear or cell membrane. The flux tubes would continue through the membrane and split during topological quantum computation. The time-like braiding of flux tubes makes possible topological quantum computation via timelike braiding and the induced space-like braiding makes possible the representation of memories. The model allows general vision about the deeper meaning of the structure of cell and makes testable predictions about DNA. A good metaphor is dancers with feet connected to the walls of the dancing hall by threads. The dance representing quantum computation is coded to the braiding of the threads.

One prediction is the coloring of braid strands realized by an association of quark or antiquark to nucleotide so that scaled up dark copy of QCD in cellular length scale would be involved. Color and spin of quarks and antiquarks would thus correspond to the quantum numbers assignable to braid ends. Color isospin could replace ordinary spin as a representation of qubit and quarks would naturally give rise to qutrit, with third quark would have interpretation as unspecified truth value. Fractionization of these quantum numbers takes place which increases the number of degrees of freedom.

This prediction would relate closely to the discovery of topologist Barbara Shipman [A26] that the model for the honeybee dance suggests that quarks are in some manner involved with cognition -something totally unimaginable unless one accepts the possibility of fractal hierarchies of electroweak and hadronic physics. Also microtubules associated with axons connected to a space-time sheet outside axonal membrane via lipids could be involved with topological quantum computation and actually define an analog of a higher level programming language.

4. The strange findings about the behavior of cell membrane are summarized in [I61] and discussed in TGD framework in [K56]. Mention only the finding that metabolic deprivation does not lead to the death of cell, the discovery that ionic currents through the cell membrane are quantal, and that these currents are essentially similar than those through an artificial membrane, suggest that the ionic currents are dark ionic Josephson currents along magnetic flux tubes. A high percent of biological ions would be dark and ionic channels and pumps would be responsible only for the control of the flow of ordinary ions through cell membrane.

A further important finding is that the water in the cell interior in gel phase is ordered and nearer to ice than liquid [I61]. This explains nicely the stability of DNA and various biopolymers as being due to the fact that depolymerization by hydration is not possible in this phase. One could envisage the resting state of cell as a cellular winter during which proteins are folded or frozen to unfolded configurations by strong hydrogen bonds. External perturbation feeds energy to the system and induces periods during which the ice is frozen and proteins wake up and begin to unfold or fold and form aggregates as a response to the perturbation and return to the ground state after the energy of the signal is dissipated.

5. These findings together with the discovery that also nerve pulse seems to involve only low dissipation lead to a model of nerve pulse in which dark ionic currents automatically return back as Josephson currents without any need for pumping. This does not exclude the possibility that ionic channels might be involved with the generation of nerve pulse. In TGD inspired model [K56] nerve pulse would result as a perturbation of $f \simeq 1$ kHz frequency soliton sequence mathematically equivalent to a situation in which a sequence of gravitational penduli rotates with constant phase difference between neighbors except for one pendulum which oscillates and oscillation moves along the sequence with the same velocity as the kHz wave. The oscillation would be induced by a "kick" for which one can imagine several mechanisms. Nerve pulse would be like dissonance in background harmony. This view conforms with the general vision that any equilibrium in living matter is homeostasis rather than analog of equilibrium in mechanical system.

The model explains some features of nerve pulse not explained by Hodgkin-Huxley model. These include the mechanical changes associated with axon during nerve pulse, the outwards force generated by nerve pulse with a correct prediction for its order of magnitude, the adiabatic character of nerve pulse, and the small rise of temperature of membrane during pulse followed by a reduction slightly below the original temperature.

The model predicts that the time taken to travel along any axon is a multiple of time dictated by the resting potential so that synchronization is an automatic prediction and would have nothing to do with transmitters. Not only kHz waves but also a fractal hierarchy of EEG (and EXG) waves are induced as Josephson radiation by voltage waves along axons and microtubules and by standing waves assignable to neuronal (cell) soma. The value of Planck constant involved with flux tubes determines the frequency scale of EXG so that a fractal hierarchy results.

The model forces to challenge the existing interpretation of nerve pulse patterns and the function of neural transmitters. Neural transmitters need not represent actual/only) signal but could be more analogous to links in quantum web. The transmitter would code the address of the receiver, which could be a gene inside neuronal nucleus. Nerve pulses would build a connection line between sender and receiver of nerve pulse along which actual signals would propagate. Also quantum entanglement between receiver and sender can be considered.

6. Acupuncture points, meridians, and Chi are key notions of Eastern medicine and find a natural identification in terms of magnetic body lacking from the western medicine. Also a connection with well established notions of DC currents and potentials discovered by Becker and with TGD based view about universal metabolic currencies as differences of zero point energies for pairs of space-time sheets with different p-adic length scale emerges [K33]. The spectrum for increments of zero point kinetic energies represents lines which cannot be explained in terms of molecule physics and the empirical evidence for them is discussed in [K6]

Chi would correspond to these fundamental metabolic energy quanta to which ordinary chemically stored metabolic energy would be transformed. The identification nearest in spirit to the the original intuition would be in terms of negentropic entanglement. Meridians would most naturally correspond to flux tubes with large \hbar along which dark supra currents flow without dissipation and transfer the metabolic energy between distant cells. Acupuncture points would correspond to points between which metabolic energy is transferred and their high conductivity and semiconductor like behavior would conform with the interpretation in terms of metabolic energy storages.

The energy gained in the potential difference between the points would help to kick the charge carrier to a smaller space-time sheet. It is possible that the main contribution to the of charge at magnetic flux tube is magnetic energy and slightly below the metabolic energy quantum and that the voltage difference gives only the lacking small energy increment making the transfer possible. Also direct kicking of charge carriers to smaller space-time sheets by photons is possible and the observed action spectrum for IR and red photons corresponds to the predicted increments of zero point kinetic energies.

7. The notion of magnetic body implicates the notion of magnetic motor actions. Magnetic flux tubes and their motor actions could play key role in bio-catalysis and explain the magic ability of biomolecules to find each other. The model of DNA as topological quantum computer [K19]

suggest that not only DNA and its conjugate but also some amino-acid sequences acting as catalysts could be connected to DNA and other amino-acids sequences or more general biomolecules by flux tubes acting as colored braid strands. The shortening of the flux tubes in a phase transition reducing the value of Planck constant would make possible extremely selective mechanisms of catalysis allowing precisely defined locations of reacting molecules to attach to each other. With recently discovered mechanism for programming sequences of biochemical reactions (based on idea that each step in the reaction sequence means key allowing to open the door to the room containing the next key) [I66] this would make possible to understand the miraculous looking feats of bio-catalysis. Second key mechanism would be the re-connection of the magnetic flux tubes changing the topology of the Indra's net formed by magnetic flux tubes having biomolecules at their nodes.

8. Water memory is one of the highly disputed notions and motivated by the claimed effects of homeopathy. Water memory for which the work of the group led by HIV Nobelist L. Montagnier [I50] gives support would be naturally based on the coding of the biologically relevant properties of molecules to the cyclotron frequencies of its magnetic body. Water memory could rely on the copies of this magnetic body.

Quite surprisingly, the finding of the group suggest also that genetic code might have higherto unknown realization. TGD indeed predicts several realizations, for instance those based on electromagnetic field patterns [K30]. The model of watermemory [K31] in turn led to a theoretical surprise [K79]. One could understand DNA, RNA, tRNA, and aminoacids in terms of states of dark nucleons constructed from three quarks and that vertebrate genetic code follows as a prediction in the sense that the numbers of counterparts of DNA codons coding for given amino-adic are predicted correctly [L9]. Prebiotic evolution as a process leading to a chemical realization of fundamental codes and counterparts of biomolecules existing already at the level of elementary particle physics together with the reduction of metabolic currencies to increments of zero point energies would solve two egg or hen problems of theoretical biology.

There is no reason to assume that dark genes would not be still there and in close interaction with ordinary genes and in principle they could make possible controlled evolution analogous to industrial R&D process based on the construction of new genetic variants at the virtual world level of dark genes and the transcriptions to ordinary genes so that the new options could be tested under real life situations.

9. Although not directly related to the notion of magnetic body, the ability to construct "stories", temporally scaled down or possible also scaled up representations about the dynamical processes of external world, deserves to be mentioned. This ability might be actually one of the key aspects of intelligence [K19]. There is direct empirical evidence for this activity in hippocampus [J73]. The phase transitions reducing or increasing the value of Planck constant would indeed allow to achieve this by scaling the time duration of the zero energy space-time sheets providing cognitive representations.

Dark water and water memory: genetic code realized at elementary particle level?

The assumption was that water -possibly in liquid crystal like state- provides representations of molecules and in this manner makes possible water memory, frequency imprinting.

The hierarchy of Planck constants has brought additional details to this picture.

There is experimental evidence for what might be called dark hydrogen associated with water. The chemical formula of water is $H_{1.5}O$ in attosecond time scale and this could be explained if 1/4 of hydrogens are in dark phase. The dark portion of water could explain the numerous anomalies of water as a condensed matter phase. Water memory can be assigned with the magnetic bodies of the water molecule clusters and braiding would again be an excellent candidate for memory representations. Cyclotron Bose-Einstein condensate provide representation of water memory as temporal radiation patters. They could be generated in the liquid flows inducing braiding. An interesting idea is that archetypal liquid flows are selected as asymptotic self-organization patterns and are accompanied by characteristic radiation patterns making possible "naming" of these patterns and symbolic dynamics.

A simple model for dark nucleons, their states of dark predicts that the dark nucleon states are in one-one correspondence with DNA, RNA, tRNA, and aminocids in a natural manner and that

vertebrate genetic code emerges in a natural manner from the model. This suggests that genetic code is realized at nucleon level for the dark component of water and chemical realization is only secondary realization. This leads to a dramatic modification of views about the evolution of genome. It would not be anymore random choice followed by selection but much more like R&D in industry. The assumption that there is transcription of dark variants of the basic biomolecules to their chemical counterparts would make the new view possible. The basic mechanism of homeopathy would be basic mechanism of evolution allowing to modify genome as a response to environmental factors and also transfer the modifications to offspring.

The identification of biophotons as ordinary photons resulting in the phase transition reducing the Planck constant assignable to dark photons is very natural and revises the model suggested in the article A model for biophotons. Dark photons propagating along magnetic flux tube would play a key role also in the physics of biological body and brain and would provide an additional very fast communication channel besides nerve pulse transmission and various biochemical signalling mechanisms. This leads to a proposal for a model of cell membrane.

Direct experimental evidence for the notion of magnetic body carrying dark matter

The list of nice things made possible by the magnetic body is impressive and one can ask whether there is any experimental support for this notion. The evidence from water memory has been already mentioned. An explanation for the impressive list of anomalies of water [D7] discussed in [K18] provide one possible manner to justify the notion. For instance, it is known that in attosecond time scales water behaves as $H_{1.5}O$ [D6, D8, D17] as if part of hydrogen atoms would be dark.

The findings of Peter Gariaev and collaborators give evidence for the representation of DNA sequences based on the coding of nucleotide to a rotation angle of the polarization direction as photon travels through the flux tube and for the decoding of this representation to gene activation [I34], for the transformation of laser light to light at various radio-wave frequencies having interpretation in terms of phase transitions increasing \hbar [I1], and even for the possibility to photograph magnetic flux tubes containing dark matter by using ordinary light in UV-IR range scattered from DNA [I57].

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 cyclotron 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 is 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.

Genetic code and dark nucleon states

New realization of the genetic code in terms of dark proton sequences identified as dark nucleons was discovered [L9, K31].

1. The states of dark proton are in natural one-one correspondence with DNA, RNA, tRNA, and amino-acids and vertebrate genetic code is realized in a natural manner. Dark nucleons realized DNA codons as entangled quark triplets. The effective chemical formula $H_{1.5}O$ for water in atto-second time scale supports this view [K16]. How the notion of dark nucleon relates to negentropic entanglement of electrons? Could dark electron pairs and dark nucleons correspond to the same value of Planck constant? Could both dark protons and dark electrons play a key role in metabolism.
2. The simplest guess is that DNA strands are accompanied by dark nuclei with one dark proton per DNA nucleotide. The resulting positive charged would stabilize the system by partially neutralizing the negative charge density due to the phosphorylation (2 negative charges per nucleotide). Dark proton sequences could be associated also with other important bio-polymers. If the spins of the dark protons are parallel the dipole magnetic fields give rise to flux tubes connecting the protons and one can assign to the large \hbar protons a macroscopically quantum coherent phase.
3. The natural guess would be that dark nucleus realization of the genetic code induces the biological realization as evolution assigns to dark nucleon sequences DNA, RNA, and aminoacid sequences with 1-1 correlation between dark nucleon state and basic unit of the sequence. The dark realization of genetic code suggest a totally new view about biological evolution as a process, which is analogous to R&D in high tech industry rather than being completely random [K31]. The candidates for new genes could be tested at dark matter level and in the case that they work they would be transcribed to their chemical equivalents.

4.2.7 How to build a quantum computer from magnetic flux tubes

Magnetic flux tubes play a key role in TGD inspired model of quantum biology. Could the networks of magnetic flux tubes containing dark particles with large \hbar in macroscopic quantum states and carrying beams of dark photons define analogs of electric circuits? This would be rather cheap technology since no metal would be needed for wires. Dark photon beams would propagate along the flux tubes representing the analogs of optical cables and make possible communications with maximal signal velocity.

I have actually made much more radical proposal in TGD inspired quantum biology. According to this proposal, flux tube connections are dynamical and can be changed by reconnection of two magnetic flux tubes. The signal pathways $A \rightarrow C$ and $B \rightarrow D$ would be transformed to signal pathways to $A \rightarrow D$ and $B \rightarrow C$ by reconnection. Reconnection actually represents a basic stringy vertex. The contraction of magnetic flux tubes by a phase transition changing Planck constant could be fundamental in bio-catalysis since it would allow distant molecules connected by flux tubes to find each other in the molecular crowd.

DNA as a topological quantum computer is the idea that I have been developing for 5 years or so. I have concentrated on the new physics realization of braids and devoted not much thought to how the quantum computer problems might run in this framework. I was surprised to realize how little I know about what happens in even ordinary computation. Instead of going immediately to Wikipedia I take the risk of publicly making myself fool and try to use my own brain.

What can one learn from ordinary computer programs

One could begin with the question what happens in classical computation. How the program is realized and how it runs? The notion of Turing machine represents an extreme abstraction mentioning nothing about the technical side and does not help much in attempts to answer these questions. Turing paradigm also assumes that program is a temporal sequence of operations. These operations could however correspond to a linear spatial sequences and inputs and outputs in this case would correspond to boundary values at the ends of the linear structure. This requires that the dynamics is such that evolution in spatial direction is analogous to a deterministic time evolution. In this case it is much easier to imagine biological realizations of quantum computer programs in TGD inspired bio-world.

To develop concrete ideas, one can start from the picture provided by ordinary computer program.

1. Programs consist of temporal/spatial sequences of commands and commands represent basic functions from which one can build more complex functions by the composition of functions having some numbers of input and output arguments. The eventual output variable can be expressed by printing of a piece of text or as an image in the computer screen. Each step in the program corresponds to a composition of functions: $f_{n+1} = g_{n+1} \circ f_n$. There is some minimal set of primitive/prime functions from which one builds up more complex functions by composition.
2. How this is realized at the level of hardware? One can assume that the basic functions are at some fixed places in the computer memory having addresses given by integers represented as bit sequences. This address represents the command - a name of the function. The names for input variables and output variables are bit sequences giving the addresses of the places containing the values of these variables. Program is a sequence of commands represented as bit sequences giving the address of the function to be computed at a given step and the addresses of inputs and outputs. As the processing unit reads the command, it generates/activates connections from the addresses of inputs to the address representing the function and from this address to the addresses of outputs.

Essentially the challenge is to reconnect, build/activate connections. An interesting question is whether learning identified as strengthening of synaptic connections [J12] is one particular example of this process.

3. How the sequence of bits representing command address is realized? As the processing unit reads the address of command it should automatically create/activate a connection from this address to the command address. The connections from the processing unit to the addresses could exist physically as wirings.
4. It is not necessary that program is dynamical so that the inputs and outputs would be initial and final values of variables. Inputs and outputs could also correspond to values of variables at the ends of a linear structure. In topological quantum computation space-like entanglement would represent superposition of input-output pairs characterizing a function as a rule with instances represented as instances appearing in the superposition.

If this picture is roughly correct, re-connection would be the basic process. Reconnection is the basic process for magnetic flux tubes and $\text{ADP} \leftrightarrow \text{ATP}$ has been assigned to this process with ATP molecule serving as a relay activating the flux tube connection. Maybe ADP-ATP process, which is usually seen as a basic step of metabolism, could be seen as the core step for quantum computation performed by living matter. One expects that the presence ATP makes the rule represented by negentropic quantum entanglement conscious.

Quantum computation magnetic flux tubes as connections

Consider now quantum computation could take place in a circuitry having magnetic flux tubes as wires and some bio-molecules or groups of them as units defining prime functions. DNA as topological quantum computer could be taken as a starting point. The outcome of quantum computation is determined statistically as ensemble average so that a large number of copies of the program should be present and realized in terms of groups of cells or molecules connected by braidings if the quantum computation is space-like. This option seems more natural than time-like quantum computation realized as a 2-D liquid flow of lipids in the lipid layers of the cell membrane.

1. *The hardware*

Consider first the hardware of topological quantum computation using space-like braids.

1. Magnetic flux tubes would represent the wires along which inputs and outputs travel in the case of classical computation or dynamical quantum computation. In the case of space-like topological quantum computation entanglement is between the ends of the flux tubes.
2. Variables could be represented in many manners. For space-like quantum computations they could correspond to spin states of dark electrons at flux tubes or to polarization states of dark electrons at the flux tubes. In the original model of DNA as topological quantum computer quarks and antiquarks were proposed as a representation of genetic codons: also this quite science fictive option could make sense in TGD Universe since TGD predicts scaled versions of QCD like dynamics and presence of elementary particles in several p-adic scales and in scales dictated by value of Planck constant for given p-adic length scale.

The spin states of electron pair has been proposed as one possible representation of the 4 genetic codons. Quantum variables would be represented by qubit sequences and the measurement of qubit would give a bit sequence characterizing the classical value of the variable. Bio-molecules would be natural places for storing the values of the variables. For dynamical computations the values of variables could be transmitted using dark photons.

3. There would exist basic processing units calculating the prime functions from which more complex functions would be obtained as composites. Basic units could correspond to bio-molecules. In the case of classical computation the inputs to molecules and outputs from them would travel along the flux tubes. In quantum computation these signals could be used to control the initial values of the variables. Molecules could also serve as gates for quantum computation.

2. *Representation of programs*

The basic program units in the case of quantum computation would be represented by braidings.

1. If the ends of braid strands are able to move freely when needed, it becomes possible to re-write programs. Lipid layers of cell membrane can be in liquid crystal state so that these are ideal for this purpose. The time-like braiding resulting from lipid flow and representing running topological quantum computation program would induce space-like braiding representing space-like topological quantum computation or a rule. A particular quantum computer program represented as space-like braiding of the flux tubes would result as liquid crystal melts for a moment and freezes again.

The process in which proteins covered by ordered water analogous to ice temporarily melt and form aggregates [I13] is basic process induced by the feed of energy to the cellular system and could be compared to cellular summer. This process could mean quite generally molecular re-programming induced by the flow of cellular water inducing molecular flows inducing re-braidings. The braiding would also store the highlights of the cellular summer to cellular memory! This could be also seen learning by a modification of various quantum computer programs.

2. Negentropic entanglement is highly suggestive and would conform with the idea that the rule represented by entanglement represents conscious information or information which can become

conscious. The process of becoming conscious information could involve $\text{ATP} \rightarrow \text{ADP}$ and deactivating the flux tube and destroy the information. Time-like braiding represented by liquid flow would modify space-like braiding.

It is not quite clear whether the information is conscious when negentropic entanglement (and ATP) is present - as Bohm's notion of active information [J3] would suggest - or when ATP is transformed to ADP and connection becomes passive. Negentropic entanglement can be stable with respect to NMP [K42] so that the presence of ATP could mean period of conscious experience - negentropic entanglement could be analogous to active information.

TGD based model for the memory recall by sending negative energy signals to geometric past suggests that the absorption of negative energy photon transforms ATP to ADP. Conscious experience is regenerated in the geometric now where the negative energy signal came from - perhaps by transforming ADP to ATP by using the negative resulting by sending of negative energy signal! Conscious reading would be actually memory recall and analogous to teleportation? The destruction of the representation of memory in the geometric past would have interpretation in terms of no-cloning theorem [B3].

3. Static realizations of the programs are easier to imagine since no temporal codes are needed for the transfer of bits. An attractive idea is that the computations are represented by static entanglements for linear structures and that time-like braiding allows to modify the programs.

3. *The realization of program*

The program would be basically a sequence of address lists. Address list would contain the address of the function to be performed and the addresses of the input molecules and output molecules. How to represent the address physically?

1. The simplest manner to realize this would use existing flux tubes connecting the processing unit to all possible input and output addresses as well as command addresses, and activate those flux tubes to which input and output data are assigned and reconnect them to the flux tubes connecting processing unit to the unit representing the function. The processing unit would have flux tubes coming from all possible inputs, going to all possible outputs, flux tubes going to places representing functions and coming from these places. Processing unit would be like a relay station or old fashioned telephone center whose sole purpose would be to create connections by reconnecting flux tubes. ATP molecule would be probably involved with the activation and - allowing a sloppy language - one could say that communication line becomes conscious when ATP is attached to it.
 - (a) Addressing would be just selection of activated molecules and analogous to that used in telephone network or computer network connected by cables. This would require static flux tube network and flux tubes could be either active or passive. In passive state flux tubes could be short-cut by a reconnection with hydrogen bond so that the ends of cut flux tube would end up to water molecules. This is however not necessary. Activation in absence of the short cut would involve reconnection of a flux tube with a flux tube connecting two parts of ATP - possibly hydrogen bond again- so that ATP becomes part of the flux tubes. If also short cut is involved, the strands coming to the two water molecules reconnect and generate hydrogen bond and flux tube to which ATP would attach in the proposed manner. As ATP is used it transforms to ADP and de-attaches from the flux tube.
 - (b) One can imagine also a dynamical addressing based on the generation of magnetic flux tubes between inputs and submodules. The computational process could be still space-like. The first manner to realize dynamical addressing would be by attaching to the ends of dynamical flux tubes biomolecules, which bind to specific receptors. Receptor mechanism would allow to connect distant cells to each other and build a magnetic flux tube connection between them. Computational unit specialized to run a specific program could excrete biomolecules binding to the input and output receptors: this program would realized function in terms of space-like entanglement. Glands emit hormones binding to receptors and various glands could in principle serve as computational units. Various information molecules bind very selectively and this might also relate to quantum space-like computations.

- (c) Second mechanism of dynamical addressing would use dark photons. In this case resonant interaction selecting the target would replace the receptor mechanism. In this kind of situation one can claim that flux tubes are un-necessary, one can use just resonance to build connection to a desired place just as one does in radio communications. Of course, topological light rays could be accompanied by flux tubes. For instance, DNA nucleotide could attach by flux tube to its conjugate in distant DNA molecule and if the connection is based on resonance only similar nucleotide sequences could connect with each other. I have discussed this kind of mechanism in a model for remote replication of DNA [K95] based on the experimental work by Peter Gariaev and his group. The resonance mechanism could also make possible to establish flux tube connections and the quantum computation could be a static operation.
2. DNA as topological quantum computer vision gives some idea about how the computer program could be realized as a spatial linear structure.
 - (a) Program would be a sequence of topological quantum computations. Given topological quantum computation would be represented by a braiding of flux tubes connecting DNA nucleotides with the lipid molecules of the inner lipid layer. Program would correspond to a linear sequence of cells with the outer lipid layer connected to the DNA of the second cell.
 - (b) Lipid flows at given lipid layer could be used to rewrite programs and the programs could respond to the changes in environment in this manner: this would require that the lipid layer is in liquid crystal state during the period when program is changed. Also nerve pulse patterns would induce these flows. Programs would also represent memories as rules realized as quantum abstractions or as quantum functions.
 - (c) The program would "run" in the spatial direction. The selection of active input and output variables would be by acting the connection from molecule in question by attaching ATP as a relay through which the reconnected flux tube would traverse. This would be also part of the writing of the program. The superposition of entangled inputs and outputs could be seen as a quantum superposition of classical programs assigning outputs to inputs. Also microtubule-lipid layer braiding suggested also to play a key role in the realization of memories could give rise to similar space-like quantum computation representing rules.
 - (d) The effective 2-dimensionality implied by strong form of holography implied in turn by strong form of general coordinate invariance means that the physics depends on partonic 2-surfaces and 4-D tangent space data at them. This suggests that the dynamics on space-like 3-surfaces and light-like orbits of partonic 2-surfaces is fixed by a process analogous to gauge selection. Does just this effective gauge symmetry make possible to write quantum computer programs? Already ordinary deterministic computer program means selection of one particular dynamics from several alternative options suggesting that strict determinism is broken.
 3. What could be the role of bio-catalysis in the computation? Bio-catalysis is a central part of the biological information processing and it would not be surprising if the catalysts connected by flux tubes to substrate molecules were involved with the computations. An attractive idea is that various information molecules binding to receptors involved with bio-control (neurotransmitters, hormones, etc...) are involved with building the flux tube connections between cells. These bio-molecules could carry the ends of flux tubes to special places for which receptors serve as addresses and in this manner build hardware for topological quantum computation involving inputs and outputs in distant parts of the body. The final output could be transformed to controlled gene expression. Quite generally, catalysts bind very selectively and could play a role similar that played by information molecules in building up the quantum computer programs.
 4. One can imagine also purely classical computation based on catalytic mechanism probably allowing generalization to quantum case. The idea is that computer program - understood now as dynamical structure - is analogous to what happens in fairy tale in which hero finds a key which fits to a lock of a room containing a key which... There exists a beautiful realization of classical computation in terms of chemical concentrations using DNA. The output of given

reaction representing computational step appears in the next reaction provide the system contains additional participating molecules, which could be both substrate molecules and catalysts. The program could be represented as concentrations of molecules needed at intermediate steps and lock-to-key mechanism guarantees that they are performed in the correct temporal order. Inputs and output molecules could be connected by flux tubes to bio-molecules which bind to specific receptors associated with the molecule representing the particular subprogram. This would automatically create a large number of classical computations proceeding in fixed order, maybe even quantum computations.

4.2.8 DNA as topological quantum computer

The vision about how DNA might act as a topological quantum computer (TQC) [B9] is few years old [K19]. TQC means that the time-like braidings of braid strands define TQC programs and M -matrix (generalization of S -matrix in zero energy ontology) defining the time-like entanglement between states assignable to the end points of strands define the TQC program coded as unitary time evolution for Schrödinger equation in the standard framework. One can end up to the model in the following manner.

1. Darwinian selection for which the 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. As a matter fact, the flux tubes would correspond to what I have used to call wormhole magnetic fields [K86] having pairs of space-time sheets carrying opposite magnetic fluxes. The wormholes themselves could have interpretation as dark scaled variants of ordinary elementary particles. The large value of Planck constant would zoom up the magnetic fields associated with ordinary elementary particles from weak scale to much longer length scale given by cell size or even a longer length scale.
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. There is also a connection with hologram idea: EEG rhythm corresponds to reference wave and nerve pulse patterns to the wave carrying the information and interfering with the reference wave.

4. Fluid flow would naturally 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. Also nerve pulse patterns could induce the flow of lipids inducing the braiding so that nerve pulse patterns would define TQC programs and be coded into memories.

5. The topology of the braid traversing cell membrane cannot be 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.

This is one possible realization and it is of course clear that one can imagine several alternatives. There are several problems related to the details of the realization.

1. How nucleotides A,T,C,G are coded to the strand color and what this color corresponds to physically? The original proposal was that there are two options which could be characterized as fermionic and bosonic.
 - (a) Magnetic flux tubes having quark and anti-quark at their ends with u, d and u_c, d_c coding for A,G and T,C. CP conjugation would correspond to conjugation for DNA nucleotides.
 - (b) Wormhole magnetic flux tubes having wormhole contact and its CP conjugate at its ends with wormhole contact carrying quark and anti-quark at its throats. The latter are predicted to appear in all length scales in TGD Universe.

Recently it became clear that there is much simpler realization involving only spin 1/2 fermion pairs assignable to pairs of flux tubes. The spin states of fermion pairs form triplet and singlet and code for A,T,C,G. The first guess is that fermion is proton or electron but this does not allow coding of color qualia. Taking fermion to be u quark one can realize color qualia in terms of quark color and has good hopes about Coulomb stability since the charge assigned to nucleotide reduces from -2 to -2/3 (Coulomb stability of DNA is a well-known problem). Flux tubes are ordinary flux tubes. One ends up also to a concrete model for happens when color qualia are generated. An unexpected bonus is that statistics constraint implies that color and spin entanglement forces spatial entanglement realized as braiding of the flux tubes so that entanglement indeed has classical space-time correlate.

2. How to split the braid strands in a controlled manner? High T_c super conductivity provides a possible 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.
3. How magnetic flux tubes can be cut without breaking the conservation of the magnetic flux? The notion of wormhole magnetic field could save the situation now: after the splitting the flux returns back along the second space-time sheet of wormhole magnetic field. An alternative solution is based on reconnection of flux tubes. Since only flux tubes of same color can reconnect this process can induce transfer of color: "color inheritance": when applied at the level of amino-acids this would give strong constraints on the model of protein folding [K3]. Reconnection makes possible breaking of flux tube connection for both the ordinary magnetic flux tubes and wormhole magnetic flux tubes.
4. How magnetic flux tubes are realized? The interpretation of flux tubes as correlates of directed attention at molecular level suggests a rather concrete picture. Hydrogen bonds are by their asymmetry natural correlates for a directed attention at molecular level. Also flux tubes between acceptors of hydrogen bonds must be allowed and acceptors can be seen as the subjects of directed attention and donors as objects. Examples of acceptors are aromatic rings of nucleotides, $O =$ atoms of phosphates, etc.. A connection with metabolism is obtained if it is assumed that various phosphates $XMP, XDP, XTP, X = A, T, G, C$ act as fundamental acceptors and plugs in the connection lines. The basic metabolic process $ATP \rightarrow ADP + P_i$ allows an interpretation as a reconnection splitting flux tube connection, and the basic function of phosphorylating enzymes would be to build flux tube connections as also of breathing and photosynthesis.

The model makes several testable predictions about DNA itself. In particular, matter-antimatter asymmetry and slightly broken isospin symmetry at the level of dark quarks have counterparts at DNA level induced from the breaking of these symmetries for quarks and antiquarks associated with the flux tubes. DNA cell membrane system is not the only possible system that could perform TQC like activities and store memories in braidings: flux tubes could connect biomolecules and the negentropic

braiding could provide an almost definition for what it is to be living. Even water memory might reduce to braidings.

The model leads also to an improved understanding of other roles of the magnetic flux tubes containing dark matter. Phase transitions changing the value of Planck constant for the magnetic flux tubes could be key element of bio-catalysis and electromagnetic long distance communications in living matter. There is also a fascinating connection with Peter Gariaev's work [I57] suggesting that the phase transitions changing Planck constant have been observed and wormhole magnetic flux tubes containing dark matter have been photographed in his experiments [K77].

4.2.9 What is the role of magnetic body in DNA replication, mitosis, meiosis, and fertilization?

If magnetic body uses biological body as a motor instrument and sensory receptor, the natural question is whether basic process such as mitosis, meiosis. could be induced by more fundamental processes for the magnetic body. One can argue that if magnetic flux tubes are responsible for making living organism and even population a kind of Indra's net, cell division should be induced by magnetic body and should produce automatically this Indra's net.

As a matter of fact, cell division brings strongly in mind division of magnetic dipole but also the reconnection of magnetic flux tubes can be considered as a basic mechanism. At least the following basic mechanisms can be considered.

1. Consider a pair of magnetic flux tubes with opposite fluxes connecting objects A and B. The division of A+B to A and B would be induced by a reconnection process for the members of the pair producing two loops associated with A and B but no connection between A and B anymore. The problem of this option is that the flux tube connection defined in this manner might not be stable enough.
2. Magnetic dipole would correspond to a flux tube at the core of the dipole field itself decomposing to flux tubes with weaker magnetic flux at its ends. The division to two dipoles would correspond to a formation of segment in which flux tube decomposes into several flux tubes, which need not be parallel anymore. Two new dipole ends are formed and the old dipole ends remain connected so that the repetition of this process would yield a kind of Indra's net predicting that all cells of living organism are connected by the flux tubes to single coherent whole.

The division of flux tube to several flux tubes could also correspond to the increase of Planck constant by integer factor n along a segment of flux tube. The resulting n flux sheets would corresponds to the sheets of the covering. The length of the segment would be scaled up by n .

3. If one has pair of dipoles A-B and C-D with same total flux, a reconnection leading to A-D and C-B is possible.

Could biochemical processes associated with cell division be induced by some of the listed processes? The two latter options would predict that the cells produced in cell division remain connected by magnetic flux tubes. The division of dipole creates two new dipole ends connected by short flux tube. The already existing ends remain connected by "long" flux tubes carrying weak magnetic fields as compared to that carried by the dipole itself. Also the processes of meiosis and fertilization could respect the presence of long flux tubes connecting the cells participating in the process so that flux tube connections could also exist between parents and offspring. The members of population could form a kind of super-organism. Remote interactions between DNA and other biomolecules of closely related members of species and even shared use of DNA (and its TGD variant "dark DNA") can be imagined.

1. Consider first DNA replication and reshuffling taking place in meiosis [I10] essential for the sexual reproduction in eukariotes. The dividing nucleus (of form MMFF) is ordinary nucleus and contains two pairs of chromosomes coming both mother (MM) and father (FF). Division produces four haploid cells containing only two chromosomes (AB) with A and B obtained by reshuffling the DNAs of mother and father to obtained 4 unique chromosome pairs. In sexual reproduction these cells fuse to form diploid cells (MMFF).

- (a) The reshuffling of a pair MF of DNA strands from father and mother could be induced by a repeated reconnection process for flux tubes parallel to DNA strands. The simplest reconnection for strands A-B and C-D produces strands A-X-D and C-Y-B where A-Z and C-Y are pieces of A-B and C-D with same number of codons.
- (b) The replication of DNA takes place for all four chromosomes before reshuffling. One obtains a nucleus containing 4 pairs of doubled chromosomes. This double nucleus divides to two daughter nuclei containing 2 doubled chromosomes each. These divide further to two nuclei each containing only two chromosomes each (AB).
The DNA reshuffling could correspond to a multiple reconnection process if the two DNA strands are accompanied by long magnetic dipoles (flux tubes). Note that in absence of additional restrictions many combinations (28) are possible.
- (c) After replication and reshuffling the division of the nucleus two two intermediaries could be induced either by splitting of a flux tube connecting pairs of doubled chromosomes to flux tubes not anymore parallel to each other. The flux could diverge to a larger volume in this segment. Second possibility is that the increase of Planck constant increases the length of segment and at the same time divides the flux into sub-fluxes. Dipole field flux tube would give long flux tubes and split dipole shorter flux tubes connecting the resulting cells together.
- (d) Also the chromosome pairs of the resulting intermediate nuclei could be connected to each other by flux tubes to form a connected structure A-B-C-D and reconnection process could divide it to A-B plus C-D (say) and lead to a division of the nucleus producing 4 ordinary daughter nuclei.
2. In mitosis [I11] the initial nucleus corresponds to MMFF and DNA replication leads to pairs of doubled chromosomes but without re-shuffling. One doubled pair from mother and one pair from father the members of doubled chromosomes are connected by a kind of bridge. In the mitosis proper the doubled chromosome pairs are split and two chromosome pairs containing one chromosome from father and mother are formed. After this division leads to two diploid cells similar to the dividing cell.
3. In fertilization [I6] gametes from father and mother fuse together to form a single cell with two pairs of chromosomes from both father and mother. The question is how the two gametes are able to find each other. The reconnection of closed magnetic flux tubes associated with the gametes could lead to a formation of bridges connection the two gametes and a phase transition reducing the value of Planck constant could lead the two gametes near each other and make possible the fusion.

DNA replication [I4] is clearly the fundamental process, and the question is whether also this step could be reduced to a reconnection for a pair flux tubes: first would connect the separated DNA strands and second one free nucleotide and its conjugate.

1. Suppose that there are flux tubes connecting nucleotides of DNA and corresponding nucleotides of the conjugate strand: they could be rather short flux tubes of length shorter than 1 nm in the normal situation but could grow longer when DNA strands separate. This might involve a phase transition increasing temporarily the value of Planck constant assignable to these flux tubes and increasing the length of the segment and of connecting flux tube and therefore the distance of DNA strands.
2. There are also free DNA nucleotides and their conjugates in the environment which can be used in the replication process as building bricks. If also free nucleotides and their conjugates are connected in a pairwise manner by similar flux tubes and if the value of magnetic flux characterizes a given pair then reconnection could take place for these two kinds of flux tubes and lead to a correct pairing of DNA strand with conjugate nucleotides. Same would happen for the conjugate strand. The reduction of Planck constant would lead to a pair of ordinary DNA double strands.
3. The details of the dynamics would be determined by other factors but the outcome would be fixed by the nucleotide-conjugate pairing and dependence of the flux on the nucleotide pair. In

particular, conservation of magnetic flux would guarantee that the nucleotides can be assigned only with their conjugates.

These arguments suggest that reconnection of magnetic flux tubes, temporary change of the Planck constant, and coding of nucleotide-conjugate pairs by magnetic flux could be key element of meiosis, mitosis, and reshuffling of chromosomes in meiosis. Also higher level processes - such as cell division and fertilization - could involve reconnection process as a fundamental step. These mechanisms would appear in several length scales corresponding to DNA, nucleus, and cell length scale. In an approach based on mere chemistry, this must be assumed as a result of kinematics.

4.3 The relationship between information processing and metabolism in TGD Universe

After the writing of the first version of this chapter for about decade ago several new ideas have emerged and the challenge is to unify these ideas.

4.3.1 Three different views about living matter as a macroscopic quantum system

There are three different views about how living system manages to be a macroscopic quantum system.

1. The first vision is based on various kinds of super-conductivities [K10]. Electronic super-conductivity is assigned with the cell membrane and plays a key role in the model of cell membrane as a Josephson junction. Furthermore, the effects of ELF em fields on vertebrate brain [K17] suggest that biologically important ions form macroscopic quantum states and cyclotron Bose-Einstein condensates of bosonic ions have been suggested. The TGD based view about atomic nuclei predicts exotic nuclei chemically equivalent with ordinary ones but being bosons rather than fermions. Also these exotic ions could also form cyclotron Bose-Einstein condensates. Large value of Planck constant would guarantee that cyclotron energies proportional to \hbar are above thermal energy.
2. A more precise view about hierarchy of Planck constants as an implication of the enormous vacuum degeneracy of Kähler action has emerged [K20]. According to this view non-standard values of Planck constant are only effective.

As the idea about the hierarchy of Planck constants emerged, I proposed that favored values of Planck constant could come as powers of 2^{11} . This was just a first guess inspired partially by the observation that the mass ratio of proton and electron is $940/.5 = 1880 \sim 2^{11}$. I managed to find indications supporting this hierarchy and also this chapter contains traces of this idea. I became later skeptic but one could actually imagine a mechanism implying this kind of hierarchy. Dark protons with say $r = \hbar/\hbar_0 = 1836 = 4 \times 3^3 \times 17$ would correspond to approximately same Compton length as ordinary electrons. It is natural to assign this value of \hbar also to electrons and this gives Compton length 44.6 Angstroms not far from the p-adic length scale $L(149) \simeq 50$ Angstroms assigned with the lipid layer of cell membrane. The condition that dark proton corresponds to this Compton length gives $r = 1836^2$: the electron Compton length comes now $8.1 \mu\text{m}$, which corresponds to cell size scale. One could continue the resulting hierarchy of Planck constants indefinitely.

3. The notion of negentropic entanglement making sense for rational and even algebraic entanglement probabilities has emerged as a possible characterizer of living matter [K42]. Quantum arithmetics [K89] allows to generalize the notion of rational so that p-adic real correspondence mediated by canonical identification is fixed uniquely and is both continuous and respects symmetries [K89]. One implication is an explanation for Shnoll effect [K4], which could be important also in living matter.

This raises several questions.

1. How high T_c super conductivity based on dark electron pairs and negentropic entanglement relate?

2. Could it be that electron pairs in valence bonds are the carriers of negentropic entanglement and that they generate the magnetic flux tubes as parts of their magnetic bodies? This makes sense only if the valence electron pairs in living matter have spin 1. The Cooper pairs of high T_c super-conductors are indeed known to have spin 1 [?] If this view is correct, biological evolution would favor the maximization of covalent electron pairs and this indeed seems to be the case.
3. Why large \hbar would make possible negentropic entanglement or even force it? Is there some purely number theoretic reason for this?

4.3.2 New ideas related to metabolism

Also new ideas related to metabolism have emerged at the same time when evidence for quantal aspects of photosynthesis has been emerging [I38, I15, I14, I5]. The ideas about the detailed relationship between metabolism and negentropic entanglement are still in a state of turmoil. Let us sum up those concepts and ideas which could serve as starting point.

1. Negentropic entanglement is the first basic notion. There is a strong tendency to consider the presence of a magnetic flux tube connecting two objects and carrying negentropically entangled quantum state as a fundamental structure giving rise to a directed attention. Negentropic entanglement would be basic element of conscious cognition, and one can assign to it various attributes like experience of understanding. The mildest assumption is that negentropic entanglement is associated with the flux tube. A stronger assumption is that it is between states assignable to the ends of the flux tube identifiable as observer and target of attention.

An analogy with Orch OR is suggestive. The period of negentropic entanglement - period of directed attention - would correspond to Orch Or and its end to state function reduction.

2. Negentropic entanglement leads also to the idea about energy metabolism and negentropy transfer as different sides of the same coin. The model for DNA as topological in turn suggest that $ADP \rightarrow ATP$ and its reverse can be interpreted as a standardized reconnection process re-organizing connections between distant molecules connected by magnetic flux tubes by the relay defined by ATP molecule. Metabolic energy would - or at least could - go to the re-organization of the flux tube connections and therefore of the negentropic quantum entanglement. The question is how to fuse this vision with the hypothesis about metabolic currencies as differences of zero point kinetic energies for space-time sheets.
3. An attractive interpretation is that the presence of ATP at magnetic flux tube serves as a signature of negentropic entanglement. The period of negentropic entanglement could be seen as the analog of Orch OR period ending with state function reduction. This period would be accompanied by consciousness to which one can assign various attributes such as experience of understanding and positively colored emotions. It is of course difficult to say what the counterparts of these experiences are at the level of flux tubes. One can imagine two options.
 - (a) The high energy phosphate bond in ATP is the carrier of the negentropic entanglement. The transformation of ATP to ADP would liberate the metabolic energy and mean end of the period during which one can assign negentropic entanglement to the flux tube. ATP would be the correlate for consciousness at the flux tube level - the molecule of consciousness.
 - (b) $ATP \rightarrow ADP$ transfers metabolic energy quantum to the magnetic flux tube and creates a excited with negentropic entanglement. This process could correspond to either generation of negentropic entanglement (period of negentropic entanglement would begin with $ATP \rightarrow ADP$ rather than end) or transfer of it from ATP to the flux tube.
4. The radiation from Sun defines the fundamental metabolic currency. Solar radiation cannot be said to negentropic since negentropic entanglement is a 2-particle property. Solar photons could possess a large value of \hbar or - more plausibly - suffer at the magnetic body of the living system a phase transition increasing the value of \hbar . Could the absorption of large \hbar photons arriving from Sun or from magnetic body by electrons generate spin 1 valence electron pairs pairs or provide the metabolic energy needed to re-arrange the flux tube connections between distant molecules by $ADP + P_i \rightarrow ATP$ process?

5. The identification of the increments zero point kinetic energies as universal metabolic energy quanta is one of the oldest hypothesis of TGD inspired theory of consciousness. Zero point kinetic energy is associated with the zero point motion of particle at space-time sheet. The finite size of the space-time sheet gives rise to this energy for which non-relativistic parametrization is $E_0 = k \times 3\hbar^2\pi^2/2mL^2(k)$. $L(k) = 2^{(-k+151)/2}L(151)$, $L(151) \simeq 10$ nm is the p-adic length scale of the space-time sheet, and k numerical factor not far from unity. Particle in 3-D box gives $k = 1$.

As particle is transferred to a larger space-time sheet the zero point kinetic energy is reduced, and the difference is liberated as usable metabolic energy. For proton the size scale of this space-time sheet could be atomic size scale $k = 137$. For electron it could electron Cooper pair $k = 149$ (prime) corresponding to a lipid layer of cell membrane could be in question. Entire hierarchy of metabolic energy quanta is predicted and the energy scale depends on the particle mass and p-adic length scale and geometric factors characterizing the shape of space-time sheet only.

One can ask whether the high energy phosphate bond in the phosphate of ATP molecule contains this kind of smaller space-time sheet and in the transition $ATP \rightarrow ADP$, electron or proton drops from this kind of space-time sheet. The following considerations show that this hypothesis is not necessary, and that one can also modify the identification of the fundamental metabolic energy quantum as zero point kinetic energy without losing anything. Therefore the details of the scenario are far from being fully nailed down.

6. Magnetic flux tubes are carriers of charged particles and the hypothesis is that cyclotron Bose-Einstein condensates for fermionic Cooper pairs and bosonic ions are relevant for consciousness. In particular, cyclotron transitions in which bosons in these condensates are excited would be important for the generation of conscious experiences. The hierarchy of Planck constants and the fact that cyclotron energy is proportional to \hbar allows to have arbitrarily high cyclotron energies in given magnetic field. This is essential in the model for the effects of ELF em fields on living matter [K6].
7. Becker's finding about the relevance of DC currents for healing of wounds lead to an idea about how electromagnetic radiation interacts with the charged particles at magnetic flux tubes [L26]. What would happen is that charged particles experience the electric and magnetic fields of the radiation field described in terms of massless extremals (topological light rays). Electric field would generate acceleration in the direct of the flux tube and could excite Becker currents which would give rise to biological effects - healing of wound in the simplest case. The proposal has been that this process gives rise to what could be seen as a loading of metabolic batteries.

The combination of this view with the notion of cyclotron BE condensate leads to a slightly more complex picture. Radiation field can excite single boson states both in transversal and longitudinal degrees of freedom. Transversal ones correspond to cyclotron states with energies $E_{c,n} = (n + 1/2)E_c$, $E_c = \hbar qB/m$ and the energies of excitations are of form nE_c . Longitudinal degrees of freedom correspond to a particle in 1-D box -possibly in presence of longitudinal electric field: a simple model for the states was derived in the model for Becker's DC currents.

In the absence of longitudinal electric field the energy spectrum is $E_n = n^2E_0$, $E_0 = \hbar^2\pi^2/2mL^2$, L the length of the flux tube. Longitudinal excitations correspond to energies $(n_f - n_i)^2E_0$ and would classically correspond to the acceleration in the electric field component parallel to the flux tube giving rise to Becker currents. For both excitations negentropically entangled states result very naturally as superpositions of single particle excitations and possibly also multi-particle excitations. Both incoming photons and liberation of metabolic energy quantum as photon can induce the excitation.

One could reinterpret the idea about universal metabolic energy quanta by interpreting them as increments of longitudinal energies at flux tube. For the excitation $n = 1 \rightarrow 2$ the energy would be $3\hbar^2\pi^2/2mL^2$ which is same as zero point kinetic energy for a particle in 3-D box of side L . Quantitative prediction is therefore same as that of the original model. One can of course consider also the original option that the transfer of particles from the flux tube to a larger space-time sheet indeed liberates metabolic energy.

Let us now try to weave these ideas to an internally consistent picture. It is perhaps best to proceed by making questions.

1. Could one assign negentropic entanglement with high energy phosphate bond? If so, the period of negentropic entanglement (having Orch OR as a counterpart) would correspond to the presence of ATP and the end of this period to $ATP \rightarrow ADP$. I have considered this possibility earlier. The problem is that it is difficult to understand how negentropic entanglement could be assigned simultaneously both to ATP and to the magnetic flux tube whose length and thickness are proportional to \hbar and therefore varies. One should treat ATP and flux tube as single basic structure and this does not sound convincing since the scales of flux tubes are expected to be much longer than the size scale of ATP molecule. Therefore there are two options.
 - (a) ATP is just what it is believed to be: provider of metabolic energy only. One can leave also open the question whether high energy phosphate bond can be interpreted in terms of zero point kinetic energy or not.
 - (b) ATP carries both metabolic energy and negentropic entanglement assignable to the phosphate bond and metabolic energy corresponds to zero point kinetic energy difference. In $ATP \rightarrow ADP$ a possibly dark photon or photons are emitted and is absorbed by a magnetic flux tube containing cyclotron Bose-Einstein condensate and the resulting delocalized single particle excitation as quantum superposition of various single particle excitations carries negentropic entanglement in the length scale associated with the magnetic flux tube, which can be much longer. Even several flux tubes could be excited simultaneously. This would regenerate long range negentropic entanglement stable under NMP. Transfer of negentropic entanglement would be in question.
2. Could the non-local excitations of cyclotron Bose-Einstein condensates by large \hbar photon give rise to the negentropically entangled states? Excitation of cyclotron BE condensate requires energy so that metabolic energy is required. ATP could provide this energy. Cyclotron energy quantum is given by $E_c = \hbar q B / m$, q and m are charged and mass of the boson. As already found, the energy of boson is sum of two contributions: energy $E_n \propto n^2$ associated with free longitudinal motion and magnetic energy $E_{c,n} \propto n + 1/2$. Longitudinal excitations could be assigned to the generation of Becker currents. This proposal would integrate metabolism, negentropy generation, and quantum like behavior of ELF em fields in living matter to single picture.
3. Could it be that ATP - instead of being a carrier of negentropic entanglement as suggested earlier - only provides the metabolic energy quantum transformed to cyclotron energy quantum or longitudinal energy quantum when negentropic entanglement is generated by exciting the cyclotron BE condensate? Or could ATP carry both metabolic energy and negentropic entanglement and both of them are transferred to the magnetic flux tube in $ATP \rightarrow ADP$ process?
 - (a) Cyclotron energies are quite too small for this to make sense for the ordinary value of Planck constant. The nominal value of the metabolic energy quantum is $E_0 = 0.5$ eV which by $E_0 = h_0 f_0$ corresponds to frequency $f_0 = 5 \times 10^{13}$ Hz in near infrared. The value of electron's cyclotron frequency in the endogenous magnetic field $B_{end} = .2 \times 10^{-4}$ Tesla postulated to explain the effects of ELF em fields on vertebrate brain is $f_{c,e} \simeq 6 \times 10^5$ Hz. If metabolic energy quantum is to excite cyclotron state ($n \rightarrow n + 1$), one must have $E_c = E_0$.
 Even for electron E_c is much below E_0 small for $B = B_{end}$ and $\hbar = \hbar_0$. One can however scale both B from B_{end} and \hbar from \hbar_0 . Requiring $E_c(\hbar, B) = E_0$ and using $E_c = hf$ gives $f_{ce}/f_0 = r_1 r$, $r_1 = \frac{B}{B_{end}}$ and $r = \frac{\hbar}{\hbar_0}$, where \hbar_0 denotes the standard value of Planck constant. This gives $r_1 r \simeq (5/6) \times 10^8$.
 - (b) There are many manners to achieve the desired upwards scaling of cyclotron energies. Magnetic flux quantization gives further constraints. One could require that magnetic flux is quantized, and that for $\hbar = \hbar_0$ the flux quantum has radius of order $L(151)$ (1 nm, cell membrane thickness) corresponding to the thickness of a flux tube assignable to single DNA nucleotide.

The radius of flux quantum corresponds to the magnetic length $r_B = \sqrt{\hbar}qB$. In the scaling $B_{end} \rightarrow 1$ Tesla ($r_1 = 2.5 \times 10^4$), magnetic length scales as $r_B \simeq 2.5 \mu\text{m} \rightarrow 11$ nm. From the condition $r_1 r = (5/6) \times 10^8$ one has for the scaling of Planck constant $r \sim 3.3 \times 10^3$. The scaling of the flux tubes length of $L(151)$ would give flux tube length of order $3 \times 10 \mu\text{m}$, which corresponds to cell size so that a flux tube connecting DNA and cell membrane could be in question. Note that the scaling of \hbar does not affect zero point kinetic energy in the longitudinal direction since L scales as \hbar .

- (c) For flux tube length $L(151)$ and for $\hbar = \hbar_0$ the energy of the lowest longitudinal excitation is same order of magnitude as metabolic energy quantum so that the excitation of longitudinal states could be in key role in the generation of Becker's currents. There is evidence about non-local excitations of electrons in photosynthesis, [I18], which suggests that the longitudinal energy excitation could indeed play the role of fundamental metabolic energy quantum transferred to the the energy of high energy phosphate bond of ATP. This interpretation leaves open the structure of high energy phosphate bond and there is no absolute need to assign zero point kinetic energy with it.

Longitudinal energies are negligible, one must require flux tube length to be considerably longer than $L(151)$ for the ordinary value of \hbar . Longitudinal energies are significant only for electron for given flux tube length. Indeed, Becker currents are known to be carried by electrons.

- (d) If one allows ionic Bose Einstein condensates the value of Planck constant must be scaled up by the mass ratio m_I/m_e , where m_I and m_e are the masses of ion and electron. For proton this would give scaling ratio $r = 2^{11}$ and one would end up with the hierarchy of Planck constants coming as powers of 2^{11} suggests years ago. What is remarkable that in cyclotron degrees of freedom also protons and ions can play a signification role: the quantal effects of ELF em fields on vertebrate brain suggest that this is the case.

4. What happens if one has just electrons rather than Cooper pairs? In both transversal and longitudinal degrees of freedom one would have the analog of Fermi sphere with electron states filled up to some maximum values integers characterizing cyclotron energy and longitudinal momentum. Transitions induce also now negentropic entanglement. For cyclotron states the energy increment would be E_c so that basic metabolic energy quantum can induce the transitions. In longitudinal degrees of freedom the minimal energy increment would be $(2N + 1)E_0$, where N characterizes the populated state with maximal longitudinal momentum. This energy should be equal to the metabolic energy quantum. This can be arranged but is not so natural. Experimental work is sooner or later bound to reveal whether electrons or their Cooper pairs are in question.

The option developed above is perhaps the most elegant found hitherto: it would raise the BE condensates of electronic and ionic Cooper pairs in a special position, it would lead to an explicit proposal for what negentropic entanglement is at the level of flux tubes, and in minimal form it would require no modification of the ideas related to ATP, even the standard view about ATP can be kept. Also the original hypothesis that ATP carries metabolic energy as zero point kinetic energy makes sense and also ATP could carry negentropic entanglement.

This view suggests that electronic cyclotron BE condensates are essential also for the understanding of photosynthesis. The absorption of dark photon would generate a non-local excitation of BE condensate of electron Cooper pairs - also a negentropically entangled state. The energy gain in this process could be also interpreted as a fundamental metabolic energy quantum - the interpretation is to some degree a matter of taste- and the subsequent steps in photosynthesis would only take care of the storage of the energy transferred eventually to ATP. Also chemical storage could be storage of negentropic entanglement. The metabolic energy liberated in $\text{ATP} \rightarrow \text{ADP}$ could be realized universally as IR dark photon absorbed by cyclotron BE condensate at magnetic flux tube so that dark photon beams would become the key actors of metabolism and negentropy generation. Note that a maximal negentropy gain is obtained if the number of Cooper pairs in the condensate is power of prime. Relatively small primes in the scale defined by the p-adic length scales assignable to elementary particles would be in question.

4.3.3 Pessimistic generalization of the second law of thermodynamics

The possibility of negentropic entanglement raises the question about the fate of the second law of thermodynamics. The proposal for a generalization of the second law of thermodynamics (see chapter *Negentropy Maximization Principle* of [?]) based on the most pessimistic vision is that entropy indeed increases also when negentropic entanglement is generated in state function reduction. If the generation of negentropic entanglement is accompanied by a compensating entropic entanglement, how it is generated? Or is the maximally pessimistic generalization really necessary? Is it implied automatically in time scales longer than the characteristic time scale associated with the causal diamonds serving as the basic correlates for conscious selves. One must apply ensemble description in these time scales: does the non-determinism of quantum jump imply second law at the level of ensemble automatically. If this argument is correct, second law would cease to hold in time scales than that characterizing the relevant causal diamond (*CD*). based on the most pessimistic vision is that entropy indeed increases also when negentropic entanglement is generated in state function reduction. If the generation of negentropic entanglement is accompanied by a compensating entropic entanglement, how it is generated? Or is the maximally pessimistic generalization really necessary? Is it implied automatically in time scales longer than the characteristic time scale associated with the causal diamonds serving as the basic correlates for conscious selves. One must apply ensemble description in these time scales: does the non-determinism of quantum jump imply second law at the level of ensemble automatically. If this argument is correct, second law would cease to hold in time scales than that characterizing the relevant *CD*.

4.3.4 How to understand differentiation and de-differentiation?

Differentiation and de-differentiation are fundamental processes in biology. Differentiation means specialization and more restricted gene expression and de-differentiation a reversal of this process. De-differentiation to the stem cell state takes place in healing of wounds and is induced by Becker's DC currents. Note that cancer cells are de-differentiated cells but Becker currents induce a further de-differentiation making them omnipotent.

De-differentiation and differentiation are strongly time-irreversible processes. Could differentiation and de-differentiation be seen as time reversals of each other and correspond to state function reductions at opposite boundaries of *CD*? De-differentiation would mean change of geometric arrow of time but basically a dissipative process would be in question.

The following argument based on purely entropic entanglement shows that this view cannot be correct.

1. There are two manners to see arrow of time corresponding to imbedding space level and space-time level. The arrow of geometric time alternates only at the level of imbedding space at space-time level alone it does not if irreversibility of quantum dynamics has space-time correlates as quantum classical correspondence requires. Space-time surface is not able to detect its own effective folding forth and back in time in the imbedding space and the internal arrow of time remains the same. *CD* is able to detect the imbedding space arrow of time for its sub-*CD*:. sub-*CD* seems to develop in reverse direction of geometric time. Dissipation occurs always in subjective time so that second law remains true.
2. Suppose that it makes sense to think that *CD* scans given sub-*CD*s again and again in time direction, which corresponds to its own arrow of geometric time. Suppose for definiteness that the scale of sub-*CD* is 1 year. *CD* observes evolution of sub-*CD* from 1 to 2 years then from 3 to 2 years, then from 5 to 4 years. Aging occurs on the average. System would get 2 years older in sudden steps at both boundaries. The sudden agings by 2 years are compensated by 1 year of apparent rejuvenation between state function reductions. The interpretation as dedifferentiation is not possible. For instance, return to omnipotent stem cell stage is not possible for differentiated cells.

What is lacking is the notion of negentropic entanglement. Illness is a loss of negentropic entanglement and healing its regeneration. Aging is a loss of negentropic entanglement and de-differentiation identified as rejuvenation is regeneration of negentropic resources.

1. De-differentiation must involve a generation of negentropic entanglement defining the fundamental step in rejuvenation. Aging is due to state function reductions destroying entanglement. Negentropically entangled states can be however stable under NMP and NMP can even force the reversal of aging.
2. At the level of basic metabolism generation of ATP accompanies the generation of negentropic entanglement and its transformation to ADP to its disappearance. The creation of ATP would be fundamental process of rejuvenation, and ATP could be seen as elixir of youth at the molecular level. The analogy between ATP-ADP cycle and Karma's cycle is also rather precise. This picture conforms also with the model for healing currents as a tool to generate metabolic energy, ATP, and negentropic entanglement.

4.4 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 [I64] . 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 [I51, I27, I74, I36, I24]. One of the pioneers in the field has been Gilbert Ling [I51] , 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 [I61]) 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 [K19] . Magnetic flux tubes could also act as Josephson junctions between widely separated structures.

4.4.1 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 [I27] 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 [I51] . This cohesion gives rise to liquid [F3] [D3] like structure of water implying among other things layered structures and internal electric fields orthogonal to the plane of the layers [I41, I47, I51] . For instance, cell membranes can be understood as resulting from the self-organization of liquid crystals [K12] . The fundamental importance of electret nature of biomatter was also realized by Fröhlich [I37] 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.

4.4.2 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 [I64]. 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 [D3] would have probably led to different ideas about how homeostasis between cell interior and exterior is realized [I41, I47, I51].

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 [I61] 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 [I61]! This does not however prove that pumping and channelling is the main function of these proteins on the case of basic biological ions 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 in the case of basic ions 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.

The only reasonable way to circumvent the problem is to assume that there is kind of binary coding of various chemical compounds but it is difficult to see how this could be achieved in the framework of the standard chemistry. The notion of fractional atom proposed in [K18] to give rise to the emergence of symbols at the level of biochemistry could however allow this kind of coding. Channels and pumps (or whatever these structures actually are) could be also generated by self-organization process when needed.

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 has 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 [I51] 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 [I67] (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 [I36] 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 [I24] 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 [I74] 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 their properties seem to be universal and depend only on very weakly on the properties of the membrane. This conclusion need not apply to the currents of polar molecules for which genetically coded pump and channel proteins certainly exist. Neither does it imply that pumps and channels could not be used to achieve a more efficient transfer of ions.

4.4.3 Cytoplasm as gel

The solution to the above described anomalies proposed by Pollack is that cytoplasm is gel phase [I61]. 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 $1 \mu\text{m}$ without an appreciable effect on the functioning of the cell and also show that these holes remain as such for long periods of time [I61] . 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 [I61] . 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 [K10] .
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 Hodgkin-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 Hodgkin-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-membrated 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 [I61] . 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 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.

4.4.4 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 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 ratchet followed by a phase transition reducing the value of \hbar and shortening the flux tube and forcing the cargo to move forward. The metabolic energy might be provided by the micro-tubule rather than molecular motor.
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 [I61] . If wormhole magnetic flux 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.

Besides basic ions cell membrane is non-permeable to various polar molecules such as the basic building bricks of DNA and aminoacids. The safest assumption is that genetically coded pump and channel proteins make possible the transfer. One must of course consider the possibility that channels and pumps are used to make the transfer of basic ions more effective. Taking this into account, the proposed vision does not differ so radically from the standard one as one might think first and only the model for nerve pulse generation must be modified radically.

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.

4.5 Quantum model for the direct currents of Becker

Robert Becker [J16] proposed on basis of his experimental work that living matter behaves as a semiconductor in a wide range of length scales ranging from brain scale to the scale of entire body. Direct currents flowing only in preferred direction would be essential for the functioning of living manner in this framework.

One of the basic ideas of TGD inspired theory of living matter is that various currents, even ionic currents, are quantal currents. The first possibility is that they are Josephson currents associated with Josephson junctions but already this assumption more or less implies also quantal versions of direct currents.

TGD inspired model for nerve pulse [K56] assumed that ionic currents through the cell membrane are probably Josephson currents. If this is the case, the situation is automatically stationary and dissipation is small as various anomalies suggest. One can criticize this assumption since the Compton length of ions for the ordinary value of Planck constant is so small that magnetic flux tubes carrying the current through the membrane look rather long in this length scale. Therefore either Planck constant should be rather large or one should have a non-ohmic quantum counterpart of a direct

current in the case of ions and perhaps also protons in the case of neuronal membrane: electronic and perhaps also protonic currents could be still Josephson currents. This would conform with the low dissipation rate.

In the following the results related to laser induced healing, acupuncture, and DC currents are discussed first. The obvious question is whether these direct currents are actually currents and whether they could be universal in living matter. A TGD inspired model for quantal direct currents is proposed and its possible implications for the model of nerve pulse are discussed.

Whether the model for quantum direct currents is consistent with the proposed vacuum extremal property of the cell membrane [K56] remains an open question but both options explain the special role of Ca^{++} currents and current of Na^+ Cooper pairs in the generation of nerve pulse as in would take place in TGD Universe. In fact, it is not clear what one exactly means with the vacuum extremal property of cell membrane. Many-sheeted space-time allows to consider space-time sheets which can be both almost vacuum extremals and far from vacuum extremals. Also space-time sheets for which Planck constant is so large that both electronic and protonic Josephson currents become possible. Various pumps and channels could actually correspond to magnetic flux tubes along which various ionic supra currents or even Josephson currents can flow. The condition that both electronic and protonic supra currents are possible in same length scale leads to the hierarchy of Planck constants coming approximately as powers of $m_p/m_e \simeq 2^{11}$ proposed originally as a general truth. Radiation at Josephson frequency serves as a signature for Josephson currents.

In the following a TGD inspired quantum model for the direct currents of Becker as direct quantum currents is developed and shown to be consistent with what is known about nerve pulse generation. The model of nerve pulse based on this model is discussed in [K56].

4.5.1 Connection between laser induced healing, acupuncture, and association of DC currents with the healing of wounds

The findings of Robert Becker (the book "Electromagnetism and Life" by Becker and Marino can be found from web [J16]) meant a breakthrough in the development of bioelectromagnetics. One aspect of bioelectromagnetic phenomena was the discovery of Becker that DC currents and voltages play a pivotal role in various regeneration processes. Why this is the case is still poorly understood and Becker's book is a treasure trove for anyone ready to challenge existing dogmas. The general vision guiding Becker can be summarized by a citation from the introduction of the book.

Growth effects include the alteration of bone growth by electromagnetic energy, the restoration of partial limb regeneration in mammals by small direct currents, the inhibition of growth of implanted tumors by currents and fields, the effect upon cephalocaudal axis development in the regenerating flatworm in a polarity-dependent fashion by applied direct currents, and the production of morphological alterations in embryonic development by manipulation of the electrochemical species present in the environment. This partial list illustrates the great variety of known bioelectromagnetic phenomena.

The reported biological effects involve basic functions of living material that are under remarkably precise control by mechanisms which have, to date, escaped description in terms of solution biochemistry. This suggests that bioelectromagnetic phenomena are fundamental attributes of living things ones that must have been present in the first living things. The traditional approach to biogenesis postulates that life began in an aqueous environment, with the development of complex molecules and their subsequent sequestration from the environment by membranous structures. The solid-state approach proposes an origin in complex crystalline structures that possess such properties as semiconductivity, photoconductivity, and piezoelectricity. All of the reported effects of electromagnetic forces seem to lend support to the latter hypothesis.

Observations relating to CNS

The following more quantitative findings, many of them due to Becker, are of special interest as one tries to understand the role of DC currents in TGD framework.

1. CNS and the rest of perineural tissue (tissue surrounding neurons including also glial cells) form a dipole like structure with neural system in positive potential and perineural tissue in negative potential. There is also an electric field along neuron in the direction of nerve pulse propagation (dendrites correspond to - and axon to +) (note that motor nerves and sensory nerves form a

closed loop). Also microtubules within axon carry electric field and these fields are probably closely related by the many-sheeted variants of Gauss's and Faraday's laws implying that voltages along two different space-time sheets in contact at two points are same in a static situation.

2. A longitudinal potential along front to back in brain with frontal lobes in negative potential with respect to occipital lobes and with magnitude of few mV was discovered. The strength of the electric field correlates with the level of consciousness. As the potential becomes weaker and changes sign, consciousness is lost. Libet and Gerard observed traveling waves of potentials across the cortical layers (with speeds of about 6 m/s: TGD inspired model of nerve pulse predicts this kind of waves [K56]). Propagating potentials were discovered also in glial cells. The interpretation was in terms of electrical currents.
3. It was found that brain injury generated positive polarization so that the neurons ceased to function in an area much larger than the area of injury. Negative shifts of neuronal potentials were associated with incoming sensory stimuli and motor activity whereas sleep was associated with a positive shift. Very small voltages and currents could modulate the firing of neurons without affecting the resting potential. The "generating" potentials in sensory receptors inducing nerve pulse were found to be graded and non-propagating and the sign of the generating potential correlated with sensory input (say increase/reduction of pressure). Standard wisdom about cell membrane has difficulties in explaining these findings.
4. The natural hypothesis was that these electric fields are accompanied by DC currents. There are several experimental demonstrations for this. For instance, the deflection of assumed DC currents by external magnetic field (Hall effect) was shown to lead to a loss of consciousness.

Observations relating to regeneration

The second class of experiments used artificial electrical currents to enhance regeneration of body parts. These currents are nowadays used in clinical practice to induce healing or retard tumor growth. Note that tissue regeneration is a genuine regeneration of an entire part of organism rather than mere simple cell replication. Salamander limb generation is one of the most studied examples. Spontaneous regeneration becomes rare at higher evolutionary levels and for humans it occurs spontaneously only in the fractures of long bones.

1. An interesting series of experiments on Planaria, a species of simple flatworm with a primitive nervous system and simple head-to-tail axis of organization, was carried out. Electrical measurements indicated a simple head-tail dipole field. The animal had remarkable regenerative powers; it could be cut transversely into a number of segments, all of which would regenerate a new total organism. The original head-tail axis was preserved in each regenerate, with that portion nearest the original head end becoming the head of the new organism. The hypothesis was that the original head-tail electrical vector persisted in the cut segments and provided the morphological information for the regenerate. The prediction was that the reversal of the electrical gradient by exposing the cut surface to an external current source of proper orientation should produce some reversal of the head-tail gradient in the regenerate. While performing the experiment it was found that as the current levels were increased the first response was to form a head at each end of the regenerating segment. With still further increases in the current the expected reversal of the head-tail gradient did occur, indicating that the electrical gradient which naturally existed in these animals was capable of transmitting morphological information.
2. Tissue regeneration occurs only if some minimum amount of neural tissue is present suggesting that CNS plays a role in the process although the usual neural activity is absent. The repeated needling of the stump had positive effect on regeneration and the DC current was found to be proportional to innervation. Hence needling seems to stimulate innervation or at least inducing formation of DC currents. Something like this might occur also in the case of acupuncture.
3. Regeneration involves de-differentiation of cells to form a blastema from which the regenerated tissue is formed. Quite early it was learned that carcinogens induce de-differentiation of cells because of their steric properties and by making electron transfer possible and that denervation induces tumor formation. From these findings Becker concluded that the formation of blastema

could be a relatively simple process analogous to tumor growth whereas the regeneration proper is a complex self-organization process during which the control by signals from CNS are necessary and possibly realized in terms of potential waves.

4. Regeneration is possible in salamander but not in frog. This motivated Becker and collaborators to compare these situations. In an amputated leg of both salamander and frog the original negative potential of order -1 mV went first positive value of order $+10$ mV. In frog it returned smoothly to its original value without regeneration. In salamander it returned during three days to the original base line and then went to a much higher negative value around -20 mV (resting potential is around -70 mV) followed by a return to the original value as regeneration had occurred. Thus the large negative potential is necessary for the regeneration and responsible for the formation of blastema. Furthermore, artificial electron current induced regeneration also in the case of frog and in even in the denervated situation. Thus the flow of electrons to the stump is necessary for the formation of blastema and the difference between salamander and frog is that frog is not able to provide the needed electronic current although positive potential is present.
5. It was also learned that a so called neural epidermic junction (NEJ) formed in the healing process of salamander stump was responsible for the regeneration in the presence of nervation. The conclusion was that the DC voltage and electronic current relevant for regeneration can be assigned the interface between CNS and tissue rather than with the entire nerve and regeneration seems to be a local process, perhaps a feed of metabolic energy driving self-organization. Furthermore, NEJ seems to make possible the flow of electrons from CNS to the stump.
6. The red blood cells of animals other than mammals are complete and possess thus nuclei. Becker and collaborators observed that also red blood cells dedifferentiated to form blastema. Being normally in a quiescent state, they are ideal for studying de-differentiation. It was found that electric current acted as a trigger at the level of cell membrane inducing de-differentiation reflected as an increased amount of mRNA serving as signal for gene expression. Also pulsed magnetic field was found to trigger the de-differentiation, perhaps via induced electric field. By the way, the role of the cell membrane fits nicely with the view about DNA-cell membrane system as topological quantum computer with magnetic flux tubes connecting DNA and cell membrane serving as braids.
7. The experiments of Becker and collaborators support the identification of the charge carriers of DC currents responsible for the formation of large negative potential of stump as electrons. The test was based on the different temperature dependence of electronic and protonic conductivities. Electronic conductivity increases with temperature and protonic conductivity decreases and an increase was observed. In TGD based model also super-conducting charge carriers are possible and this finding does not tell anything about them.

Gene activation by electrostatic fields?

The basic question concerns the method of activation. The discovery of chemists Guido Ebner and Guido Schuerch [J8] raises the hope that these ideas might be more than over-active imagination and their work also provides a concrete proposal for the activation mechanism. Ebner and Schuerch studied the effect of electrostatic fields on the growth and morphogenesis of various organisms. Germ, seeds, or eggs were placed between conducting plates creating an electric field in the range $.5$ - 2 kV/m: note that the Earth's electric field is in the range $.1 - 4$ kV/m and of the same order of magnitude.

The outcome was rather surprising and in the year 1989 their employer Ciba Geigy (now Novartis) applied for a patent "Method of enhanced fish breeding" [J8] for what is called Ciba Geigy effect. The researchers describe how fishes (trouts) develop and grow much better, if their eggs have been conditioned in an electrostatic field. The researchers report [J8] that also the morphology of the fishes was altered to what seems to represent an ancient evolutionary form: this was not mentioned in the patent.

The chemists founded their own Institute of Pharmaceutical Research near Basel, where Guido Ebner applied for another very detailed patent, which was never granted (it is not difficult to guess the reasons why!). In the patent he describes the effect of electrostatic fields on several life forms (cress,

wheat, corn, fern, micro-organisms, bacteria) in their early stage of development. A clear change in the morphogenesis was observed. For instance, in one example fern had all sort of leaves in single plant apparently providing a series of snapshots about the evolution of the plant. The evolutionary age of the first leaf appeared to be about 300 million years whereas the last grown-up leaf looked close to its recent form.

If one takes these finding seriously, one must consider the possibility that the exposure to an electrostatic field can activate passive genes and change the gene expression so that older morphologies are expressed. The activation of not yet existing morphologies is probably more difficult since strong consistency conditions must be satisfied (activation of program requires activation of a proper hardware). This would suggest that genome is a kind of archive containing also older genomes even potential genomes or that topological quantum computer programs [K19] determine the morphology to certain extent and that external conditions such as electric field determine the self-organization patters characterizing these programs.

It is known that the developing embryo has an electric field along the head-tail axis and that this field plays an important role in the control of growth. These fields are much weaker than the fields used in the experiment. p-Adic length scale hierarchy however predicts an entire hierarchy of electric fields and living matter is indeed known to be full of electret structures. The strength of the electric field in some p-adic length scale related to DNA might somehow serve as the selector of the evolutionary age. The recapitulation of phylogeny during the ontogeny could mean a gradual shift of the activated part of the memone, perhaps assignable to tqc programs, and be controlled by the gradually evolving electric field strength.

The finding that led Ebner to his discovery was that it was possible to "wake up" ancient bacteria by an exposure to an electrostatic field. The interpretation would be in terms of loading of metabolic batteries. This would also suggest that in the case of primitive life forms like bacteria the electric field of Earth has served as metabolic energy source whereas in higher life forms endogenous electric fields have taken the role of Earth's electric field.

A TGD based model for the situation

On basis of these observations one can try to develop a unified view about the effects of laser light, acupuncture, and DC currents. It is perhaps appropriate to start with the following - somewhat leading - questions inspired by a strong background prejudice that the healing process - with control signals from CNS included - utilizes the loading of many-sheeted metabolic batteries by supra currents as a basic mechanism. In the case of control signals the energy would go to the "moving of the control knob".

1. Becker assigns to the system involved with DC currents an effective semiconductor property. Could the effective semiconductor property be due the fact that the transfer of charge carriers to a smaller space-time sheet by first accelerating them in electric field is analogous to the transfer of electrons between conduction bands in semiconductor junction? If so, semiconductor property would be a direct signature of the realization of the metabolic energy quanta as zero point kinetic energies.
2. Supra currents flowing along magnetic flux tubes would make possible dissipation free loading of metabolic energy batteries. This even when oscillating Josephson currents are in question since the transformation to ohmic currents in semiconductor junction makes possible energy transfer only during second half of oscillation period. Could this be a completely general mechanism applying in various states of regeneration process. This might be the case. In quantal situation the metabolic energy quanta have very precise values as indeed required. For ohmic currents at room temperature the thermal energies are considerably higher than those corresponding to the voltage involved so that they seem to be excluded. The temperature at magnetic flux tubes should be however lower than the physiological temperature by a factor of order 10^{-2} at least for the voltage of -1 mV. This would suggest high T_c super-conductivity is only effective at the magnetic flux tubes involved. The finding that nerve pulse involves a slight cooling of the axonal membrane proposed in the TGD based model of nerve pulse [K56] to be caused by a convective cooling due the return flow of ionic Josephson currents would conform with this picture.
3. What meridians are and what kind of currents flow along them? Could these currents be supra currents making possible dissipation-free energy transfer in the healthy situation? Does the

negative potential of order -1 mV make possible flow of protonic supra currents and loading of metabolic batteries by kicking protons to smaller space-time sheets? Could electronic supra currents in opposite direct induce similar loading of metabolic batteries? Could these two miniature metabolisms realize control signals (protons) and feedback (electrons)?

The model answering these questions relies on following picture. Consider first meridians.

1. The direct feed of metabolic energy as universal metabolic currencies realized as a transfer of charge carriers to smaller space-time sheets is assumed to underly all the phenomena involving healing aspect. Meridian system would make possible a lossless metabolic energy feed - transfer of "Chi" - besides the transfer of chemically stored energy via blood flow. The metabolic energy currencies involved are very small as compared to .5 eV and might be responsible only for "turning control knobs". The correlation of the level of consciousness with the overall strength of DC electric fields would reduce to the level of remote metabolic energy transfer.
2. The model should explain why meridians have not been observed. Dark currents along magnetic flux tubes are ideal for the energy transfer. If the length of the superconducting "wire" is long in the scale defined by the appropriate quantum scale proportional to \hbar , classical picture makes sense and charge carriers can be said to accelerate and gain energy ZeV . For large values of \hbar an oscillating Josephson current would be in question. The semiconductor like structure at the end of meridian -possibly realized in terms of pair of space-time sheets with different sizes- makes possible a net transfer of metabolic energy even in this case as pulses at each half period of oscillation. The transfer of energy with minimal dissipation would thus explain why semiconductor like property is needed and why acupuncture points have high value of conductivity. The identification of meridians as invisible magnetic flux tubes carrying dark matter would explain the failure to observe them: one further direct demonstration for the presence of dark matter in biological systems.
3. In the case of regeneration process NEJs would be accompanied by a scaled down version of meridian with magnetic flux tubes mediating the electronic Josephson current during blastema generation and protonic supra current during the regeneration proper. Space-time sheets of proton *resp.* electron correspond to k_p and $k_e = k_p + 11$. In a static situation many-sheeted Gauss law in static situation would guarantee that voltages over NJE are same.
4. One can of course worry about the smallness of electrostatic energies ZeV as compared to the thermal energy. Zero point kinetic energy could correspond also to the magnetic energy of the charged particle. For sufficiently large values of Planck constant magnetic energy scale is higher than the thermal energy and the function of voltage could be only to drive the charged particles along the flux tubes to the target: and perhaps act as a control knob with electrostatic energy compensating for the small lacking energy. Suppose for definiteness magnetic field strength of $B = .2$ Gauss explaining the effects of ELF em fields on brain and appearing in the model of EEG. Assume that charged particle is in minimum energy state with cyclotron quantum number $n = 1$ and spin direction giving negative interaction energy between spin and magnetic field so that the energy is $(g-2)\hbar eB/2m_p$. Assume that the favored values of \hbar correspond to number theoretically simple ones expressible as a product of distinct Fermat primes and power of 2. In the case of proton with $g \simeq 2.7927$ the standard metabolic energy quantum $E_0 = .5$ eV would require roughly $\hbar/\hbar_0 = 17 \times 2^{34}$. For electron $g - 2 \simeq \alpha/\pi \simeq .002328$ gives $\hbar/\hbar_0 = 5 \times 17 \times 2^{30}$.

Consider next NEJs and semiconductor like behavior and charging of metabolic batteries.

1. Since NEJ seems resembles cell membrane in some respects, the wisdom gained from the model of cell membrane and DNA as tqc can be used. The model for nerve pulse and the model for DNA as topological quantum computer suggest that dark ionic currents flowing along magnetic flux tubes characterized by a large value of Planck constant are involved with both meridians and NJEs and might even dominate. Magnetic flux tubes act as Josephson junctions generating oscillatory supra currents of ions and electrons. For large values of \hbar also meridians are short in the relevant dark length scale and act as Josephson junctions carrying oscillatory Josephson currents.

2. The findings of Becker suggest that acu points correspond to sensory receptors which are normally in a negative potential. The model for the effects of laser light favors (but only slightly) the assumption that in a healthy situation it is protons arriving along magnetic flux tubes which are kicked to the smaller space-time sheets and that negative charge density at acu point attracts protons to the acu point. Electrons could of course flow in reverse direction along their own magnetic flux tubes and be kicked to the smaller space-time sheets at the positive end of the circuit. In the case of brain, protonic end would correspond to the frontal lobes and electronic end to the occipital lobes. This kind of structure could appear as fractally scaled variants. For instance, glial cells and neurons could form this kind of pair with neurons in negative potential and glial cells in positive potential as suggested by the fact that neuronal damage generates positive local potential.
3. Classically the charge carriers would gain energy $E = ZeV$ as they travel along the magnetic flux tube to NJE. If this energy is higher than the metabolic energy quantum involved, it allows the transfer of charge carrier to a smaller space-time sheet so that metabolic resources are regenerated. Several metabolic quanta could be involved and the value of $V(t)$ would determine, which quantum is activated. The reduction of the V below critical value would lead to a starvation of the cell or at least to the failure of control signals to "turn the control knob". This should relate to various symptoms like pain at acupuncture points. In a situation requiring acupuncture the voltage along flux tubes would be so small that the transfer of protons to the smaller space-time sheets becomes impossible. As a consequence, the positive charge carriers would accumulate to the acu point and cause a further reduction of the voltage. Acupuncture needle would create a "wound" stimulating large positive potential and the situation would be very much like in regeneration process and de-differentiation induced by acupuncture could be understood.

Many questions remain to be answered.

1. What causes the de-differentiation of the cells? The mere charging of metabolic energy batteries perhaps? If so then the amount of metabolic energy- "chi"- possessed by cell would serve as a measure for the biological age of cell and meridian system feeding "chi" identified as dark metabolic energy would serve as a rejuvenating agent also with respect to gene expression. Or does the electric field define an external energy feed to a self-organizing system and create an electromagnetic environment similar to that prevailing during morphogenesis inducing a transition of cells to a dedifferentiated state? Or could DNA as tqc allow to understand the modification of gene expression as being due to the necessity to use tqc programs appropriate for regeneration? Or should cells and wounded body part be seen as intentional agents doing their best to survive rather than as passive parts of biochemical system?
2. Acupuncture and DC current generation are known to induce generation of endorphins. Do endorphins contribute to welfare by reducing the pain or do they give a conscious expression for the fact that situation has improved as a result of recharging of the metabolic energy batteries?
3. Could the continual charging of metabolic energy batteries by DC currents occur also in the case of cell membrane? The metabolic energy quantum would be around .07 eV in this case and correspond to p-adic length scale $k = 140$ for proton (the quantum is roughly a fraction 1/8 of the fundamental metabolic energy quantum .5 eV corresponding to $k = 137$).

4.5.2 Quantum model for effective semiconductor property

Becker [J16] summarizes his findings by stating that living matter is effective semiconductor. There are pairs of structures in positive and negative potential in various scales and the current between the plates of this effective capacitor flows when above some minimum potential difference. The current flows from positive to negative pole and could be electron current. Also proton current in opposite direction can be considered but electron current is experimentally favored. For instance consciousness is lost when magnetic field is used to deflect the current.

In TGD framework natural carriers of these currents would be magnetic flux tubes carrying also electric fields. A very simple deformation of the imbeddings of constant longitudinal magnetic fields

gives also longitudinal electric field. With a slight generalization one obtains helical electric and magnetic fields. A crucial difference is that these currents would be quantal rather than ohmic currents even in the length scale of biological body and even longer scales assignable to the magnetic body.

The following argument allows to understand the physical situation.

1. A precise everyday analogy is vertical motion in the gravitational field of Earth between surface and some target at given height h . If the kinetic energy is high enough, the particle reaches the target. If not, the particle falls back. In quantum case one expects that the latter situation corresponds to very small probability amplitude at the target (tunneling to classically forbidden kinematic region).
2. Now electric field replaces gravitational field. Suppose that the classical electric force experienced by the particle is towards the capacitor plate taking the role of the surface of Earth. Below critical field strength the charged particle cannot reach the target classically and quantum mechanically this occurs only by tunneling with vanishingly small probability.
3. Particles with opposite value of charge experience force which accelerates them and classically they certainly reach the second plate. What happens in quantum situation? It seems that this situation is essentially identical with the first one: one has linear potential in finite interval and wave functions are localized in this range. One can equivalently regard these states as localized near the second capacitor plate.
4. A good analogy is provided by atoms: classically electron would end down to the nucleus but quantization prevents this. Also now one can imagine stationary solutions for which the electric currents for individual charges vanish at the plates although classically there would be a current in another direction. Also quantum mechanically non-vanishing conserved current is possible: all depends on boundary conditions.

Basic model

Consider now the situation at more quantitative level.

1. One can assign complex order parameters Ψ_k to various Bose-Einstein condensates of supra phases and obey Schrödinger equation

$$i\partial_t\Psi_k = \left(-\frac{\hbar^2}{2m_k}\partial_z^2 + q_k Ez\right)\Psi_k . \quad (4.5.1)$$

Here it is assumed that the situation is effectively one-dimensional. E is the value of constant electric field.

2. The Schrödinger equation becomes non-linear, when one expresses the electric field in terms of the total surface charge density associated with the plates of effective capacitor. In absence of external electric field it is natural to assume that the net surface charge densities σ at the plates are of opposite sign so that the electric field inside the capacitor is proportional to

$$\sigma = E = \sum \sigma_i = \sum_i q_i \bar{\Psi}_i \Psi_i . \quad (4.5.2)$$

This gives rise to a non-linear term completely analogous to that in non-linear Schrödinger equation. A more general situation corresponds to a situation in which the region interval $[a, b]$ bounded by capacitor plates a and b belongs to a flux longer tube like structure $[A, B]$: $[a, b] \subset [A, B]$. In this case one has

$$E_{tot} = E + E_0 . \quad (4.5.3)$$

This option is needed to explain the observations of Becker that the local strengthening of electric field increases the electron current: this would be the case in the model to be discussed if this field has a direct opposite to the background field E_0 . One could also interpret E as quantized part of the electric field and E_0 as classical contribution.

3. The electric currents are given by

$$j_k = \frac{i\hbar q_k}{2m_k} \bar{\Psi}_k \partial_z^{\leftrightarrow} \Psi_k . \quad (4.5.4)$$

In stationary situation the net current must vanish:

$$\sum_k j_k = 0 . \quad (4.5.5)$$

A stronger condition is that individual currents vanish at the plates:

$$j_k = 0 . \quad (4.5.6)$$

It must be emphasized that this condition does not make sense classically.

Explicit form of Schrödinger equation

Consider now the explicit form of Schrödinger equation in given electric field.

1. The equation is easy to solve by writing the solution ansatz in polar form (the index k labelling the charge particle species will be dropped for notational convenience).

$$\Psi = R(a \exp(iU) + b \exp(-iU)) \exp(-iE_n t) \quad (4.5.7)$$

For real solutions current vanishes identically and this is something which is not possible classically. It is convenient to restrict the consideration to stationary solutions, which are energy eigen states with energy value E_n and express the general solution in terms of these.

2. The Schrödinger equation reduces with the change of variable

$$\begin{aligned} z &\rightarrow \frac{(z - z_0)}{z_1} \equiv x , \\ z_0 &= \frac{E_n}{qE} , \quad z_1 = \left(\frac{\hbar^2}{2mqE}\right)^{1/3} . \end{aligned} \quad (4.5.8)$$

to

$$(\partial_x^2 + x)\Psi = 0 . \quad (4.5.9)$$

The range $[0, z_0]$ for z is mapped to the range $[-z_0/z_1, 0]$. z_0/z_1 has positive sign as is easy to verify. The value range of x is therefore negative irrespective of the sign of qE . This is equation for Airy functions [B1]. Airy functions are encountered in WKB approximation in the approximation that potential function is linear. These functions appear also in the model of rainbow.

The change of variable leads automatically to solutions restricted near the plate where the situation is completely analogous to that in gravitational field of Earth. For stationary solutions test charge in a given background field would be localized near capacitor plate with opposite sign of charge. A strong background field could be created by charges which do not correspond to the ionic charges defining ionic currents. Electrons and protons could define this field possibly associated with flux tubes considerably longer than the distance between capacitor plates.

3. Using the polar representation $\Psi = \text{Exp}(iU)$ Schrödinger equation reduces to two equations

$$\begin{aligned} [(\partial_x^2 - U_x^2 + x)R] \cos(U) + [U_{xx} + 2\partial_x R \partial_x U] \sin(U) &= 0 , \\ [(\partial_x^2 - U_x^2 + x)R] \sin(U) - [U_{xx} - 2\partial_x R \partial_x U] \cos(U) &= 0 . \end{aligned} \quad (4.5.10)$$

Note that both (R, U) and $(R, -U)$ represent solutions for given value of energy so that the solution can be chosen to be proportional to $\cos(U)$ or $\sin(U)$. The electric current j is conserved and equal to the current at $x = 0$ and given by

$$j = \frac{\hbar}{2m} \frac{U_x}{z_1} R^2 , \quad z_1 = \left(\frac{\hbar}{2mqE}\right)^{1/3} . \quad (4.5.11)$$

The current vanishes if either U_x is zero or if the solution is of form $\Psi = R \sin(U)$.

Semiclassical treatment

In semiclassical approximation potential is regarded as so slowly varying that it can be regarded as a constant. In this situation one can write the solution of form $\text{Exp}(iU)$ as

$$\Psi = R_0 \exp\left(\frac{i}{\hbar} \int_0^z \sqrt{2m} \sqrt{E - qEz} dz\right) = R_0 \exp\left(i \int_0^x x^{1/2} dx\right) . \quad (4.5.12)$$

The plate at which the initial values are given can be chosen so that the electric force is analogous to gravitation at the surface of Earth. This requires only to replace coordinate z with a new one vanishing at the plate in question and gives to the energies a positive shift $E_0 = qE_0 h$.

1. The semiclassical treatment of the equation leads to Bohr rules

$$\frac{\oint p_z dz}{\hbar} = \frac{2}{\hbar} \int_0^h p_z dz = n . \quad (4.5.13)$$

This gives

$$\frac{\oint p_z dz}{\hbar} = \frac{2\sqrt{2m}}{\hbar} \int_0^h \sqrt{E_n - qEz} dz = 2 \int_0^{x_0} x^{1/2} = \frac{4}{3} x_0^{3/2} = n . \quad (4.5.14)$$

Note that the turning point for classical orbit corresponds to $z_{max} = E_n/qE$.

2. One obtains

$$E_n = \frac{1}{2} \left(\frac{nqE\hbar^2}{r\sqrt{m}} \right)^{2/3}, \quad r = \int_0^1 (1-u)^{1/2} du = \frac{2}{3}. \quad (4.5.15)$$

The value of z_{max} is

$$z_{max} = \frac{E_n}{qE} = \frac{n^{2/3}}{2r^{2/3}} \left(\frac{\hbar^2}{qEm} \right)^{1/3}. \quad (4.5.16)$$

3. The approximation $R = R_0 = \text{constant}$ can make sense only if the position of the second plate is below z_{max} . This is possible if the value of n is large enough ($n^{2/3}$ proportionality), if the mass m of the charged particle is small enough ($m^{-1/3}$ proportionality raising electron and also proton to special position, or if the strength of electric field is small enough ($E^{-1/3}$ proportionality). The value z_{max} is proportional to $\hbar^{2/3}$ so that a phase transition increasing Planck constant can induce current flow.

Possible quantum biological applications

The proposed model for quantum currents could provide quantum explanation for the effective semiconductor property of DC currents of Becker.

1. The original situation would be stationary with no currents flowing. The application of external electric field in correct direction would reduce the voltage below the critical value and currents would start to flow. This is consistent with Becker's findings if there is background electric field E_0 so that the applied field has direction opposite to E_0 so that the field strength experienced by charged particles is reduced and it is easier for them to reach the second plate. This is of course a possible objection against the proposal.
2. Becker's DC currents appear in several scales. They are assigned with the pairs formed by CNS and perineural tissue (this includes also glia cells) and by frontal and occipital lobes. Acupuncture could involve the generation of a DC supra current. The mechanism would be essential in the healing. Also the mechanism generating qualia could involve generation of supra currents and dielectric breakdown for them. The role of the magnetic flux tubes in TGD inspired biology suggests that the mechanism could be universal. If this were the case one might even speak about Golden Road to the understanding of living matter at basic level.

Even the generation of nerve pulse might be understood in terms of this mechanism. One can argue that neurons have higher evolutionary level than the system pairs to which only electron currents or electron and proton currents can be assigned. This because the value of Planck constant is higher for the magnetic flux tubes carrying the quantal ionic currents.

1. For Bose-Einstein condensate the simplest choice is $n = 1$ at both plates. The energy eigenvalues would naturally differ by the shift $E_0 = qE_0\hbar$ at the two plates for given particle type. Under these assumptions the current can flow appreciably only if the voltage is below the minimum value. This is certainly a surprising conclusion but brings in mind what happens in the case of neuronal membrane. Indeed, hyper-polarization has a stabilizing - something difficult to understand classically but natural quantum mechanically.
2. The reduction of membrane potential slightly below the resting potential generates nerve pulse. Also a phase transition increasing the value of Planck constant might give rise to quantal direct currents and generate flow of ionic currents giving rise to nerve pulse. Stationary solutions are located near either capacitor plate. What comes in mind is that nerve pulse involves a temporary change of the capacitor plate with this property.

3. If electron and proton currents flow as direct currents, one encounters a problem. Nerve pulse should begin with direct electronic currents and followed by direct protonic currents and only later ions should enter the game if at all. The existing model for nerve pulse however assumes that at least electrons flow as oscillating Josephson currents rather than direct quantal currents. This is quite possible and makes sense if the cell membrane thickness small - that is comparable to electron Compton length as assumed in large \hbar model for the nerve pulse. This assumption might be necessary also for proton and would make sense if the Planck constant for protonic flux tubes is large enough. For ions the Compton length would be much smaller than the thickness of cell membrane and direct currents would be natural.

If the Planck constant is same for biologically important ions, direct quantum currents would be generated in definite order since in $\hbar < z_{max}$ one has $z_{max} \propto m^{-1/3} \propto A^{-1/3}$. The lightest ions would start to flow first.

- (a) Nerve pulses can be generated by voltage gated channels for potassium and calcium. Voltage gated channels would correspond to magnetic flux tubes carrying electric field. For voltage gated channels Na^+ ions with atomic weight $A = 23$ and nuclear charge $Z = 11$ start to flow first, then K^+ ions with atomic weight $A = 39$ and $Z = 19$ follow. This conforms with the prediction that lightest ions flow first. The nerve pulse duration is of order 1 millisecond at most.
- (b) Nerve pulses can be also generated by voltage gated Ca^{++} channels. In this case the duration can be 100 ms and even longer. Ca has $A = 40$ and $Z = 20$. The proper parameter is $x = r^2/qA$, $r = \hbar/\hbar_0$. One has

$$\frac{x(\text{Ca}^{++})}{x(\text{Na}^+)} = \left(\frac{r(\text{Ca}^{++})}{r(\text{Na}^+)}\right)^2 \times \frac{23}{2 \times 40} . \quad (4.5.17)$$

$r^2(\text{Ca}_{++}) \sim 2r^2(\text{Na}_+)$ would allow to compensate for the increased weight and charge of Ca_{++} ions.

4. The objection is that Na^+ and K^+ are not bosons and therefore cannot form Bose-Einstein condensates. The first possibility is that one has Cooper pairs of these ions. This would imply

$$\frac{x(\text{Ca}^{++})}{x(2\text{Na}^+)} = \left(\frac{r(\text{Ca}^{++})}{r(\text{Na}^+)}\right)^2 \times \frac{23}{20} .$$

Ca^{++} and Na^+ pair would be in very similar position for a given value of Planck constant. This is a highly satisfactory prediction. Another manner to circumvent the problem is more science fictive and assumes that the Na^+ ions are exotic nuclei behaving chemically as Na^+ but having one charged color bond between nucleons [L9].

It remains to be seen whether this model is consistent with the model of cell membrane as almost vacuum extremal or whether the vacuum extremal based model could be modified by treating ionic currents as direct currents. In the vacuum extremal model classical Z^0 gauge potential is present and would give a contribution to the counterpart of Schrödinger equation. The ratio $x(\text{Ca}^{++})/x(2\text{Na}^+)$ for the parameter $x = r^2/q(A-Z)A$ (em charge q is replaced with neutron number in good approximation) equals to 1.38 and is not therefore very far from unity.

The many-sheetedness of space-time is expected to play a key role and one should precisely specify which sheets are almost vacuum extremals and which sheets are far from vacuum extremals. One expects that magnetic flux tubes are far from vacuum extremals and if voltage gated ionic channels are magnetic flux tubes, the proposed model might be consistent with the model of cell membrane as almost vacuum extremal.

Negentropic entanglement, metabolism, and acupuncture

It is interesting to try to develop a detailed model of acupuncture in TGD framework. Consider following assumptions.

1. ATP (metabolic energy) - negentropic entanglement connection is true and formation of high energy phosphate bond generates somehow negentropic entanglement.
2. Pain means loss of negentropic entanglement and healing at the fundamental level - in particular pain relief - involves regeneration of negentropic entanglement.
3. Fundamental metabolic energy currencies correspond to zero point kinetic energies $E_0 \simeq \pi^2/2mL^2$ at space-time sheets labelled by p-adic primes determining their size scale $L = (\hbar/\hbar_0)L_p$. Therefore the generation of metabolic energy storages means at fundamental level driving charged particles to smaller space-time sheets (the smaller the space-time sheet, the higher the zero point kinetic energy). The driving force is basically electric force so that electric fields are needed.
4. Metabolic energy storage - generation of ATP - means generation of negentropic entanglement. Assume that this entanglement is assignable to the smaller space-time sheet.
 - (a) The simplest possibility is that the electrons at this space-time sheet form Cooper pairs and negentropic entanglement is between them. The decay of Cooper pairs would make ATP unstable and the decay to ADP would mean use of metabolic energy quantum and also a loss of negentropic entanglement. This conforms with the generalized form of the second law allowing generation of genuine negentropy but predicting that it does not last for ever. The lifetime of ATP - about 40 minutes [I72] - gives an estimate for the life time of the electronic Cooper pairs. The negative charge of ATP would be due to the electronic Cooper pairs.
 - (b) A simple estimate for the order of magnitude of Kähler magnetic energy of the flux tube assuming far from vacuum extremal and quantization of the Kähler magnetic flux ($B_K S = n\hbar$ for constant magnetic field in a flux tube of cross section S) shows that the Kähler magnetic energy is much higher than zero point kinetic energy of electron pair. Especially so for large values of \hbar since magnetic energy behaves as $E_B \propto \hbar^3 L_0/S$ by the proportionalities $B \propto \hbar B_0$ and $L = \hbar L_0$. In this case the magnetic flux tube should be pre-existing and correspond to acupuncture meridian emerging from the node.
 - (c) For near vacuum extremals the flux tube could be generated in the process. The use of the metabolic energy would mean dropping of electrons to larger space-time sheet and possibly even the disappearance of the magnetic flux tube in this case. This option does not look too plausible however.
5. The generation of metabolic energy storages (ATP) requires energy feed. In the formation of ATP from ADP the acceleration of protons and electrons in the electric of cell membrane plays a key role. The electric energy gained in the process is transformed to metabolic energy and could mean the formation of a flux tube carrying the Cooper pair. Assume that a similar process occurs also in much longer length scales for weaker electric fields scaling like $1/\hbar^2$ for given p-adic prime (and $1/L_p^2$ as function of p-adic length scale) so that electric potential between the ends of the flux tube remains the same. Assume that quantum direct currents are in question. If so, the function of the direct currents of Becker can be identified as a manner to generate metabolic energy and negentropic entanglement. This is natural since healing is involved.

Armed with these assumptions one can try to understand why metal needles are essential for acupuncture.

1. The basic idea is that the presence of the needle makes possible the generation of direct quantal currents accelerating electrons in electric field which is sum of pre-existing field and the field possibly generated by the needle. After gaining some minimum energy electrons can jump to a smaller space-time sheet and give rise to negentropically entangled Cooper pairs.
2. The needle could serve as a mere donor of electrons giving rise to a quantal direct current in turn leading to the generation of metabolic energy and negentropic entanglement.
3. Second possibility is that the needle also generates a strong additional contribution to the existing electric field.

- (a) Basic wisdom from electrostatics is that any sharp conducting charged object - such as metal needle- tends to create a strong electric field around the tip. This is the reason for why one should not go below a tree during thunder storm. Suppose that acupuncture needle becomes charged when touching the skin. One could test this assumption by replacing acupuncture needles with non-conducting material to see whether the healing effect is lost. One could also test whether the metal needle is in non-vanishing potential with respect to Earth or measure directly the electric field in the vicinity of the needle tip.
- (b) If the needle generates negative charge, an opposite charge must be generated somewhere else and electric field lines connecting the needle and its end to it. These field lines could be along magnetic flux tubes carrying also longitudinal electric field. The natural assumption is that the flux tubes correspond to meridians emanating from the acupuncture node to which needle is stuck to. Another possibility is that needle remains neutral as total but develops a density of surface charge via polarization in existing electric field. Also in this case an additional electric field is generated and should be analogous to that of a thin electric dipole in external electric field.
- (c) Under these assumptions quantum currents can flow along the meridians and load the metabolic batteries provided the strength of the generated field is high enough. The situation could resemble quite closely to that for the generation of nerve pulse. There would be pre-existing electric field along flux tube not too far from critical for the generation of quantal direct current. The field generated by the needle would induce depolarization so that quantal direct current of some minimal strength could flow between the ends of the flux tube with acceleration giving providing electrons with energy making possible transfer to the smaller space-time sheet.

Nanna Goldman et al have provided empirical evidence [I32] for the expectation that the healing effect of the acupuncture involves metabolism (see the popular article in Sciencedaily [I17]).

The group has found that adenosine is essential for the pain killing effects of acupuncture. For mice with a normal adenosine level acupuncture reduced discomfort by two-thirds. In special "adenosine receptor knock-out mice" acupuncture had no effect. When adenosine was turned on in the tissues, the discomfort was reduced even in the absence of acupuncture. During and after an acupuncture treatment, the level of adenosine in tissues near the needles was 24 times higher than before the treatment. In the abstract of the article it is stated that it is known for long time that acupuncture generates signals which induce brain to generate natural pain killing endorphins but that also adenosine acts as a natural pain killer.

Adenosine is the basic building block of AXP, X=M,D,T (adenosine-X-phosphate, X=mono,di,tri). Therefore the findings suggest that the electric fields generated or amplified by the presence of acupuncture needles loads metabolic batteries by generating ATP. Adenosine could be partially generated as decay products of AXPs. Tissue itself could increase adenosine concentration to make possible its transformation to AXP utilizing electric field energy. From the popular article one cannot conclude whether the authors propose a connection with metabolism. The results are consistent with the assumption that the AXPs generated from adenosine accompany negentropic entanglement. This can occur in the scale of entire body and meridians could also make possible direct signalling with brain.

The effects of ELF em fields on vertebrate brain

The effects of ELF em fields on vertebrate brain occur both in frequency and amplitude windows. Frequency windows can be understood if the effect occur at cyclotron frequencies and correspond to absorption of large \hbar photons. A finite variation width for the strength of magnetic field gives rise to a frequency window. The observed quantal character of these effects occurring at harmonics of fundamental frequencies leads to the idea about cyclotron Bose-Einstein condensates as macroscopic quantum phases. The above considerations support the assumption that fermionic ions form Cooper pairs.

I have tried to understand also the amplitude windows but with no convincing results. The above model for the quantum currents however suggests a new approach to the problem. Since ELF em fields are in question they can be practically constant in the time scale of the dynamics involved. Suppose that the massless extremal representing ELF em field is orthogonal to the flux tube so that the ions flowing along flux tube experience an electric force parallel to flux tube. What would happen that

the ions at the flux tube would topologically condensed at both the flux tube and massless extremal simultaneously and experience the sum of two forces.

This situation is very much analogous to that defined by magnetic flux tube with longitudinal electric field and also now quantum currents could set on. Suppose that semiconductor property means that ions must gain large enough energy in the electric field so that they can leak to a smaller space-time sheet and gain one metabolic quantum characterized by the p-adic length scale in question. If the electric field is above the critical value, the quantum current does not however reach the second capacitor plate as already found: classically this is of course very weird. If the electric field is too weak, the energy gain is too small to allow the transfer of ions to smaller space-time sheet and no effect takes place. Hence one would have an amplitude window.

The amplitude window occur in widely separate ranges 1-10 V/m and around 10^{-7} V/m. Of course, also other frequency ranges might be possible. Fractality and the notion of magnetic suggests a possible explanation for the widely different frequency ranges. Both p-adic length scale hypothesis and the hierarchy of Planck constants suggest that some basic structures associated with the cell membrane have fractal counterparts in a wide length scale range and correspond to binary structures. Magnetic flux tubes carrying quantal DC currents of Becker would be the most natural candidate in this respect since these currents appear in several length scales inside organism. Also the counterparts of lipid layers of cell membrane could be involved. If so, one must include to the hierarchy of amplitude windows also fields in the range corresponding to the cell membrane resting potential of about 6×10^6 V/m. This is of course only a rough order of magnitude estimate since perturbations of these field are in order.

By fractality the most natural guess is that the voltage along the flux tube is invariant under the scale of Planck constant. This would mean that the electric field would behave as $1/L^2 \propto 1/\hbar^2$ as a function of the length scale characterizing the scale variant of the structure. If so the range $E = 1 - 10$ V/m assignable also to EEG would correspond to a length scale of $7.7 - 24 \mu\text{m}$ corresponding to cell length scale. Perhaps the direct currents run between cells layers. $E = 10^{-7}$ V/m would in turn correspond to 7.8 cm which corresponds to size scale of human brain hemisphere (experiments were carried out for vertebrates). Could the direct quantum currents in question run between brain hemispheres along corpus callosum?

Effects of 50 Hz magnetic fields on living matter

The vision about the role of cyclotron Bose-Einstein condensates was inspired by the effects of ELF em fields on vertebrate brain. The magnetic field strength explaining the effects was about .2 Tesla, 2/5 of the nominal value for the strength of Earth's magnetic field.

There are also other experiments have demonstrated that oscillating electromagnetic fields have effects on living matter. In particle oscillatory magnetic fields with frequency of 50 Hz and with field strengths typically in the range .1-1 mT are used: these effects are summarized in [J59]. Even fields of order .14 Tesla are used.

It is interesting to look at the values of basic parameters associated with these fields.

1. For 50 Hz oscillation frequency the wave length λ is 6000 km to be compared with the radius of Earth which is 6371 km. If one takes seriously the notion of magnetic body this need not be an accident. I do not know how essential it is to have just 50 Hz frequency. The magnetic field is nearby oscillating dipole field up to distances of order λ and radiation field at much longer distances. Therefore the field in question is in good approximation nearby field as far as biological body is considered. For magnetic body the radiation field could dominate
2. For the endogenous magnetic field $B_{end} = .2$ Gauss cyclotron frequencies of ions are in EEG range: Ca^{++} cyclotron frequency is 15 Hz. The scaling up to $r = .1-1$ mT means scaling of cyclotron frequencies by a factor 5 - 50. For Ca^{++} this would give frequency range 75-750 Hz. For K^+ and Cl^+ ions the frequency range would be about 35-375 Hz.
3. The magnetic length $r = \sqrt{2/eB}$ characterizing flux tube thickness for flux quantization with minimum value of flux is for $B = .05$ mTesla equal to $5 \mu\text{m}$. For the fields in the range .1-1 mTesla it is in the range $3.5 \mu\text{m} - 1.1 \mu\text{m}$. $2.5 \mu\text{m}$ corresponds to p-adic length scales $L(k)$ associated with Gaussian Mersenne $M_{G,k} = (1+i)^k - 1$, $k = 167$, and Gaussian Mersenne corresponding to $k = 163$ would correspond to p-adic length scale $.36 \mu\text{m}$. .14 Tesla corresponds

to magnetic length of 9.4 nm rather near to cell membrane thickness of 10 nm which corresponds to p-adic length scale $L(151)$ assignable to Gaussian Mersenne $M_{G,151}$.

The effects of polarized light on living matter

Polarized light is known to have effects on living matter [J59]. For instance, Peter Gariaev has found that the polarized light generated by living matter sample irradiated by polarized laser light has effects on distant organism and there are even indications that genetic code might be realized in terms of radiation patterns [K95]. The quantum model for Becker currents suggest that these effects result as a modification of the voltage between the ends of magnetic flux tubes. If the flux tubes are near criticality for the generation of quantal DC currents, polarized light could be utilized both for communication and control purposes whereas the acceleration in the electric fields along flux tubes would serve as a provider of metabolic energy allowing to load metabolic batteries. This process could be initiated by an electromagnetic signal inducing generation of quantal currents. The same basic mechanism could be at work also in DNA transcription, replication and other similar processes.

If the polarized low frequency radiation corresponds to a massless extremal (ME) orthogonal to the flux tube such that the polarization of the radiation is parallel to the flux tube, the voltage is affected by a contribution given by $\Delta V = Ed$, d the thickness of ME. If the flux tube is near criticality to a generation of quantal currents this change of voltage could serve as a signal inducing the generation of quantal currents.

The maximal effect is obtained for the flux tubes having direction parallel to the electric polarization so that the effect is highly selective. In the case of DNA double strand the direction of flux tube changes so that the effect would be maximal on DNAs which correspond to the same angular position on the super-coil of radius of order 10 nm formed by DNA double helix. This allows to imagine signals for which temporal variation of polarization direction means scanning of DNA.

It is known that the energy of radiation can be transformed to metabolic energy. For instance, IR light for which photons have energies of order metabolic quantum has biological effects [I49]. The mechanism could be following. Suppose that the electric field of IR photon is parallel to the flux tube which carries an electric field and is near criticality for the generation of quantal DC currents. If the direction of polarization is correct, the additional contribution to electric field induces direct current and acceleration of electrons and protons and their transfer to smaller space-time sheets and therefore loading of metabolic batteries. This could also make generation of ATP possible.

Suppose that one takes seriously the model for remote replication of DNA [K95] involving flux tubes connecting identical DNA nucleotides and that the radiation propagating along them induces quantal currents along the receiving DNA inducing replication and perhaps even transcription. The direction of polarization for the emitted radiation should be parallel to the DNA strand locally and during its travel to the target the polarization should remain orthogonal to the flux tube so that one would have what might be called polarization window. Parallel translation of the polarization vector in the induced metric suggests itself.

Support for the proposed interaction mechanism of em radiation fields with flux tubes

The basic prediction of the interaction mechanism is that the effects of em field with a given frequency occur only at the second half period when the direction of electric field is "correct". This prediction might be testable. In fact, there is evidence for this interaction mechanism in the case of theta waves of EEG. The memory storage occurs only at the second half of the theta wave. This is discussed from different point of view in [K19].

The place coding by phase shifts was discovered by O'Reefe and Recce [J44]. In [J73, J72]. Y. Yamaguchi describes the vision in which memory formation by so called theta phase coding is essential for the emergence of intelligence. It is known that hippocampal pyramidal cells have "place property" being activated at specific "place field" position defined by an environment consisting of recognizable objects serving as landmarks. The temporal change of the percept is accompanied by a sequence of place unit activities. The theta cells exhibit change in firing phase distributions relative to the theta rhythm and the relative phase with respect to theta phase gradually increases as the rat traverses the place field. In a cell population the temporal sequence is transformed into a phase shift sequence of firing spikes of individual cells within each theta cycle.

Thus a temporal sequence of percepts is transformed into a phase shift sequence of individual spikes of neurons within each theta cycle along linear array of neurons effectively representing time axis. Essentially a time compressed representation of the original events is created bringing in mind temporal hologram. Each event (object or activity in perceptive field) is represented by a firing of one particular neuron at time τ_n measured from the beginning of the theta cycle. τ_n is obtained by scaling down the real time value t_n of the event. Note that there is some upper bound for the total duration of memory if scaling factor is constant.

One can say that neurons in ensemble provide a representation for the external world and the location of the rodent in the external world is represented as a firing of a neuron in this landscape. Besides this also temporal scaling down by a factor about ten is carried out so that actual event is represented as much shorter copies of it. Obviously this represents temporal fractality.

This scaling down - story telling - seems to be a fundamental aspect of memory. Our memories can even abstract the entire life history to a handful of important events represented as a story lasting only few seconds. This scaling down is thought to be important not only for the representation of the contextual information but also for the memory storage in the hippocampus. Hierarchy of Planck constants and phase transitions changing Planck constant make this story building possible.

The finding of Yamaguchi and collaborators relevant in the recent context is that the gradual phase shift occurs at half theta cycle whereas firings at the other half cycle show no correlation [J73]. The proposed model for the interaction of theta waves with flux tubes could explain this naturally. The relevant neural sub.system would be critical to the generation of quantal DC current only when the direction electric field of synchronizing theta wave generated by magnetic body is correct. Hence synchronous neural activity would be induced only at second half cycle of theta wave and firing would be random during the other half cycle.

4.5.3 A model for remote gene expression

If one accepts the notion of magnetic body as intentional agent, the basic challenge is to understand how magnetic body realizes its intents as remote mental interactions on biological body. This model must of course apply also to the more conventional remote mental interactions such as remote realization of intent.

The hypothesis is that electromagnetic and possibly also other massless classical fields assignable to so called massless extremals are in a key role. Also cyclotron frequencies characterizing magnetic bodies play a key role. The vision is that magnetic flux sheets traverse many-sheeted DNA in various scales giving rise to a hierarchy of genomes and coherent gene expression in scales of cell, organelles, organism, and even population, and species. Hierarchy of Planck constants is in an essential role in realizing this hierarchy in terms of photons with energies above the thermal energy at physiological temperature and having spectrum of wavelengths coming as multiples $\lambda = n\lambda_0$, $n = \hbar/\hbar_0$.

The findings of Benveniste and followers relating to water memory and homeopathy, the recent work of group led by HIV Nobelist Luc Montagnier coupling the findings with genetics and suggesting a new nanoscale realization of genetic code (see this [L21]), the work of the group of Popp with biophotons identified as decay produces of large \hbar photons with visible energies (in particular dark EEG photons), and the work of Peter Gariaev and collaborators supporting remote gene expression and replication discussed here suggest that electromagnetic radiation is indeed involved [K95]. In the case of water memory and homeopathy the spectrum of cyclotron frequencies for the chemical invader characterizes it and induces immune response trying to eliminate it. I have also proposed a model for how genes coding for proteins eliminating the invader could be generated almost automatically: the model is based on the predicted realization of vertebrate genetic code in terms of dark proton states (see this [K31]). DNA would like an animal which sniffs the invaders magnetic body and automatically reacts to the smell.

The discussions with Lian Sidorov and people who have realized that new era is beginning in biology have served as a driving force in the attempts to formulate in more detail TGD inspired view about how remote mental interactions - which are basic element of the model in TGD framework - might be realized. As a matter fact, I have added to my homepage a new book summarizing briefly the recent view about quantum TGD and its applications to quantum consciousness, quantum biology, to quantum neuroscience, and to remote mental interactions with some proposals for possible tests [K93] (see this) .

To start with, suppose that in the case of biological target realization of intent in the simplest situation reduces to expression of genes. This is of course a strong limitation to the type of remote mental interactions. The challenge is to develop a model for remote realization of genetic activities like replication, and transcription. For some time ago I proposed a model with Peter Gariaev [K95] but it was still too clumsy since it required too much of information transfer between the genomes of sender and receiver. Much simpler model involving only sending of simple commands initiating genetic programs suggests itself. The following proposal tries to achieve this and involves three basic ideas.

1. The idea of password and addressing is familiar from ordinary computers. Collection of frequencies as password/address allows to reach tuned targets without specific targeting of the command. This is a dramatic improvement to the previous model.
2. Password and fractal addressing realized in terms of frequencies coupling resonantly (already in the original model: I did not however realize the implications of resonant coupling!) and the hierarchy of Planck constants to realize the hierarchical addressing. I have discussed analogous addressing based on information molecules and their receptors at the biochemical level to realize magnetic flux tube connections between sender and target inside organism (hormonal action would be very analogous to what I am proposing here).
3. Becker's DC currents as supra currents [L26] flowing along DNA and activated optimally when the incoming laser light has polarization parallel to DNA's local direction, activation of super currents would mean activation of the gene. This is second new element to the original model.

In the following I discuss this with more details.

The analogy with ordinary computer

Consider first the analog of remote mental interactions for ordinary computer. Computer sends a password to the other computer and after that it can use it to run programs of the other computer. Whistling to a dog is another example: extremely simple command activates arbitrary complex programs.

In the recent case electromagnetic radiation with a given frequency coupling resonantly like radio signal to a tuned radio receiver would be the simplest command activating the target. There would no need to specify the direction or distance of the target precisely since essentially mass communications would be in question: intent would be enough. Password could consist of several frequencies which must be received simultaneously by the target before it would activate and tunes to receive more frequencies representing simple commands - perhaps acting on the intronic portion of DNA and activating the genome to remote gene expression or something else such as activating DNAs of other cells by sending similar em addresses!

I have discussed topological quantum computer programs based on braiding could look like in this framework [L25]. Also here addressing but now realized as information molecule-receptor pair would play a key role.

Hierarchy of Planck constants and hierarchical addressing

Fractal hierarchy of frequencies (in Peter's experiment laser light induced generation of radiation at frequencies down to about 10 kHz) would allow to transform passwording to addressing. Very naively, the longest wavelengths: about 10^4 meters would reach the tuned receivers in nearly the same phase in a region of this size. One would have some subregions in tune. The shorter wavelengths would allow to pinpoint the tuned receivers inside each of these subregions and so on. This would be fractal addressing with most significant bits correspond to the longest wavelengths. Only those receivers which would be tuned to all frequencies would start to express the gene in the case of AND logic. Of course, also other Boolean functions of tuned-not tuned bits can be considered.

A good guess is that all photons correspond to same energy of visible photon and only Planck constant varies. For ordinary value of Planck constant one would have a photon with wavelength of order size scale of single cell, and the frequencies in this range would select single gene in the genome of a particular kind of cell, say neuron within particular region of brain.

In Peter Gariaev's experiment involving 2 eV incoming red laser light the outgoing photons would have same energy but larger Planck constant so that also wavelengths would be longer and range down to at least 3×10^4 meters corresponding to radiofrequency scale of 10 kHz. What is interesting that 2 eV is 4 times the nominal value of the metabolic energy quantum of .5 eV identifiable as zero point kinetic energy of electron or proton for the p-adic length scale $L(151)$ corresponding to cell membrane thickness and Gaussian Mersenne $M_{151} = (1 + i)^{151} - 1$. Could it be that 2 eV could be preferred photon energy or is its use simply due to the unavailability of continuous frequency spectrum for laser light. And why the laser light induces the generation of the command inducing remote gene expression?

This picture conforms with Peter's experiment and with the reports of Benveniste and followers about the possibility of representing homeopathic remedy using very low frequency spectrum - presumably cyclotron frequencies - assignable to remedy. These frequencies would be addresses for genes activating genes transcribing building bricks of biomolecules of immune response eliminating the substance from the organism. The proposal could be seen as a generalization of Benveniste's observation and realization of wave DNA proposal.

DNA supra currents and activation of genes by Becker mechanism

The third building brick of the model would be quantum model for Becker currents [L26] as supra currents or quantal DC currents [L26]: also this element is new. Assume - in accordance with the general vision - that these supra currents can flow also along the strands of many-sheeted DNA (flux sheets associated with the strand, entire hierarchy labelled by the values of \hbar). Assume also that the interaction of polarized photons addressing for genes with DNA is such that the electric fields of DNA flux tube and "massless extremal" representing laser beam superpose and charges (electrons) experience the superposition of field already present and the field of ME. If the net electric field is near criticality originally (think as analog neuronal membrane) and becomes over-critical, quantal Becker current starts to flow and the machinery responsible for gene activation is activated.

This means also the activation of metabolic machinery since the acceleration of electrons in the electric field gives them energy making possible a transfer to smaller space-time sheets where they form Cooper pair like states with negentropic entanglement. Metabolic energy corresponds to zero point kinetic energy and negentropic entanglement is relevant from the point of view of consciousness: in the case of healing understood as a regeneration of negentropic resources this aspect is especially important. This mechanism generates high energy phosphate bonds in ATP and the decay $ATP \rightarrow ADP$ liberates the metabolic energy and destroys the negentropic entanglement possibly associated with ATP so that the second law in generalized form [L22] allowing local generation of genuine negentropy (but assigned to information carried by entanglement defining a quantum rule) wins after all.

It could also happen that the decay of ATP generates dark photon or photons absorbed by cyclotron condensate at magnetic flux tube. The excited state is non-local single particle excitation and involves very simple negentropic entanglement between the particles of the condensate. In this case the negentropy of ATP would be transformed to the negentropy of the magnetic flux tube or even several of them if large value of Planck constant is associated with the photon. This mechanism could allow the generation of negentropic entanglement associated with attention. The storage of metabolic energy in photosynthesis could involve similar excitation of cyclotron state at the first step. The most plausible candidate is cyclotron condensate for electron Cooper pairs. Also electrons filling state up to some Fermi energy could be in question. In this case the excitations would be excitation in longitudinal degrees of freedom of the flux tube generating current.

4.5.4 DNA, speech, music, and ordinary sound

Peter Gariaev's group has made rather dramatic claims about DNA during years [I33, I58, I57, I59].

1. The group has proposed that the statistical distributions of nucleotides and codons in the intronic portion of DNA resemble the distribution of letters and words in the natural languages [I59]. For instance, it is proposed that Zipf law [J74] applying to natural languages applies to the distributions of codons in the intronic portion of DNA. One can study the popularity of the words in natural languages and order them against their popularity. Zipf law states that the

integer characterizing popularity is in constant proportion to the number of times it appears in given long enough text.

2. It has been also claimed that DNA can be reprogrammed using modulated laser light or even radio waves. I understand that reprogramming means a modified gene expression. Gariaev's group indeed proposes that the meaning of the third nucleotide (having a rather low significance in the DNA-aminoacid correspondence) in the genetic codon depends on the context giving rise to a context dependent translation to amino-acids. This is certainly a well-known fact for certain variants of the genetic code. This context dependence might make possible the re-programming. The notion of dark DNA allows to consider much more radical possibility based on the transcription of dark DNA to mRNA followed by translation to aminoacids. This could effectively replaced genes with new ones.
3. Also the modulation of the laser light by speech is claimed to have the re-programming effect. The broad band em wave spectrum resulting in the scattering of red laser light on DNA is reported to have rather dramatic biological effects. The long wave length part of this spectrum can be recorded and transformed to sound waves and these sound waves are claimed to have the same biological effects as the light. The proposal is that acoustic solitons propagating along DNA represent this effect on DNA.

I do not have the competence to make statements about the plausibility of these claims. TGD view about quantum biology makes also rather strong claims. The natural question is however whether a justification for the claims of Gariaev and collaborators could be found in TGD framework? In particular, can one say about possible effects of sound on DNA. One intriguing fact about sound perception is that music and speech have meaning whereas generic sounds do not. Could one say something interesting about how this meaning is generated at the level of DNA?

Basic picture

Before continuing it is good to restate the basic TGD inspired ideas about the generation of meaning.

1. The generation of the negentropic entanglement is the correlate for the experience of the meaning. In the model inspired by Becker's findings [L26], the generation of negentropic entanglement involves a generation of supra currents along flux tubes moving in the electric field parallel to them. This is a critical phenomenon taking place when the voltage along the flux tube is near critical value. The generation of nerve pulse near critical value of the resting potential is one example of this criticality. Becker's direct currents involved with the healing of wounds is another example.

The flow of the supra current gives rise to the acceleration of charges along the flux tubes and generation of Cooper pairs or even many-electrons systems at smaller space-time sheets in negentropically entangled state and carrying metabolic energy quantum as zero point kinetic energy. The period of negentropic entanglement gives rise to a conscious experience to which one can assign various attributes such as understanding, attention, and so on. Negentropic entanglement would measure the information contained by a rule having as instances the state pairs in the quantum superposition defining the entangled state. When the period of negentropic entanglement ceases, the metabolic energy is liberated.

2. Remote activation of DNA by analogs of laser beams is another essential piece of TGD inspired quantum biology [L26]. In the proposed addressing mechanism a collection of frequencies serves as a password activating intronic portions of DNA. This would take place via a resonance for the proposed interaction between photons and dark supra currents flowing along magnetic flux tubes and perhaps also along DNA strands or flux tubes parallel to them. The superposition of electric fields of photons (massless extremals) with the electric fields parallel to flux tubes (so that massless extremals serving as correlates for laser beams would traverse the flux tube in orthogonal direction).
3. The flux tubes, and more generally flux sheets labelled by the value of Planck constant, and along which the radiation arrives would be transversal to DNA and contain DNA strands. This kind of flux tubes and sheets also define the connections to the magnetic body, and form parts of it. A

given flux sheet would naturally select the portion of DNA, which is activated by the radiation: it could be a portion of intronic part of DNA activating in turn a gene. These flux tubes and sheets could be connected to the lipids of nuclear and cell membranes - also cell membranes of other cells - as assumed in the model of DNA as topological quantum computer [K19]. The sheets could also give rise to a hierarchy of genomes - besides genome one would have super-genome in which genomes are organelles are integrated by flux sheets to a large coherently expressed structure containing individual genomes like page of a book contains lines of text. These pages would be in turn organized to a book - hyper-genome as I called it. One could have also libraries, etc... There would fractal flux quanta inside flux quanta structure.

Phonons and photons In TGD Universe

Consider next phonons and their coupling to photons in TGD Universe.

1. Sound waves could quite well transform to electromagnetic radiation since living matter is piezo-crystal transforming sound to radiation and vice versa. Microwave hearing represents an example of this kind transformation. This would require that photons of given energy and varying value of Planck constant couple to phonons with the same energy, Planck constant, and frequency.
2. Whether one can assign to phonons a non-standard value of Planck constant is not quite clear, but there seems to be no reason preventing this. If so, even photons of audible sounds would have energies above thermal threshold and have direct quantal effects on living matter if they have same Planck constant as the photons with same frequency.
3. Acoustic phonons represent longitudinal waves and this would require longitudinal photons. In Maxwell's electrodynamics they are not possible but in TGD framework photon is predicted to have a small mass and also longitudinal photons are possible.
4. For general condensed matter systems one can have also optical phonons for which the polarization is orthogonal to the wave vector and these could couple to ordinary photons. The motion of the charged particles in the electromagnetic field of massless extremal (topological light ray) would be a situation in which phonons and photons accompany each other. This would make possible the piezo-electric mechanism.

Under these assumptions the collections of audible frequencies could also represent passwords activating the intronic portion of the genome and lead to gene expression or some other activities. If one believes on the hypothesis that DNA acts like topological quantum computer based on the braid strand connections between nucleotides in the intronic portion of DNA with the lipids of the nuclear and/or cell membranes, also topological quantum computation type processes could be activated by the collections of sound frequencies [K19].

What distinguishes speech and music from sounds without meaning?

Speech and music are very special form of sound in that they have direct meaning. The more one thinks about these facts, the more non-trivial they look. For music - say singing - the frequency of the carrier wave is piecewise constant whereas for speech it remains constant and the amplitude modulation is important. In fact, by slowing down the recorded speech, one gets the impression that carrier frequency is actually modulated like in chirp (frequency goes down and covers a range of frequencies). What is the mechanism giving to speech and music its meaning and in this manner distinguishes them from other sounds?

Besides the frequency also phase is important for both speech and music experience. Speech and reverse speech sound quite different the intensity in frequency space is same. Therefore the relative phases associated with the Fourier coefficients of various frequencies must be important. For music simple rational multiples of the fundamental define the scale. Could it be that also the frequencies relevant to the comprehension of speech correspond to these rational multiples?

Suppose that one indeed believes on the proposed vision based on the fundamental role of negentropic entanglement in generation of meaning and takes seriously the proposed mechanisms for generating it. Can one understand why music and speech differ from general sounds and what distinguishes between them?

1. With these assumptions suitable collections of frequencies sound wave would indeed activate the intronic portion of DNA by generating negentropic entanglement. Also other dark flux tubes than those assignable to DNA are involved. For instance, hair cells responsible for hearing of sounds around particular frequencies could involve flux tubes and utilize similar mechanism. Allowing only hair cells would define the conservative option. On the other hand, one could well claim that what happens in ear has nothing to do with the understanding of the speech and music, it could take place only at the level of neuronal nuclei.
2. Could the direct interaction of sound waves with magnetic flux tubes generate the experiences of speech and music? In other words, assign meaning to sounds? The criterion for sound to have an interpretation as speech or music would be that it contains the resonance frequencies needed to activate the DNA, or more generally generate dark super currents generating Cooper pairs in this manner loading metabolic energy storages. This would apply to both speech and musical sounds.
3. The pitch of the speech and musical sound can vary. We are aware of the key of the music piece and of modulations of the key and remember the starting key, and it is highly satisfactory to make a return to "home" defined by the original key. This would imply that the overall scale of the collection of frequencies can be varied and that the pitch of the speech defines a natural expectation value of this scale. For persons possessing so called absolute ear this scaling symmetry would be broken in a well-defined sense.
4. Musical scales involve frequencies coming as rational multiples of the basic frequency. Octaves - power of two multiples- of the frequency can be said to be equivalent as far musical experience is considered. One might understand the special role of rational multiples of the basic frequency if the Fourier components have same phase periodically so that the experience is invariant under discrete time translations. This requires commensurable frequencies expressible as rational multiples of the same fundamental frequency. The preferred role of p-adic primes coming as powers of two could relate to the octave phenomenon.
5. Are the relative phases of different Fourier components important for music experience? If one requires a periodical occurrence of maximal possible intensity (maximal constructive interference) then the relative phases must vanish at the values of time for maximal possible intensity. What seems essential that the presence of commensurate frequencies gives rise to time translation invariant sensation whereas speech consists of pulses.

Are speech and music quantum duals like position and momentum?

Frequencies are crucial for music experience. In the case of speech the relative phases are very important as the example of reverse speech demonstrates. How a given phoneme is heard is determined to high degree by the frequency spectrum in the beginning of the phoneme (this distinguishes between consonants). Vowels are nearer to notes in vocalization. Speech consists of pulses and destructive interference between different frequencies is required to generate pulses and different pulse shapes so that phase information is important. At least the harmonics of the basic rational multiples of the fundamental are necessary for speech.

One can criticize the previous discussion in that it has been completely classical. Phase and frequency are in wave mechanics canonically conjugate variables analogous to position and momentum. Is it really possible to understand the difference between music and speech purely classically by assuming that one can assign to sound waves both frequencies and phases simultaneously - just like one assigns to a particle sharp values of both momentum and position? Or should one use either representation either in terms numbers of phonons in different modes labelled by frequencies or as coherent states of phonons with ill defined phonon numbers but well defined amplitudes? Could the coherent states serve as the analogs of classical sound waves. Speech would be as near as possible to classical sound and music would be quantal. Of course, there is a large variety of alternative choices of basis states between these two extremes as a specialist in quantum optics could tell.

Suppose that this picture is more or less correct. What could be the minimal scenario allowing to understand the differences between speech and music?

1. Only a subset of frequencies could activate DNA (or if one wants to be conservative, the hair cells) also in the case of speech. One could still pick up important frequencies for which the ratios are simple rational numbers as in the case of musical scale plus their harmonics. If this assumption is correct, then speech from which all frequencies except for the harmonics of the simple rational multiples of the fundamental are removed, should still be comprehensible as speech. The pitch of the speech would determine a good candidate for the fundamental frequency.
2. The harmonics of frequencies activating DNA would be crucial for speech. Harmonics are present also in music and their distribution allows to distinguish between different instruments and persons. The deviation of musical notes from ideal Fock states would correspond to this.
3. The naive guess is that the simple rational multiples of fundamental and the possibility of having their harmonics could be reflected in the structure of intronic portions of DNA as repetitive structures of various sizes. This cannot be the case since the wavelengths of ordinary photons would be so small that the energies would be in keV range. Neither is this expected to be the case. It is magnetic flux tubes and sheets traversing the DNA which carry the radiation and the natural lengths assignable to these flux quanta should correspond to the wave lengths. The larger, the flux quantum, the lower the frequency and the larger the value of Planck constant. Harmonics of the fundamental would appear for given flux tube length naturally.

The DNA strands and flux tubes and sheets form a kind of electromagnetic music instrument with flux quanta taking the role of guitar strings and DNA strands and other structures such as lipids and possible other molecules to which flux tubes get attached taking the role of frets in guitar. This analogy suggests that for wave lengths measured in micrometers the basic frequencies correspond to the distances between "frets" defined by cell and nuclear membranes in the tissue in the scale of organism. This would relate the spectrum of resonance frequencies to the spectrum of distances between DNAs in the tissue.

For wave lengths corresponding to very large values of Planck constant giving rise to frequencies in VLF and ELF range and corresponding also to audible frequencies, the preferred wave lengths would correspond to lengths of flux quanta in Earth size scale. One should understand whether the quantization of these lengths in simple rational ratios could take place for the preferred extremals.

4. Could the pulse shape associated with massless extremals (MEs, topological light rays) allow to distinguish classically between speech and music at the level of space-time correlates? Linear superposition of Fourier components in the direction of ME is possible and this allows to speak about pulse shape. It allows also the notions of coherent state and Fock state for given direction of wave vector. Essential would be the restriction of the superposition of fields in single direction of propagation to be distinguished from the superposition of the effects of fields associated with different space-time sheets on multiply topologically condensed particle. Maybe this would allow to make testable predictions.

4.6 Water and life

4.6.1 Latest view about water memory

The notion of water memory has several aspects. Water memory was introduced by Benveniste [I28, I29] to explain the claimed ability of homeopathically treated water to behave as if it contained the original molecules. Already Benveniste discovered the connection with very low frequency electromagnetic radiation and claimed that the patterns of this radiation carry the information about the molecule and represent its biologically relevant aspects. Water memory has been also assigned to the observation suggesting that the human intent has effect on the crystal structures formed as water near criticality freezes [I73, I16].

Basic aspects of water memory

The first aspect of water memory relates to homeopathy and is discussed from strongly skeptic point of view in Wikipedia article. Mae Wan-Ho takes a more balanced view on homeopathy in her article

discussing the recent findings of the research group of HIV Nobelist Luc Montagnier providing strong support for water memory and suggesting also a connection with gene level [I50, I30].

The basic principle of homeopathy is "let like be cured by like". Homeopathic remedies are highly diluted preparations believed to cause in the healthy individuals effects similar to the undesired symptoms of the person treated. Homeopathy is not in accordance with the naive materialistic beliefs about what water is (just the letters $H_2O!$) and what happens in succession process producing the remedy. Not surprisingly, hard-nosed skeptics are not able to discuss the subject without bursts of rage. Obviously, the claimed effect of homeopathic remedy resembles that of vaccine and one might say that the harmful substance serves as its own antibody eliminating the effect of the harmful substance. If one takes homeopathy seriously, the challenge is to explain this auto-antibody behavior. One can of course ask whether this behavior could in some sense be the basic mechanism of immune system.

In Benveniste's experiments [I28, I29] antibodies of human basophils were dissolved in water and the claim of experiments was that basophils added to the homeopathically treated water produced allergic reaction serving usually as a signature for the presence of antibody. As if water were able to mimic the antibodies in biologically relevant aspects. Later Benveniste was labeled as a fraud but the research has continued and it has been for long time thought that low frequency electromagnetic fields are essential for water memory. The frequencies in question extend to kHz range and cannot relate to molecular transitions. Cyclotron frequencies assignable to charged particles at the magnetic body of the molecule are the natural candidate in TGD framework.

Second aspect of water memory relates to the claim that human intent has an effect on the molecular structure of water. Clearly a special variant of remote mental interaction would be in question. Masaru Emoto [I73] has photographed water crystals resulting from water contained by a glass and subject to human intent. Depending on the origin of water the resulting water crystals can vary from random to very organized and aesthetic. Words, pictures, and music are used to generate the crystals. It is important to not forget that human intent is a decisive factor so that water need not be able to read as one especially simplistic and aggressive fanatic ridiculizing Emoto claimed! Emoto has published several books containing pictures of the crystals and makes explicit that he is not a scientist but photographer who has discovered a fascinating new phenomenon and loves to document it.

Mae Wan-Ho has written an article titled Crystal Clear - Messages from Water [I73] in which she discusses Emoto's work with intellectual honesty and giving primacy for facts instead of dogmas. The basic argument of skeptic is that water is just H_2O as we learned in school and therefore Emoto must be a swindler. The Wikipedia article [I9] about Masaru Emoto's work represents a rather civilized skeptic reaction as compared to Harriet Hall's piece of bad rhetorics filled with nasty ad hominem attacks. More ambitious skeptic believer bothers to develop an argument claiming that aesthetic appeal is highly subjective measure to characterize the water crystals. Here common sense and intellectual honesty clash with materialistic dogmas categorically denying this kind of effects, and the reader of these books must make a personal decision about what might be the truth - unless they decide to become photographers of water crystals.

The reader can also form his or her opinion about this aspect of water memory by looking the You tube video Water has Memory [I16] prepared in Aerospace Institute in Stuttgart illustrating that the effect of human intent on the structure of water droplets is same for droplets from same source, is repeatable, and characterizes the operator. Also the effect of flowers dropped into the water is illustrated. All drops from a given source give rise to same structure characterizing the flower. It is suggested that water is a huge information source and serves as a kind of data medium. This proposal is highly trivial and would mean a profound modification of world view.

A simple model for water memory

Suppose that we just for a moment decide to overcome our intellectual laziness and are not satisfied with the standard rhetoric tricks of skeptics to convince ourselves that water memory researches must be swindlers or fools. In other words, we take the experimental evidence supporting water memory as something worth of considering seriously and try to build a model for the claimed phenomena. We can indeed imagine when we do not know. The challenge of the model for water memory is to explain the claimed basic aspects of water memory with minimal assumptions. Let us the restrict the model building further by assuming that we live in TGD Universe and that our vision about this Universe is roughly correct.

The ability of water molecule clusters to mimic the possibly harmful substances - call them just H - dissolved in water in some biologically relevant aspects could explain the effectiveness of homeopathic remedies. Water should make possible a symbolic representation of the molecules or their magnetic bodies.

1. Suppose H is a polar molecule so that it is biologically effective and that magnetic body characterizes the relevant biological effects of a polar molecule. Suppose that mechanical agitation causes some polar molecules to lose their magnetic bodies so that they attach to water molecule clusters, which therefore become "actors" representing H . In the dilution the density of the fake molecules is also reduced but if the energy provided by shaking can be used as metabolic energy makes possible for the "actors" to replicate and their population can survive and even evolve in the sequence of "environmental catastrophes" induced by repeated succussions possibly also inducing evolution as an increase of Planck constant for the magnetic body of the "actor". Also the replication of the magnetic body of the "actor" is required. Cyclotron frequency spectrum would serve as a characterizer of molecule's magnetic body and cyclotron radiation would make possible communications between fake molecules and their magnetic body.
2. What the dropping of magnetic bodies really means? To answer the question consider a general vision about what happens as energy is fed into a system consisting of proteins dissolved in water. The proteins originally in closed globular configuration open as the ordered water covering their surfaces with "ice" melts. This leads to a protein aggregation during the short "molecular summer" provided by the energy feed. The outcome is braiding and reconnection of flux tubes. Suppose that this mechanism is at work also when proteins are replaced with harmful polar molecules. During "molecular summer" a reconnection process for closed loops emerging from water clusters and polar molecules would connect them with water clusters. Also the magnetic bodies of polar molecules would generate connections to water clusters via molecules. Self-reconnection for the flux tubes going through H molecules makes possible the transfer of the magnetic body of H to water molecule cluster. Water molecule cluster would "steal" the magnetic coat of H and H molecules would be left with short-cut closed flux tubes after the reconnection.
3. What is required that these water clusters or something associated with them can replicate and develop to a population representing the original molecules. The needed metabolic energy would come from mechanical agitation. Note that this replication should involve also the replication of magnetic bodies which suggests that linear structures generating planar flux tubes emanating from the basic building bricks of the structure are involved. This will be discussed below.

What could then be the healing mechanism in homeopathy? Why the presence of the fake molecules in organism would prevent the harmful actions of real molecules in the organism? What could be the translation of "Let like be cured by like" to the language of quantum TGD?

1. Suppose that the effects of H on bio-molecules are due to cyclotron radiation along the flux tubes of its magnetic body connecting it to bio-molecules of the organism. Suppose that the fake representatives of H contained by the homeopathic remedy and real molecules H reconnect so that the flux loops associated with H and fake H reconnect to a pair of flux tubes connecting H and fake H . Suppose that this happens with such high a rate that the fraction of the connections to other biomolecules remains low.
2. If so, fake H would effectively act antibody of H and the effects of H via its magnetic body on organism would be minimized. Like would indeed cure like. Could this reconnection mechanism be at work also when antibody attaches to the harmful molecule? If so, the basic mechanism of immunization would be universal and involved the notion of magnetic manner in an essential manner.

Dark nucleon genetic code as realization of water memory, and homeopathic mechanism as basic mechanism of immune system

The proposal says nothing about the detailed structure of water clusters, and does not mention dark nucleons nor the proposal for the realization of genetic code based on them. A more refined model

would include also these and give a connection for how immune system would utilize the reconnection of flux tubes defining the basic mechanism of homeopathy.

1. TGD predicts a realization of vertebrate genetic code at the level of dark nucleons. Dark nucleons correspond to the states of DNA, RNA, tRNA, and amino-acids and represent vertebrate genetic code under rather general assumptions [L9]. One could even consider the extension of the genetic code to a naming of polar molecules by sequences of representatives of DNA letters. Suppose that dark proton sequences are attached to a polar molecule dissolved in water, and define a representation of the molecule in terms of code letters realized as exotic protons with Compton length in nano-scale. The assignment of the magnetic body of the molecule to water cluster would give it the same "name" as for the original molecule. It is of course possible to have other representation and one of them would be in terms of dark u quarks providing representation of A,T,C,G in terms of spin states.
2. If the population of dark DNA molecules assigned with the harmful substance H is able to use the energy provided by the succession process as a metabolic energy for replication, the disappearance of H is compensated by the replication of dark DNA representing it. Dark DNA becomes the representative of H . The growing population would consist of dark DNA and the flux tubes of the magnetic body connect to dark DNA strands. Replication would be the analog of that for ordinary DNA and involve also the replication of magnetic bodies. The water would contain pairs of dark DNA and its conjugate connected by a flux tube and these flux tubes would reconnect with flux tubes connecting the dark DNA sequence representing H and connected by flux tubes to its conjugate.
3. It is known that the DNA of the immune system evolves with an especially high rate. Could the universal naming mechanism allow the immune system to generate new immune responses via the transcription of the dark DNA sequence representing the harmful molecule to a real DNA, which in turn codes for amino-acid attaching to the harmful molecules along the dark nucleon sequence? A model for homeopathy would extend to a model for the functioning of immune system. This would be of course also a mechanism of evolution as a reaction to changing chemical environment. This would explain also the effect of the homeopathic remedy as an effect at gene level.

It is difficult to exaggerate the potential significance of this mechanism for biology, genetic engineering, and medicine. Understanding of the contemptible homeopathy could induce decisive step in the understanding of biology. This possibility shows how dangerous it is to take the claims forced by a particular belief system like materialism as final truths.

Reader has certainly noticed that reconnection mechanism pops up again and again in the model and would be also the fundamental mechanism of ordinary DNA replication, transcription, translation of mRNA to proteins, and of process catching tRNA molecules carrying amino-acids to form protein at mRNA. This mechanism would be realized even in the mutual interactions between living organisms and between living organisms and inanimate matter.

Braiding represents as a higher level aspect of water memory

Braiding represents another aspect of water memory relating to the representation as dark nucleon sequences as the quantum computer programs represented by braidings to DNA in the model of DNA as topological quantum computer [K19]. The memories represented by braiding would be about the flow of water and molecules rather than about substances present in the water. The model of qualia [K26] is based on flux tube connections between system representing self and environment. For polar molecules the qualia would relate to charge and electric polarization. Could the qualia assignable to polar molecule plus environment have scaled down fractal variants at the level of water clusters of environment? If this were the case then water would effectively produce representations about molecule at the level of qualia. Could also these relate to water memory?

Effects of intent on water crystallization

One should understand the effect of intent on water in terms of water memory. The proposed representation of polar molecules in terms of dark DNA sequences is one possible realization of water

memory reducing naming of molecules to genetic code letters. Essentially addressing of molecules would be in question. This aspect of water memory is not relevant now. Rather, what matters is the interaction of water with human operator and reconnection of flux tubes of magnetic bodies is a good guess for how this interaction is realized. The same mechanism is involved also with the interaction of homeopathic remedy and harmful substance.

How could one understand the effect of intent on water crystallization, which characterizes the operator involved. The situation would be very much like that in the experiments of Tiller [J65]. The magnetic bodies assignable to the operator and water must interact and produce the effects. This would not be surprising if similar interaction takes place in the case of dissolved substances.

A concrete model for the interaction would be in terms of the reconnections of closed flux tubes emerging from the biological body of subject person with the flux tubes of the magnetic body of water creating direct flux tube contacts between the two bodies. The presence of magnetic flux tube connections between water sample and operator's magnetic and biological body would induce the effects on crystallization of water. Water memory should be stable in human time scales. This requires that these flux tube patterns are rather stable modification of the magnetic body of water. Large values of Planck constant assignable to the magnetic body of human agent would be needed. What is required is that the crystallization patterns and therefore structures of water clusters correlate with the structure of the magnetic body of the water sample.

Magnetic body and migrating birds

What happens when the water glass in the experiments of Emoto is taken to a large distance from operator? Does the effect prevail? If the magnetic flux tubes stretch, this interaction need not cease as the distance between operator and water glass increases unless the double flux tube splits by self-reconnection. If so, water could indeed act as a data medium as proposed in the video about water memory.

Magnetic body could play key role in understanding how birds and fish manage to find their birth places during migration is one of the many unresolved mysteries of biology. It has been suggested that orienteering in magnetic field of Earth using neuron level compass is in question but this proposal has its difficulties. Could it be that the birds and fish are connected by the magnetic flux tubes of their personal magnetic body or of that of the species to the birth place so that they would only follow Ariadne's thread?

4.6.2 Genes and water memory

After long time I had opportunity to read a beautiful experimental article about experimental biology. Yolene Thomas, who worked with Benveniste, kindly sent the article to me. The freely loadable article is *Electromagnetic Signals Are Produced by Aqueous Nanostructures Derived from Bacterial DNA Sequences* by Luc Montagnier, Jamal Aissa, Stephane Ferris, Jean-Luc Montagnier, and Claude Lavall'e published in the journal *Interdiscip. Sci. Comput. Life Sci.* (2009) [I50] .

Basic findings at cell level

I try to list the essential points of the article. Apologies for biologists: I am not a specialist.

1. Certain pathogenic micro-organisms are objects of the study. The bacteria *Mycoplasma Pirum* and *E. Choli* belong to the targets of the study. The motivating observation was that some procedures aimed at sterilizing biological fluids can yield under some conditions the infectious micro-organism which was present before the filtration and absent immediately after it. For instance, one filtrates a culture of human lymphocytes infected by *M. Pirum*, which has infected human lymphocytes to make it sterile. The filters used have 100 nm and 20 nm porosities. *M. Pirum* has size of 300 nm so that apparently sterile fluids results. However if this fluid is incubated with a mycoplasma negative culture of human lymphocytes, mycoplasma re-appears within 2 or 3 weeks! This sounds mysterious. Same happens as 20 nm filtration is applied to a minor infective fraction of HIV, whose viral particles have size in the range 100-120 nm.
2. These findings motivated a study of the filtrates and it was discovered that they have a capacity to produce low frequency electromagnetic waves with frequencies in good approximation coming

as the first three harmonics of kHz frequency, which by the way plays also a central role in neural synchrony. What sounds mysterious is that the effect appeared after appropriate dilutions with water: positive dilution fraction varied between 10^{-7} and 10^{-12} . The uninfected eukaryotic cells used as controls did not show the emission. These signals appeared for both M. Pirum and E. Choli but for M. Pirum a filtration using 20 nm filter canceled the effect. Hence it seems that the nano-structures in question have size between 20 and 100 nm in this case.

A resonance phenomenon depending on excitation by the electromagnetic waves is suggested as an underlying mechanism. Stochastic resonance familiar to physicists suggests itself and also I have discussed it while developing ideas about quantum brain [K59]. 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 species, all pathogenic. The transfer occurred only between identical bacterial species which suggests that the signals and possibly also frequencies are characteristic for the species and possibly code for DNA sequences characterizing the species.
4. A further surprising finding was that the signal appeared in dilution which was always the same irrespective of what was the original dilution.

Experimentation at gene level

The next step in experimentation was performed at gene level.

1. The killing of bacteria did not cancel the emission in appropriate dilutions unless the genetic material was destroyed. It turned out that the genetic material extracted from the bacteria filtered and diluted with water produced also an emission for sufficiently high dilutions.
2. The filtration step was essential for the emission also now. The filtration for 100 nm did not retain DNA which was indeed present in the filtrate. That effect occurred suggests that filtration destroyed a gel like structure inhibiting the effect. When 20 nm filtration was used the effect disappeared which suggests that the size of the structure was in the range 20-100 nm.
3. After the treatment by DNase enzyme inducing splitting of DNA to pieces the emission was absent. The treatment of DNA solution by restriction enzyme acting on many sites of DNA did not suppress the emission suggesting that the emission is linked with rather short sequences or with rare sequences.
4. The fact that pathogenic bacteria produce the emission but not "good" bacteria suggests that effect is caused by some specific gene. It was found that single gene - adhesin responsible for the adhesion of mycoplasma to human cells- was responsible for the effect. When the cloned gene was attached to two plasmids and the E. Choli DNA was transformed with the either plasmid, the emission was produced.

Some consequences

The findings could have rather interesting consequences.

1. The refinement of the analysis could make possible diagnostics of various diseases and suggests bacterial origin of diseases like Alzheimer disease, Parkinson disease, Multiple Sclerosis and

Rheumatoid Arthritis since the emission signal could serve as a signature of the gene causing the disease. The signal can be detected also from RNA viruses such as HIV, influenza virus A, and Hepatitis C virus.

2. Emission could also play key role in the mechanism of adhesion to human cells making possible the infection perhaps acting as a kind of password.

The results are rather impressive. Some strongly conditioned skeptic might have already stopped reading after encountering the word "dilution" and associating it with a word which no skeptic scientist in his right mind should not say aloud: "homeopathy"! By reading carefully what I wrote above, it is easy to discover that the experimenters unashamedly manufactured a homeopathic remedy out of the filtrate! And the motivating finding was that although filtrate should not have contained the bacteria, they (according to authors), or at least the effects caused by them, appeared within weeks to it! This is of course impossible in the word of skeptic.

The next reaction of the skeptic is of course that this is fraud or the experimenters are miserable crackpots. Amusingly, one of the miserable crackpots is Nobelist Luc Montagnier, whose research group discovered AIDS virus.

How TGD could explain the findings?

Let us leave the raging skeptics for a moment and sketch possible explanations in TGD framework.

1. Skeptic would argue that the filtration allowed a small portion of infected cells to leak through the filter. Many-sheeted space-time suggests a science fictive variant of this explanation. During filtration part of the infected cells is "dropped" to large space-time sheets and diffused back to the original space-time sheets during the next week. This would explain why the micro-organisms were regenerated within few weeks. Same mechanism could work for ordinary molecules and explain homeopathy. This can be tested: look whether the molecules return back to the the diluted solution in the case of a homeopathic remedy.
2. If no cells remain in the filtrate, something really miraculous looking events are required to make possible the regeneration of the effects serving as the presence of cells. This even in the case that DNA fragments remain in the filtrate.
 - (a) The minimum option is that the presence of these structures contained only the relevant information about the infecting bacteria and this information coded in terms of frequencies was enough to induce the signatures of the infection as a kind of molecular conditioning. Experimentalists can probably immediately answer whether this can be the case.
 - (b) The most radical option is that the infecting bacteria were actually regenerated as experimenters claim! The information about their DNA was in some form present and was transcribed to DNA and/or RNA, which in turn transformed to proteins. Maybe the small fragment of DNA (adhesin) and this information should have been enough to regenerate the DNA of the bacterium and bacterium itself. A test for this hypothesis is whether the mere nanoparticles left from the DNA preparation to the filtrate can induce the regeneration of infecting molecules.

The notion of magnetic body carrying dark matter quantum controlling living matter forms the basic element of TGD inspired model of quantum biology and suggests a more concrete model. The discovery of nanotubes connecting cells with distance up to 300μ [I40] 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 [K19]. 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 [L9] , [L9] 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.

4.6.3 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" [D15] and "Making Fuel from Water" [D13] . The articles summarize an experimental discovery which could be called Pollack-Zheng effect [D18, D10] . 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 [K6, K33] . The basic quanta come as $E(k) = 2^k E_0$, where k is positive or negative integer and $E_0 \simeq .5$ eV holds true. For instance, 2 eV metabolic energy quantum corresponding to red light corresponds to $k = 3$. This is actually oversimplification since there is a cascade of quanta $E(k, n) = (1 - 2^{-n}) E(k)$ converging to $E(k)$ for each p-adic length scale. These energies correspond to energies liberated when electron or proton drops to a larger space-time sheet at the limit when second space-time becomes very large and the particle starts from rest and remains to rest: this is second idealization as also the particle in a box geometry. The idea is that these universal metabolic energy quanta preceded the metabolism based on chemical storage of energy and that the primary step in photosynthesis is kicking of proton or electron to a smaller space-time sheet.
2. Second idea relies on the hierarchy of Planck constants.
 - (a) The rate of dissipation - that this the energy wasted per unit time - is inversely proportional to \hbar in the first naive guess and means that macroscopically quantum coherent dark matter dissipates very little. Could photon kick charged dark particles to smaller space-time sheet where they dissipate very little? Or could photosynthesis capture ordinary or dark photons of sunlight to some layer of the onion like structure formed by the magnetic body of the

organism, where it kicks particles to smaller space-time sheets. This light could correspond to bio-photons liberated as the biological body of the organism dies.

- (b) Could this storage of photons have preceded chemical storage of energy in living matter? And could this energy reserve explain some rather mysterious findings about the ability of some people to survive without ordinary metabolic energy feed (usually saints and this kind of people telling that light is enough for them to survive;-). Also animals are capable to these metabolic miracles [I65] : 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 [D15]

Exclusion zones

The article summarizes the sequence of events initiated by the discovery of Gerald Pollack and his student Jian-ming Zheng [D18, D10] . As a matter fact, the fascinating findings described in detail by Gerald Pollack in his book were absolutely crucial for the recent TGD based view about quantum biology in which dark matter plays key role.

1. Pollack and his student discovered that suspensions of colloids and dissolved substances are excluded from a region extending some hundreds of micrometres from the surfaces of hydrophilic gels. An exclusion zone (EZ) of this magnitude conflicts the belief that interfacial water forming at liquid-solid, or liquid-air interfaces can be no more than a few layers of molecules thick. What's observed is a million layers or more! 'Exclusion' means that the water suspension of micro-spheres moved away from the surface of gel with constant velocity and behaving like single structural unit.

Comment: The sizes of cells vary up to hundreds of micrometers and cells are by definition structures which are isolated from the environment. Maybe EZs represent protocells or their predecessors. Pollack and coauthors have indeed proposed that their finding might relate to the origin of life [D10] . That the surface was that of gel might be important. In TGD based model of living matter gels have magnetic bodies and their presence might relate to the formation of the thick water layer in non-standard phase.

2. Similar exclusion zones were found next to any hydrophilic surface including surfaces coated with a monolayer of hydrophilic molecules, and around ion exchange resin beads. Electric charge appears to be important, as EZ failed to form around charge-exhausted resin beads. Although EZ can form in pure water, it is enhanced and stabilized by low concentrations of buffer (2 to 10 mM at pH 7).

Comment: Hydrophily could correspond to the formation of magnetic flux tubes connecting the hydrophilic surface to water molecules as assumed in the model of protein folding and biocatalysis [K3] .

3. The EZ phase is very different from the bulk water. An unusually ordered crystalline phase where the molecules are less free to move is suggestive. The UV and visible absorption spectrum gave a single absorption peak at $\lambda \simeq 270$ nm in the UV region completely absent in the bulk phase. The infrared emission record showed that the EZ radiates very little compared with bulk water, as would be expected on account of the reduced mobility of water molecules. The magnetic resonance imaging mapping similarly gave a transverse relaxation time (T2) of $25.4 + 1$ ms, which is shorter than the $27.1 + 0.4$ ms recorded for the bulk water phase, again indicative of restricted motion.

Comment: The reduced radiation might mean that part of photons are dark and bound inside magnetic flux tubes defining a structure responsible for the formation of gel like phases inside cell and perhaps also inside EZ. The interpretation as bio-photons is suggestive. This phase of water could be predecessor of the water in cell interior since in the crystalline phase long bio polymers like DNA and aminoacid sequences would be stable against hydration.

4. EZ had a different electrical potential from the bulk phase, by as much as 100–200 mV, depending on the hydrophilic surface. With a negatively charged surface such as polyacrylic acid or Nafion (widely used as a proton exchange membrane), the potential is negative compared with the bulk water away from the EZ. Simultaneously, the hydrogen ion (proton, H^+) concentration is high just outside the EZ, decreasing in a gradient away from it. This indicates that the formation of the EZ is accompanied by a separation of positive and negative electrical charges, which led to the build up of electrical potential between the EZ and the bulk water. In effect, the water has become an electrical battery, and can provide electricity through an external circuit.

Comment: Cell membrane is also a battery and the potential is around 50–80 mV to be compared with 100–200 mV, and the size scale of cell varies from 5 micrometer to hundreds of micrometers so that EZs could be involved with the formation of cell and cell membranes. The kicking of electrons or protons to smaller space-time sheet could be the mechanism inducing electric potential at a given space-time sheet. The formation of battery would mean that water could some day used to store very effectively the energy of solar radiation.

A connection with photosynthesis

Separating H^+ from e^- (electron) is the first step of photosynthesis in green plants which provides energy for most of the biosphere. In this case the energy comes from solar radiation. The separation of charges requires energy also in the case of EZ and the question is where this energy comes from in the case of EZ.

1. A clue came after having inadvertently left the experimental chamber with the EZ on the microscope overnight. Next morning, the EZ had shrunk considerably. But after turning on the microscope lamp, it began to immediately grow again, restoring itself within minutes to its former size. The energy for EZ formation comes from light, as in photosynthesis, but it can use the low energy part of the solar spectrum that photosynthesis cannot.

Comment: Could one consider the possibility that photosynthesis involves unknown step and this step is just the kicking of electrons or protons to a smaller space-time sheet. This step would also induce the separation of charges and the generation of electric potential.

2. Although the entire spectrum of visible light appeared effective in making the EZ grow, the most effective part is in the infrared region, peaking at $\lambda \simeq 3100$ nm. A 10 minute exposure at that wavelength expanded the width of an EZ 3.7 times, and after an hour of exposure, the expansion was more than 6 times. After the light was turned off, the EZ remained constant for about 30 minutes before beginning to shrink, reaching halfway to its baseline level in about 15 minutes.

Comment: $\lambda = 3100$ nm corresponds to .4 eV. The nominal value of the fundamental metabolic energy quantum is around $E_0 = .5$ eV and one has $E(k=0, n=3) = 0.4375$ eV for this value of E_0 . Perhaps the photons indeed kick electrons or protons to a smaller space-time sheet.

- (a) In the case of protons the smaller space-time sheet would correspond to atomic space-time sheets characterized by $p \simeq 2^{137}$: the larger one would correspond to $k = 141$.
- (b) For electrons the size of the smaller space-time sheet would be by a factor $m_p/m_e = 940/.5 = 1880 \simeq 2^{11}$ larger and would correspond to $k = 137 + 11 = 148$. This 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.

- When the UV and visible range was tested, a peak in the degree of EZ expansion was detected at $\lambda = 270$ nm in the UV region, corresponding to the characteristic absorption peak of EZ that was identified before. However, as the optical power used in the UV and visible region was 600 times that in the IR, the most profound effect was identified in the IR region, particularly at 3 100 nm.

Comment: $\lambda = 270$ nm corresponds to the energy 4.5926 eV. $E=4$ eV is the nearest metabolic energy quantum. This energy does not correspond directly to any metabolic energy quantum assignable to .4 eV or .43 eV. One must be however cautious with conclusions since the model is very rough.

- The mechanism of EZ formation is still unknown. But the two wavelengths that expand the EZ most effectively may offer some hint. The UV wavelength 270 nm is close to the 250 nm ($\simeq 5$ eV) required to ionize water under standard state conditions and taking into account the hydration of the resulting ions. The 3 100 nm peak, on the other hand is close to the OH stretch of the ring hexamer identified as the most abundant species in infrared predissociation spectroscopy of large water clusters, and also in neon matrices by infrared spectroscopy. These results suggest that photoexcitation of ring hexamers and photoionisation followed by ejection of protons play synergistic roles in the assembly of the EZ phase. Pollack and colleagues believe that the infrared radiation, though normally insufficient to break OH bonds, can nevertheless work via resonance induced dissociation of large hydrogen-bonded networks.

Comment: Ring hexamers bring in mind the crucial role of aromatic cycles in TGD inspired model of DNA as topological quantum computer which leads also to a model of $ADP \leftrightarrow ATP$ transition involving reconnection of magnetic flux tubes and having also information theoretic interpretation as a change of the topology of the braid structure defining topological quantum computer program [K19] . Magnetic flux tubes carrying dark electrons begin from these and can end up to other bio-molecules or water. Just a guess: could they end on ring hexamers?

Summary

The findings suggest additional details to the TGD based view about living matter.

- The kicking of electrons or protons or both of them to a larger space-time sheet would be the first step in photosynthesis as I indeed suggested for years ago. The energy of 3100 nm photons indeed corresponds to that for the fundamental metabolic energy quantum. I have also proposed this process to be a fundamental step also in bio-catalysis: the temporary dropping of electron or proton of the catalyst molecule could provide the energy helping the reacting molecules to overcome the potential wall preventing the reaction from running. This metabolic coin could be returned to catalyst with high enough probability or the photons exchanged could be virtual.
- The findings suggest also a mechanism for how solar radiation generates proto cells or their predecessors. The resulting phases of water have size extending to those for largest cells and the water could involve a gel like phase in which magnetic flux tubes containing dark matter could play a key role and eventually lead to quantum computer like behavior [K19] . The kicking of electrons (or protons) to smaller space-time sheet would induce ionization at given space-time sheet so that electric potential difference would result. The magnitude of the potential difference is of a correct order of magnitude. Cell membrane scale is present as a p-adic length scale for the space-time sheet of electrons before the kicking to the smaller space-time sheet and these space-time sheets could act as templates for the formation of cell membrane.
- Interestingly, TGD based model of high T_c super conductivity predicts that both cell membrane length scale and size scale of cell are involved with the super-conductivity [K10] . Cell membrane acts as a Josephson junction in TGD based model of cell membrane, nerve pulse, and EEG.

4.6.4 A model for chiral selection

Chiral selection of bio-molecules is one of the basic mysteries of biology and it is interesting to see whether the existing bits of data combined with vision about quantum TGD could help to build a coherent picture about the situation. Let us first try to identify the most important pieces of the puzzle.

1. Chiral selection requires parity breaking in the scale of biomolecules. Standard model predicts parity breaking interactions but the effects are extremely small above intermediate boson length scale which is by a factor 10^{-7} shorter than atomic length scale. The proposed solution of the problem is that dark variants of intermediate gauge bosons are in question so that the Compton lengths of intermediate gauge bosons are scaled up by a factor $r = \hbar/\hbar_0$. Below the dark Compton length weak gauge bosons would be effectively massless and above it possess ordinary masses. Large parity breaking effects induced by dark intermediate gauge bosons would be possible.
2. For instance, for $r = 2^{44}$ for which EEG photons have energies just above thermal threshold at room temperature, the effective p-adic length scale would correspond to $L(k)$, $k = 89 + 44 = 133$ of about .2 Angstrom. This scale in turn would scale up to $L(133 + 44 = 177)$. Secondary p-adic length scale assignable to $k = 89$ which is important in zero energy ontology would correspond to $k = 2 \times 89 = 178$ which corresponds to about $L(178) \simeq 100 \mu\text{m}$, the length scale assignable to large cells and the thickness of water layers in the experiment of Pollack.
3. Parity breaking interaction is associated with spin and the interaction energy of form $ks \cdot E_Z$, where s is the spin of particle and E_Z is Z^0 electric field. Classical induced gauge fields are very strongly correlated in TGD since they are expressible in terms of four CP_2 coordinates and their gradients. Hence classical electromagnetic field E is in the generic case accompanied by classical Z^0 field $E_Z = aE$. This means that if there is classical electromagnetic field and charge density at the dark space-time sheet, large parity breaking effect is possible at the level of spin. The induced Z^0 electric field could force the spins to become parallel and in this manner induce also magnetization.

The crucial finding about which I learned three years ago is that L glutamate is more stable than R glutamate in water and that heavy water does not induce this effect [I55]. This suggests a connection with Pollack-Zheng effect [D18]. Heavy water nuclei have vanishing spin whereas hydrogen nuclei have spin 1/2 so that H_2 in water molecules can be in spin singlet or triplet states (para and ortho configurations). Could the nuclear spin of water molecules somehow induce parity breaking and the magnetic interaction distinguishing between these molecules?

1. Suppose that bio-molecules in question have magnetic moment and water carries magnetic field, most naturally at dark magnetic flux tubes. The parity breaking interaction energy $-p \cdot E$ with dark electric field remains invariant under reflection and rotation of π changing the orientation of the mirror image of the molecule with respect to electric field. The interaction energy with magnetic field however changes its sign since magnetic moment is not affected by the reflection but changes direction under rotation. The angular momentum of the molecule responsible for the magnetic moment can of course change sign but since the transformation involves acts on angular momenta only, it is not a symmetry of entire system. Indeed, if there is interaction between angular momentum degrees of freedom and geometric degrees of freedom the magnetic interaction energy for the mirror image is different. Suppose that the breaking of reflection symmetry induced by the chirality of the molecule induces internal electric field E_{int} . The parity breaking interaction energy $ks \cdot E_{int}$ would indeed break the symmetry in the transformation changing the directions of angular momenta and spins.
2. It deserves to be emphasize that the parity breaking of the molecule itself would induce the symmetry breaking if molecule possesses dark magnetic body. One can actually imagine a cascade of parity breakings proceeding from shorter to longer length scales in this manner.
3. The mechanism creating electric field could be the charging of water, perhaps by the Pollack-Zheng mechanism and having in TGD framework an interpretation as a basic mechanism storing the energy of sunlight to metabolic energy (kicking of electrons and/or protons to a smaller space-time sheet so that oppositely charge space-time sheets emerge as a consequence). A direct connection with metabolism would be admittedly a highly satisfactory feature of the mechanism.
4. Parity breaking energy $ks \cdot E$ for say dark protons assignable to hydrogen nuclei of bio-molecules in the internal electric field of the molecule or dark protons of water molecules in the electric field induced by Pollack-Zheng effect [D18] 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 .

4.6.5 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 [D15, D13, D11, D14] 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" [D15] told about the formation of exclusion zones around hydrophilic surfaces, typically gels in the experiments considered [D18]. The zones were in potential of about 100 meV with respect to surroundings (same order of magnitude as membrane potential) and had thickness ranging to hundreds of micrometers (the size of a large cell): the standard physics would suggest only few molecular layers instead of millions. Sunlight induced the effect. This finding 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?" [D11] 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 [D1]. The mystery is of course how so low frequency can induce burning. The article "The body does burn water" [D14] 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 [D12]. 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 [D13]. 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 [K33].

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 [D7, D6, D8, D17]. 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 [D1] : 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?" [D11] provides new information about burning salt water [D1] , 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) [I34] , and that even a realization of genetic code in terms of the time variation of polarization direction could be involved. TGD based model [K8, K77] 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 [D5] . 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 [D4] - 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.

4.7 Connections to the work of other researchers in the forefront

Many connections with the workers in the field have emerged. In the following I list some articles in chronological order. Some of the people included have not worked with remote mental interactions but in TGD world order their work relates rather closely to this field so that I have included them.

4.7.1 Mae Wan-Ho

Mae Wan-Ho is one of the pioneers of the new biology. She emphasizes the fact that genetic code is not enough to understand inheritance (see article *Mystery of Missing Heritability Solved* [I43]), that genes alone do not determine body patterns (see article *Genes don't Generate Body Patterns* [I42]), that there are no genes for intelligence (see article *No Genes for Intelligence in the Human Genome* [I44]). In TGD framework the notion of magnetic body could provide the umbrella concept suggesting braiding as a universal mechanism to encode interactions with environment to braiding.

Ho realizes the importance of water-protein interaction (see article *Proteins secrete water music in nanospace*) [I45]. Ho dares also to speak about homeopathy and water memory (see *Quantum Coherent Water Homeopathy* [I45]). The TGD counterpart is the vision about cellular and molecular "seasons". External energy feed melts the "ice" formed by ordered water around globular proteins. This leads to new conformations and protein aggregation. This process also updates topological quantum programs by inducing time-like braiding changing space-like braidings of the perturbed part of the system with its complement.

Ho also emphasizes the importance of liquid crystal phases in biology. Liquid crystals are associated with cell membranes, cytoskeletal and muscle proteins, collagen and other connective tissue macromolecules, and also DNA in chromosomes [?] Ho assigns morphogenic fields with them (see *Liquid Crystalline Morphogenetic Field* [I46]). Ho has introduced "Quantum Jazz" as a wonderful metaphor for what Bohm would have called active information and I call negentropic entanglement making possible highly correlated states in which particles are effectively free. Ho has proposed that these liquid crystals act as a holographic medium and based the proposal on the effects of polarized light [?] In TGD framework also magnetic flux tubes would be involved. Flux tubes would connect the basic units of liquid crystals to those of other liquid crystals. DNA nucleotides to lipids of nuclear or cell membrane (see chapter *DNA as Topological Quantum Computer* of [?]).

Spacelike braiding is modified by liquid crystal fluid flows defining time-like braidings (dance metaphor). Liquid crystals plus magnetic flux tubes could serve as the holographic medium storing dynamical patterns to spatial patterns and therefore defining also fundamental memory representations. The sensitivity of liquid crystal state and therefore of braiding to various parameters such as em fields, temperature and pressures changes, hydration, pH, concentrations of various ions makes braiding an ideal mechanism for making living matter a hologram substrate.

Also topological quantum computation like processes would become possible. The fractality crucial for holography would correspond to the possibility of having flux tubes within flux tubes within.... In other words, one would have hierarchical braiding. Braids would decompose to braids which are braided in turn. As a matter fact, this braiding is central element of the dynamics of TGD Universe, not only of TGD inspired biology.

I have commented some of the articles of Mae Wan-Ho in the chapter *TGD inspired model for nerve pulse* of [?]see article *Can Water Burn?* [?]).

4.7.2 Peter Gariaev

Peter Gariaev and his group have done a lot of pioneering work in bio-electromagnetism and the notion of wave DNA is due to him. The findings of Gariaev's group include the rotation of polarization plane of laser light by DNA [I33], phantom DNA effect [I58], the transformation of laser light to radio wave photons having biological effects [I34], the coding of DNA sequences to the modulated polarization plane of laser light and the ability of this kind of light to induce gene expression in another organisms provided the modulated polarization pattern corresponds to an "address" characterizing the organism [I33], and the formation of images of what is believed to be DNA sample itself and of the objects of environment by DNA sample in a cell irradiated by ordinary light in UV-IR range [I57]. The chapter Model for the findings about hologram generatg properties of DNA [K1] of book "Genes and Memes" represent an article written in collaboration with Peter Gariaev and published in DNADJ (DNA Decipher Journal) in January 2011. If the interpretation of the experimental data is correspond then dark matter at magnetic flux body assignable to DNA sample has been photographed. What would happen that incoming photons leak to the dark flux tubes in a phase transition changing the value of Planck constant, are reflected from the dark matter and transform back to ordinary photons generating the picture in the film.

Quantum Model for remote replication [K95] is second article written together with Peter Gariaev. There are three experimental guidelines: the phantom DNA [I58] identified as dark nucleon sequences in TGD framework and the evidence for remote activation of DNA transcription [I33] - both discovered by Gariaev's group - are assumed as the first two key elements of the model. The remote replication of DNA suggested by the experimental findings of Montagnier's group serves as a further guideline in the development of the model. Also the results of the latest experiment of Gariaev's group in many respects similar to that of Montagnier's experiment but differing in certain crucial aspects from it are used as input.

Polymerase chain reaction (PCR) is the technique used in the experiments of Montagnier's group [I12] and later in somewhat modified experiment by Gariaev's group involving irradiation of the second test tube by laser light. DNA polymerase catalyzes the formation of DNA from existing DNA sequences serving as a template. Since the catalytic interaction of DNA polymerase takes place with already existing DNA sequence, the only possibility is that first some conjugate DNA sequences are generated by remote replication after which DNA polymerase uses these sequences as templates to amplify them to original DNA sequences. Whether the product consists of original DNA or its conjugate can be tested.

In TGD inspired quantum biology the representations of genes in terms of temporal patterns of em radiation could be in central role. TGD suggest concrete model for water memory in terms of the magnetic body of biomolecule whose cyclotron frequency pattern codes for the biological effects of the molecule. Water memory would mean that water can build magnetic bodies mimicking those of biomolecules or perhaps steal them in the process of dilution which involves the shaking of the solution. The basic problem of the model is how the gene coded as a temporal field pattern could activate corresponding gene. It seems that the solution of this problem requires that also linear spatial pattern matters. A possible realization would be as planar sheets of magnetic flux tubes emerging from sender DNA and attaching to the target DNA and carrying the radiation. Remote replication would take place only if resonance condition for the frequencies depending on nucleotides is satisfied for each flux tube. Note that DNA as topological quantum computer relies on similar flux tube structure.

TGD suggest also another representation of the genetic code in terms of dark nucleons [L9] , [L9] , which could be highly relevant for the realization of water memory in terms of a dark portion of water for which there exist empirical evidence [K18]. This dark portion would also explain the numerous anomalies of water. It became as a total surprise that the states of dark nucleons correspond in natural manner to DNA, RNA, tRNA, and aminoacids. DNA would define only one particular representation of the genetic code, which in the primary form would be realized at elementary particle level and that there could exist many representations of DNA. Also the model for DNA as topological quantum computer [K19] proposes a non-standard representation of the code.

The model inspires the proposal that the magnetic body of a polar molecule codes for it using dark nucleon sequences assignable to the hydrogen bonds between the molecule and surrounding ordered water layer. Quantum antenna mechanism would allow the immune system to modify itself by developing ordinary DNA coding for amino-acids attaching to and thus "catching" the polar molecule. The mechanism could be behind water memory and homeopathic healing. Every polar molecule in living matter would have dark nucleon sequence or several of them (as in the case of amino-acids) serving as its name. This would also associate unique dark nucleon sequence also with the magnetic body of DNA so that "DNA-dark DNA" association would be automatic. Same applies to mRNA and tRNA and amino-acids. The general idea is therefore that symbolic dynamics emerges already at the molecular level: the dark DNA sequence serving as a "name" of the molecule to high extent determines the dynamics just as in human society.

The existence of a multitude of representations of the code would not be too surprising when one realizes that the information processing performed by computers involves endless variety of different representations of various codes. The problem is about attitudes: the dogma that biology is nothing but chemistry is what is being challenged and we love dogmas because they liberate us from the burden of using our own brains.

4.7.3 Luc Montagnier

The article "DNA waves and water" by L. Montagnier, J. Aissa, E. Del Giudice, C. Lavalley, A. Tedeschi, and G. Vitiello [I30] has created quite a furor even before its publication. The article was preceded by article [I50] , whose results led to my own proposal about the existence of new kind of

representation of DNA in water [L18] and the recent article indeed suggests the existence of a new kind nano-scale representation of DNA besides electromagnetic representation of the code, which was also suggested for years ago by the group of Peter Gariaev [I33] and also in TGD framework [K30]. The article DNA waves and water discussed TGD based explanation of the findings.

The claim of Montagnier's team is that the radiation generated by DNA affects water in such a manner that it behaves as if it contained the actual DNA. A brief summary of experiment of Montagnier and collaborators is in order.

1. Two test tubes containing 100 bases long DNA fragments were studied. Both tubes were subjected to 7 Hz electromagnetic radiation. Earth's magnetic field was eliminated to prevent its possible interference (the cyclotron frequencies of Earth's magnetic field are in EEG range and one of the family secrets of biology and neuroscience since eventies is that cyclotron frequencies in magnetic fields have biological effects on vertebrate brain). The frequencies around 7 Hz correspond to cyclotron frequencies of some biologically important ions in the endogenous magnetic field of .2 Tesla explaining the findings. This field is 2/5 of the nominal value of the Earth's magnetic field.
2. What makes the situation so irritating for skeptics who have been laughing for decades for homeopathy and water memory is that the repeated dilution process used for the homeopathic remedies was applied to DNA in the recent case. The dilution containing no detectable amounts DNA (dilution factor was 10^{-12}) was placed in second test tube whereas the first test tube contained 100 bases long DNA in the original concentration.
3. After 16 to 18 hours both tubes were subjected to polymerase chain reaction (PCR), which builds DNA from its basic building bricks using DNA polymerase enzyme. What is so irritating that DNA was generated also in the test tube containing the highly diluted water. Water seems to be able to cheat the polymerase by mimicking the presence of the actual DNA serving in the usual situation as a template for builing copies of DNA. One could also speak about the analog quantum teleportation.

The model explaining remote replication would apply also to the findings of Montagnier. The essential elements would be sheets formed by flux tubes emerging from DNA crucial also in the model of DNA as quantum computer and nucleotide dependent resonance condition satisfied for each flux tube allowing DNA portion to active only similar DNA portion.

4.7.4 Rupert Sheldrake

Rupert Sheldrake is very interesting thinker whose basic idea is that even genetic expression is more like a habit. Even the manner how crystallization takes place could be a habit. In TGD framework the 4-dimensional character of geometric existence and zero energy ontology in which quantum states are pairs of positive energy states assignable to the two light-like boundaries of causal diamonds conforms with Sheldrakes views (See the article Sheldrakes Morphic Fields and TGD View about Quantum Biology).

The basic idea of Sheldrake that Nature would have habits just as we do is probably one of those aspects which generate most irritation in physicalists believing that Nature is governed by deterministic laws with classical determinism replaced with quantum statistical determinism. Sheldrake is one of those very few scientists able to see the reality rather than only the model of reality. Morphic resonance would make possible to establish the habits of Nature and the past would determine to high extent the present but on organic manner and in totally different sense as in the world of physicalist.

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Chapter 5

Quantum Mind and Neuro Science

5.1 Introduction

Quantum biology-rather than only quantum brain- is an essential element of Quantum Mind in TGD Universe. Cells, biomolecules, and even elementary particles are conscious entities and the biological evolution is evolution of consciousness so that it would be very artificial to restrict the discussion to brain, neurons, or microtubules. The basic new physics inspired ideas behind TGD inspired quantum biology have been discussed already in the first article but deserve to be listed.

- Many-sheeted space-time allows the interpretation of the structures of macroscopic world around us in terms of space-time topology. Magnetic/field body acts as intentional agent using biological body as a sensory receptor and motor instrument and controlling biological body and inheriting its hierarchical fractal structure. Fractal hierarchy of EEGs and its variants can be seen as communication and control tools of magnetic body. Also collective levels of consciousness have a natural interpretation in terms of magnetic body. Magnetic body makes also possible entanglement in macroscopic length scales. The braiding of magnetic flux tubes makes possible topological quantum computations and provides a universal mechanism of memory. One can also understand the real function of various information molecules and corresponding receptors by interpreting the receptors as addresses in quantum computer memory and information molecules as ends of flux tubes which attach to these receptors to form a connection in quantum web.
- Zero energy ontology (ZEO) makes possible the proposed p-adic description of intentions and cognitions and their transformations to action. Time mirror mechanism based on sending of negative energy signal to geometric past would apply to both long term memory recall, remote metabolism, and realization of intentional acting as an activity beginning in the geometric past in accordance with the findings of Libet. ZEO gives a precise content to the notion of negative energy signal in terms of zero energy state for which the arrow of geometric time is opposite to the standard one.

The associated notion of causal diamond (*CD*) is essential element and assigns to elementary particles new fundamental time scales which are macroscopic: for electron the time scale is .1 seconds, the fundamental biorhythm. An essentially new element is time-like entanglement which allows to understand among other things the quantum counterparts of Boolean functions in terms of time-like entanglement in fermionic degrees of freedom.

- The assignment of dark matter with a hierarchy of Planck constants gives rise to a hierarchy of macroscopic quantum phases making possible macroscopic and macrotemporal quantum coherence and allowing to understand evolution as a gradual increase of Planck constant. The model for dark nucleons leads to a surprising conclusion: the states of nucleons correspond to DNA, RNA, tRNA, and aminoacids in a natural manner and vertebrate genetic code as correspondence between DNA and aminoacids emerges naturally. This suggests that genetic code is realized at the level of dark hadron physics and living matter in the usual sense provides a secondary representation for it.

The hierarchy of Planck constants emerges from basic TGD under rather general assumptions. The key element is the huge vacuum degeneracy which implies that preferred non-vacuum extremals of Kähler action form a 4-D spin glass phase. The basic implications following from the extreme non-linearity of Kähler action is that normal derivatives of imbedding space coordinates at 3-D light-like orbits of partonic 2-surfaces and at space-like 3-surfaces at ends of *CDs* are many-valued functions of canonical momentum densities: this is one of the reasons that forced to develop physics as an infinite-D Kähler geometry vision instead of trying to develop path integral formalism or canonical quantization. A convenient manner to treat the situation is to introduce local many-sheeted covering of imbedding space such that the sheets are completely degenerate at partonic 2-surfaces. This leads in natural manner to the hierarchy of Planck constants as effective hierarchy hierarchy and integer multiples of Planck constants emerge naturally.

- Living matter as conscious hologram is one of the basic ideas of TGD inspired biology and consciousness theory. The basic objection against TGD is that the interference of classical fields is impossible in the standard sense for the reason that that classical fields are not primary dynamical variables in TGD Universe. The resolution is based on the observation that only the interference of the effects caused by these fields can be observed experimentally and that many-sheeted space-time allows to realized the summation of effects in terms of multiple topological condensations of particles to several parallel space-time sheets. One concrete implication is fractality of qualia. Qualia appear in very wide range of scales: our qualia could in fact be those of magnetic body. The proposed mechanism for the generation of qualia realizes the fractality idea. The hologram idea has also rather abstract mathematical generalizations inspired by TGD. Infinite primes lead to the idea that each space-time point has a complex number theoretic anatomy and that one could see evolution also as evolution of this number theoretic anatomy. Quantum Mathematics replacing elements of number fields with Hilbert spaces characterizing their number theoretic anatomy is very similar idea and leads to holography also since one can replace the points of Hilbert spaces involved with Hilbert spaces repeatedly. In both cases this process is analogous to a repeated second quantization.
- p-Adic physics can be identified as physics of cognition and intentionality. The hierarchy of p-adic length scales predicts a hierarchy of universal metabolic quanta as increments of zero point kinetic energies. Negentropic entanglement possible for number theoretic entanglement entropy makes sense for rational (and even algebraic) entanglement and leads to the identification of life as something residing in the intersection of real and p-adic worlds. NMP respects negentropic entanglement and the attractive idea is that the experience of understanding and positively colored emotions relate to negentropic entanglement. An attractive idea is that the negentropic entanglement can be assigned with magnetic flux tube and that ATP serves as a correlate for negentropic entanglement. This leads to a rather detailed ideas about the role of phosphate bond and provides interpretation for the fact that the number of valence bonds tend to be maximized in living matter. In a loose sense one could even call ATP a consciousness molecule.
- The view about the function of brain differs from the standard view. The simplest option is that brain is builder of symbolic representations building percepts and giving them names rather than the seat of primary qualia relevant to our conscious experience. Sensory organs would carry our primary qualia and brain would build sensory percepts as standardized mental images by using virtual sensory input to the sensory organs. The new view about time is absolutely essential for circumventing the objections against this vision. The prediction is that also neuronal and even cell membranes define sensory maps with primary qualia assignable to the lipids serving as pixels of the sensory screen. These qualia would not however represent our qualia but lower level qualia. At this moment it is not possible to choose between the two options. The role of EEG and its various counterparts at fractally scaled frequency ranges is to make possible communications to the various onionlike layers of the magnetic body and the control by magnetic body. Dark matter at these layers could be seen as the intentional agent and sensory perceiver.

In the following I briefly summarize some applications. I am of course forced to leave details to the books about TGD inspired theory of consciousness at my homepage [K75, K9, K53, K29, K8, K35, K39, K68].

5.2 A general model for qualia

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

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

5.2.1 A possible classification of qualia

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

1. *Emotions as order-disorder qualia*

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

2. *Kinesthetic qualia defined by generalized forces*

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

3. *Generalized chemical qualia*

$\mu - N$ pair corresponds to 'objective existence' defined by quantum histories and N is generalized to a number of particle like excitations in the Fock state resulting in the state preparation. In this

case there must be a flow of particle number in the direction of the subjective time, that is Bose-Einstein condensation type process for, say Cooper pairs. The particle numbers in question can be numbers of ions of Cooper pairs in various magnetic states, numbers of particles with given quantum numbers, numbers of join along boundaries bonds, etc.. and one should understand chemical qualia, color vision, and perhaps also sensations of pain and pleasure as generalized chemical qualia.

4. Boolean qualia

Boolean consciousness can be assigned with fermionic states since the Fock state basis for fermions naturally forms a representation of Boolean algebra. Besides fermion number also various spin like variables automatically associated with the fermionic oscillator operator algebra can code for truth values. Zero energy ontology and negentropic entanglement allow to code rules $A \rightarrow B$ by time-like entanglement in fermionic degrees of freedom with the states in the superposition representing special instances of the rule. 'This is true' experience would correspond to the negentropic Boolean entanglement. One could interpret M -matrices as coding of laws of physics to the structure of zero energy state itself. In positive energy ontology this is not possible.

5.2.2 The mechanisms generating sensory qualia

One can imagine several basic mechanisms generating sensory qualia. The following two mechanisms were proposed before a more precise consideration about what "qualia as increments of quantum numbers in quantum jump" might mean mathematically and physically and what quantum classical correspondence allows to say about this. The third proposal brings in something genuinely new but is consistent with these mechanisms.

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

The following argument leads to an improved view about qualia and involves in an essential manner ZEO and quantum classical correspondence. The above options can be still identified as mechanisms generating a highly polarized state with second plate of capacitor identifiable as self.

Quantum numbers characterize quantum states. Therefore the increments ΔQ of quantum numbers for a subsystem should characterize quantum jumps and it is attractive to assign classify fundamental qualia in terms of quantum number increments. "The increments of quantum numbers for a sub-system representing self" looks innocent but what it really means is surprisingly difficult to make precise. The following attempt relies on ZEO.

1. For the positive energy part of state located at "lower" boundary of CD self - subsystem S - and environment E are un-entangled. At the "upper" boundary there is entanglement between S and E , and it should be able to assign qualia as quantum number increments to this entanglement.
2. Consider increments of color quantum numbers identified in terms of visual colors as an example. In the positive energy state color quantum numbers for an unentangled subsystem S vanish by color confinement. In negative energy state they can be non-vanishing for S but vanish for $S \otimes E$. The experienced qualia for S are determined as quantum averages of color quantum numbers in the entangled state and expressible in terms of the sub-system density matrix. One

can indeed assign to the zero energy state increments ΔQ_{ZEO} of color quantum numbers as difference of color quantum numbers for S at "upper" and "lower" boundaries of C . These increments characterize zero energy state rather than quantum jump.

3. In state function reduction the entanglement at upper boundary is reduced if the entanglement is entropic whereas negentropic entanglement can be stable. Quale is experienced sensorily as long as quantum jumps preserve negentropic entanglement. When entanglement is eventually reduced, the experience can be only a memory about the experienced quale. The increments ΔQ of color quantum numbers in quantum jump can be identified as $\Delta Q = \Delta Q_{ZEO}$. Hence this notion is indeed well-defined.
4. This interpretation allows to assign to the quantum jump also space-time evolution changing the quantum numbers in the same manner as they change in quantum jump. This is what quantum-classical correspondence indeed requires.

One application is the identification of basic colors in terms of color quantum number increments of quantum states [K26]. This identification makes sense if one accepts the fractal hierarchy of QCD like dynamics allowed by p-adic length scale hierarchy and by the hierarchy of Planck constants. The original concrete model was provided by the capacitor model of sensory qualia in which a large number of particles with same quantum numbers flows to a subsystem during quantum jump inducing the analog of dielectric breakdown (note the analogy with nerve pulse). Bose-Einstein condensation provides one possible realization. In this case one can say that the quantum numbers of the particle in question represent the basic quale which is amplified.

The above picture forces to modify this view by replacing a color capacitor with a fixed size with that of a variable size corresponding to the size of system S and $S \otimes E$: the second plate of capacitor either in S or environment. The flow of charges associated with the transition generating quale still makes sense and generates strong color polarization in the scale $S \otimes E$. In the model the increase of the size of the color capacitor means a formation of flux tubes between the sensory receptor and environment such that net color is non-vanishing only for these flux tubes. In state function reduction reducing entanglement the flux tubes are split and S become color neutral but can represent a memory about the quale as negentropic color neutral entanglement in the scale of S : some sub-system of S can now experience the color quale. This suggests a holographic memory in which quale eventually is represented in very small scale in terms of negentropic entanglement.

The argument involves assumption about color confinement. In the case of qualia assignable to electromagnetic charges, spin, etc... similar assumption makes sense. Even in case of momentum and angular momentum this assumption makes sense and means that subsystem in the state of experiencing momentum or angular momentum increment as quale is in a real accelerated motion in the scale of CD . As a matter of fact, the vanishing of quantum numbers of S in absence of entanglement might not be necessary for the interpretation.

5.2.3 Could some sensory qualia correspond to the sensory qualia of the magnetic body?

Concerning the understanding of a detailed model for how sensory qualia are generated, the basic guideline comes from the notion of magnetic body and the idea that sensory data are communicated to the magnetic body as Josephson radiation associated with the cell membrane. This leaves two options: either the primary sensory qualia are generated at the level of sensory receptor and the resulting mental images negentropically entangle with the "feeling of existence" type mental images at the magnetic body or they can be also generated at the level of the magnetic body by Josephson radiation -possibly as cyclotron transitions. The following arguments are to-be-or-not-to-be questions about whether the primary qualia must reside at the level of sensory receptors.

1. Cyclotron transitions for various cyclotron condensates of bosonic ions or Cooper pairs of fermionic ions or elementary particles are assigned with the motor actions of the magnetic body and Josephson frequencies with the communication of the sensory data. Therefore it would not be natural to assign qualia with cyclotron transitions. On the other hand, in zero energy ontology motor action can be regarded formally as a time reversed sensory perception, which suggests that cyclotron transitions correlated with the "feeling of existence" at magnetic body

entangled with the sensory mental images. They could also code for the pitch of sound as will be found but this quale is strictly speaking also a geometric quale in the 4-D framework.

2. If Josephson radiation induces cyclotron transitions, the energy of Josephson radiation must correspond to that of cyclotron transition. This means very strong additional constraint not easy to satisfy except during nerve pulse when frequencies varying from about 10^{14} Hz down to kHz range are emitted the system remains Josephson contact. Cyclotron frequencies are also rather low in general, which requires that the value of \hbar must be large in order to have cyclotron energy above the thermal threshold. This would however conform with the very beautiful dual interpretation of Josephson photons in terms of biophotons and EEG. One expects that only high level qualia can correspond to a very large values of \hbar needed.

For the sake of completeness it should be noticed that one might do without large values of \hbar if the carrier wave with frequency defined by the metabolic energy quantum assignable to the kicking and that the small modulation frequency corresponds to the cyclotron frequency. This would require that Josephson frequency corresponds to the frequency defined by the metabolic quantum. This is not consistent with the fact that very primitive organisms possess sensory systems.

3. If all primary qualia are assigned to the magnetic body, Josephson radiation must include also gluons and light counter parts of weak bosons are involved besides photons. This is quite a strong additional assumption and it will be found that the identification of sensory qualia in terms of quantum numbers of quark pair 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.
4. The proposed mechanism inducing color qualia would require that the experiencing of qualia about the environment of biological body requires that magnetic body and biological body represent plates of a "quantum capacitor". This would require flow of quantum numbers between biological body and magnetic body. In principle the hierarchy of Planck constants allows scaled up variants of dynamics of hadron physics even in astrophysical scales. A purely quantal mechanism for the charging of the sensory capacitor would be the exchange of W bosons in case of em charge or gluons in case of color qualia: I considered this kind of mechanism for years ago but without having qualia capacitor in my mind [K6].

One might argue that if "we" corresponds to our magnetic bodies as sensory perceivers, our qualia most correspond to the level of magnetic body in the fractal hierarchy of sensory capacitors. The lower levels would give rise to a holographic hierarchy of qualia and memories about qualia could prevail at lower levels as negentropic entanglement. This view of course conforms with the general vision provided about living systems as conscious holograms.

5.2.4 Summary about qualia

The general vision about sensory qualia and geometric qualia in TGD Universe would be as follows.

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. Boolean qualia could result in the similar manner with fermion number in given mode and spin like quantum numbers of fermions coding for the Boolean truth values.
2. Geometric qualia could correspond to the increments of zero modes characterizing the induced CP_2 Kähler form of the partonic 2-surface and of the moduli characterizing the causal diamonds serving as geometric correlates of selves. This moduli space involves the position of CD and the relative position of tips as well as position in CP_2 and relative position of two CP_2 points assigned to the future and past boundaries of CD . There are good motivations for proposing

that the relative positions are quantized. This gives as a special case the quantization of the scale of CD in powers of two. Position and orientation sense could represent this kind of qualia. Also kinematical qualia like sensation of acceleration could correspond to geometric qualia in generalized 4-D sense. For instance, the sensation about motion could be coded by Lorentz boosts of sub- CD representing mental image about the object.

3. One can in principle distinguish between qualia assignable to the biological body (sensory receptors in particular) and magnetic body. The basic question is whether sensory qualia can be assigned only with the sensory receptors or with sensory pathways or with both. Geometric qualia might be assignable to the magnetic body and could provide third person perspective as a geometric and kinematical map of the body and its state of motion represented using the moduli space assignable to causal diamonds (CD). This map could be provided also by the body in which case the magnetic body would only share various mental images.

The simplest 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.

5.3 Model for sensory receptor

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

Also in the recent view long range weak forces however play a key role [K6]. They are made possible by the exotic ground state represented as almost vacuum extremal of Kähler action for which classical em and Z^0 fields are proportional to each other whereas for standard ground state classical Z^0 fields are very weak. Neutrinos are present but it seems that they do not define cognitive or Boolean 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.

5.3.1 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 ensuing general model of how cell membrane acts as a sensory receptor allows a concrete model for sensory capacitor.

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

5.3.2 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 electromagnetic field is proportional to the induced Kähler form of CP_2 in a good approximation. The assumption about the value of Weinberg angle can be used as the basic objection against the model. 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 [K56].

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 [I37] proposed that oriented electric dipoles form macroscopic quantum systems with polarization density serving as a macroscopic order parameter. Several theories of consciousness share this hypothesis. Experimentally this hypothesis has not been verified.
2. TGD suggests much more profound role for the unique di-electric properties of the biosystems. The presence of strong electric dipole fields is a necessary prerequisite for cognition and life and could even force the emergence of life. Strong electric fields imply also the presence of the charged wormhole BE condensates: the surface density of the charged wormholes on the boundary is essentially equal to the normal component of the electric field so that wormholes are in some sense 'square root' of the dipole condensate of Fröhlich! Wormholes make also possible pure vacuum polarization type dipole fields: in this case the magnitudes of the em field at the two space-time sheets involved are same whereas the directions of the fields are opposite. The splitting of wormhole contacts creates fermion pairs which might be interpreted as cognitive fermion pairs. Also microtubules carry strong longitudinal electric fields.

This formulation emerged much before the identification of ordinary gauge bosons and their superpartners as wormhole contacts. In the recent view about TGD based on the weak form of electric-magnetic duality wormhole magnetic flux tubes having magnetically charged wormhole throats at their ends could be interpreted as scaled up variants of elementary particles having a large value of Planck constant.

Cell membrane is the basic example about electret and one of the basic mysteries of cell biology is the resting potential of the living cell. Living cell membranes carry huge electric fields: something like 10^7 Volts per meter. For neuron resting potential corresponds to about .07 eV energy gained when unit charge travels through the membrane potential. In TGD framework it is not at all clear whether the presence of strong electromagnetic field necessitates the presence of strong Kähler field. The extremely strong electric field associated with the cell membrane is not easily understood in Maxwell's theory and almost vacuum extremal property could change the situation completely in TGD framework.

1. The configuration could be a small deformation of vacuum extremal so that the system would be highly critical as one indeed expects on basis of the general vision about living matter as a quantum critical system. For vacuum extremals classical em and Z^0 fields would be proportional to each other. The second half of Maxwell's equations is not in general satisfied in TGD Universe and one cannot exclude the presence of vacuum charge densities in which case elementary particles as the sources of the field would not be necessarily. If one assumes that this is the case approximately, the presence of Z^0 charges creating the classical Z^0 fields is implied. Neutrinos are the most candidates for the carrier of Z^0 charge. Also nuclei could feed their weak gauge fluxes to almost non-vacuum extremals but not atomic electrons since this would lead to dramatic deviations from atomic physics. This would mean that weak bosons would be light in this phase and also Weinberg angle could have a non-standard value.
2. There are also space-time surfaces for CP_2 projection belongs to homologically non-trivial geodesic sphere. In this case classical Z^0 field can vanish and the vision has been that it is sensible to speak about two basic configurations.
 - (a) Almost vacuum extremals (homologically trivial geodesic sphere).
 - (b) Small deformations of non-vacuum extremals for which the gauge field has pure gauge Z^0 component (homologically non-trivial geodesic sphere).

The latter space-time surfaces are excellent candidates for configurations identifiable as TGD counterparts of standard electroweak physics. Note however that the charged part of electroweak fields is present for them.

3. To see whether the latter configurations are really possible one must understand how the gauge fields are affected in the color rotation.
 - (a) The action of color rotations in the holonomy algebra of CP_2 is non-trivial and corresponds to the action in $U(2)$ sub-group of $SU(3)$ mapped to $SU(2)_L \times U(1)$. Since the induced color gauge field is proportional to Kähler form, the holonomy is necessary Abelian so that also the representation of color rotations as a sub-group of electro-weak group must correspond to a local $U(1)$ sub-group local with respect to CP_2 point.
 - (b) Kähler form remains certainly invariant under color group and the right handed part of Z^0 field reducing to $U(1)_R$ sub-algebra should experience a mere Abelian gauge transformation. Also the left handed part of weak fields should experience a local $U(1)_L$ gauge rotation acting on the neutral left handed part of Z^0 in the same manner as it acts on the right handed part. This is true if the $U(1)_L$ sub-group does not depend on point of CP_2 and corresponds to Z^0 charge. If only Z^0 part of the induced gauge field is non-vanishing as it can be for vacuum extremals then color rotations cannot change the situation. If Z^0 part vanishes and non-vacuum extremal is in question, then color rotation rotation of W components mixing them but acts as a pure $U(1)$ gauge transformation on the left handed component.
 - (c) It might not be without importance that for any partonic 2-surface induced electro-weak gauge fields have always $U(1)$ holonomy, which could allow to define what neutral part of induced electroweak gauge field means locally. This does not however hold true for the 4-D tangent space distribution. In any case, the cautious conclusion is that there are two phases corresponding to nearly vacuum extremals and small deformations of extremals corresponding to homologically non-trivial geodesic spheres for which the neutral part of the classical electro-weak gauge field reduces to photon field.
4. The unavoidable presence of long range Z^0 fields would explain large parity breaking in living matter, and the fact that neutrino Compton length is of the order of cell size would suggest the possibility that within neutrino Compton electro-weak gauge fields or even longer scales could behave like massless fields. The explanation would be in terms of the different ground state characterized also by a different value of Weinberg angle. For instance, of the p-adic temperature of weak bosons corresponds to $T_p = 1/2$, the mass scale would be multiplied by a factor $\sqrt{M_{89}}$ and Compton lengths of weak bosons would be around 10^{-4} meters corresponding to the size scale of a large neuron. If the value of Planck constant is also large then the Compton length increases to astrophysical scale.
5. From the equations for classical induced gauge fields in terms of Kähler form and classical Z^0 field (see the appendix of any of the books about TGD)

$$\gamma = 3J - \frac{p}{2}Z^0, \quad Q_Z = I_L^3 - pQ_{em}, \quad p = \sin^2(\theta_W) \quad (5.3.1)$$

it follows that for the vacuum extremals the part of the classical electro-weak force proportional to the electromagnetic charge vanishes for $p = 0$ so that only the left-handed couplings to the weak gauge bosons remain. The absence of electroweak symmetry breaking and vanishing or at least smallness of p would make sense below the Compton length of dark weak bosons. If this picture makes sense it has also implications for astrophysics and cosmology since small deformations of vacuum extremals are assumed to define the interesting extremals. Dark matter hierarchy might explain the presence of unavoidable long ranged Z^0 fields as being due to dark matter with arbitrarily large values of Planck constant so that various elementary particle Compton lengths are very long.

6. The simplest option is that the dark matter -say quarks with Compton lengths of order cell size and Planck constant of order $10^7 \hbar_0$ - are responsible for dark weak fields making almost vacuum extremal property possible. The condition that Josephson photons correspond to EEG frequencies implies $\hbar \sim 10^{13} \hbar_0$ and would mean the scaling of intermediate gauge boson Compton length

to that corresponding to the size scale of a larger neuron. The quarks involved with with DNA as topological quantum computer model could be in question and membrane potential might be assignable to the magnetic flux tubes. The ordinary ionic currents through cell membrane -having no coupling to classical Z^0 fields and not acting as its source- would be accompanied by compensating currents of dark fermions taking care that the almost vacuum extremal property is preserved. The outcome would be large parity breaking effects in cell scale from the left handed couplings of dark quarks and leptons to the classical Z^0 field. The flow of Na^+ ions during nerve pulse could take along same dark flux tube as the flow of dark quarks and leptons. This near vacuum extremal property might be fundamental property of living matter at dark space-time sheets at least.

Ionic Josephson frequencies defined by the resting potential for nearly vacuum extremals

If cell membrane corresponds to an almost vacuum extremal, the membrane potential potential is replaced with an effective resting potential containing also the Z^0 contribution proportional to the ordinary resting potential. The surprising outcome is that one could understand the preferred frequencies for photo-receptors [J9] as Josephson frequencies for biologically important ions. Furthermore, most Josephson energies are in visible and UV range and the interpretation in terms of biophotons is suggestive. If the value of Planck constant is large enough Josephson frequencies are in EEG frequency range so that biophotons and EEG photons could be both related to Josephson photons with large \hbar .

1. One must assume that the interior of the cell corresponds to many fermion state -either a state filled with neutrinos up to Fermi energy or Bose-Einstein condensate of neutrino Cooper pairs creating a harmonic oscillator potential. The generalization of nuclear harmonic oscillator model so that it applies to multi-neutrino state looks natural.
2. For exact vacuum extremals elementary fermions couple only via left-handed isospin to the classical Z^0 field whereas the coupling to classical em field vanishes. Both K_+, Na_+ , and Cl_- $A - Z = Z + 1$ so that by p-n pairing inside nucleus they have the weak isospin of neutron (opposite to that of neutrino) whereas Ca_{++} nucleus has a vanishing weak isospin. This might relate to the very special role of Ca_{++} ions in biology. For instance, Ca_{++} defines an action potential lasting a time of order .1 seconds whereas Na_+ defines a pulse lasting for about 1 millisecond [J2]. These time scales might relate to the time scales of CDs associated with quarks and electron.
3. The basic question is whether only nuclei couple to the classical Z^0 field or whether also electrons do so. If not, then nuclei have a large effective vector coupling to em field coming from Z^0 coupling proportional to the nuclear charge increasing the value of effective membrane potential by a factor of order 100. If both electrons and nuclei couple to the classical Z^0 field, one ends up with difficulties with atomic physics. If only quarks couple to the Z^0 field and one has $Z^0 = -2\gamma/p$ for vacuum extremals, and one uses average vectorial coupling $\langle I_L^3 \rangle = \pm 1/4$ with + for proton and - for neutron, the resulting vector coupling is following

$$\begin{aligned} \left(\frac{Z-N}{4} - pZ\right)Z^0 + q_{em}\gamma &= Q_{eff}\gamma, \\ Q_{eff} &= -\frac{Z-N}{2p} + 2Z + q_{em}. \end{aligned} \quad (5.3.2)$$

Here γ denotes em gauge potential. For $K^+, \text{Cl}^-, \text{Na}^+, \text{Ca}^{++}$ one has $Z = (19, 17, 11, 20)$, $Z - N = (-1, -1, -1, 0)$, and $q_{em} = (1, -1, 1, 2)$. Table 1 below gives the values of Josephson energies for some values of resting potential for $p = .23$. Rather remarkably, they are in IR or visible range.

$E(Ion)/eV$	$V = -40 \text{ mV}$	$V = -60 \text{ mV}$	$V = -70 \text{ mV}$
Na^+	1.01	1.51	1.76
Cl^-	1.40	2.11	2.46
K^+	1.64	2.47	2.88
Ca^{++}	1.68	2.52	2.94

Table 1. Values of the Josephson energy of cell membrane for some values of the membrane voltage for $p = .23$. The value $V = -40 \text{ mV}$ corresponds to the resting state for photoreceptors and $V = -70 \text{ mV}$ to the resting state of a typical neuron.

Are photoreceptors nearly vacuum extremals?

In Hodgkin-Huxley model ionic currents are Ohmian currents. If one accepts the idea that the cell membrane acts as a Josephson junction, there are also non-dissipative oscillatory Josephson currents of ions present, which run also during flow equilibrium for the ionic parts of the currents. A more radical possibility is that 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 [J9, J4]. 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 [J9] 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 $V = .055 \text{ V}$, 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 $V = -40 \text{ mV}$ [J11]. 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 $V = -40 \text{ mV}$ and $p = .0295$ required by the model the energies of Cl^- and K^+ Josephson photons correspond to red light. 2 eV for Cl^- corresponds to a basic metabolic quantum. For Na^+ and Ca^{++} the wave length is below the visible range. Na^+ Josephson energy is below visible range. This conforms with the interpretation of Na^+ current as a counterpart for the sensation of darkness.

3. For $V = -55$ mV - the threshold for the nerve pulse generation- and for $p = .0295$ the Josephson energies of Na^+ , Ca^{++} , and K^+ correspond to the peak energies for cones sensitive to red, green, and blue respectively. Also Cl^- is in the blue region. Ca^{++} Josephson energy can be identified as the peak energy for rods. The increase of the hyperpolarization to $V = -59$ mV reproduces the energy of the maximal wave length response exactly. A possible interpretation is that around the criticality for the generation of the action potential ($V \simeq -55$ mV) the qualia would be generated most intensely since the Josephson currents would be strongest and induce Josephson radiation inducing the quale in other neurons of the visual pathway at the verge for the generation of action potential. This supports the earlier idea that visual pathways defines a neural window. Josephson radiation could be interpreted as giving rise to biophotons (energy scale is correct) and to EEG photons (for large enough values of \hbar the frequency scales is that of EEG).
4. In a very bright illumination the hyperpolarization is $V = -65$ mV [J11], 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^{++}
$E_J(.04 \text{ mV}, p = .23)/eV$	1.01	1.40	1.51	1.76
$E_J(.065 \text{ V}, p = .23)/eV$	1.64	2.29	2.69	2.73
$E_J(40 \text{ mV}, p = .0295)/eV$	1.60	2.00	2.23	1.68
$E_J(50 \text{ mV}, p = .0295)/eV$	2.00	2.49	2.79	2.10
$E_J(55 \text{ mV}, p = .0295)/eV$	2.20	2.74	3.07	2.31
$E_J(65 \text{ mV}, p = .0295)/eV$	2.60	3.25	3.64	2.73
$E_J(70 \text{ mV}, p = .0295)/eV$	2.80	3.50	3.92	2.94
$E_J(75 \text{ mV}, p = .0295)/eV$	3.00	3.75	4.20	3.15
$E_J(80 \text{ mV}, p = .0295)/eV$	3.20	4.00	4.48	3.36
$E_J(90 \text{ mV}, p = .0295)/eV$	3.60	4.50	5.04	3.78
$E_J(95 \text{ mV}, p = .0295)/eV$	3.80	4.75	5.32	3.99
Color	R	G	B	W
E_{max}	2.19	2.32	3.06	2.49
energy-interval/eV	1.77-2.48	1.97-2.76	2.48-3.10	

Table 2. 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.

5.3.3 General model for 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 [K19]. 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 [J33], and 160 Hz to cerebellar synchrony [J35]. 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 [K56] remain to be disentangled.
3. The understanding of the Negentropy Maximization Principle [K42] and the role of negentropic entanglement in living matter together with the vision about life as something in the intersection of real and p-adic worlds was a dramatic step forward. In particular, space-like and time-like negentropic entanglement become basic aspects of conscious intelligence and are expected to be especially important for understanding the difference between speech and music.
4. The most important implication concerning the model of sensory receptors however relate to the vacuum degeneracy of Kähler action. It has been clear from the beginning that the nearly vacuum extremals of Kähler action could play key role in living systems. The reason is their criticality making them ideal systems for sensory perception. These extremals carry classical em and Z^0 fields related to each other by a constant factor and this could explain the large parity breaking effects characterizing living matter. The assumption that cell membranes are nearly vacuum extremals and that nuclei can feed their Z^0 charges to this kind of space-time sheets (not true for atomic electrons) in living matter leads to a modification of the model for the cell membrane as Josephson junction [K56]. 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) [I26] 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.

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.

5.3.4 Cell membrane as a map with pixels colored by qualia

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.

Lipids as pixels colored by qualia

The proposed vision about qualia requires a lot of new physics provided by TGD. What leads to a highly unique proposal is the intriguing coincidence of fundamental elementary particle time scales with basic time scales of biology and neuro science and the model of DNA as topological quantum computer [K19].

1. Zero energy ontology brings in the size scale of CD assignable to the field body of the elementary particle. Zero energy states with negentropic time-like entanglement between positive and negative energy parts of the state might provide a key piece of the puzzle. The negentropic entanglement between positive energy parts of the states associated with the sub- CD assignable to the cell membrane and sub- CD at the magnetic body is expected to be an important factor.

2. For the standard value of \hbar the basic prediction would be 1 ms second time scale of d quark, 6.5 ms time scale of u quark, and .1 second time scale of electron as basic characterizes of sensory experience if one accept the most recent estimates $m(u) = 2$ MeV and $m(d) = 5$ MeV for the quark masses [C1]. 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 [J35]). Hence quarks could be the most interesting particles as far as qualia are considered and the first working hypothesis would be that the fundamental quantum number increments correspond to those for quark-anti-quark pair. The identification in terms of quantum numbers of single quark is inconsistent with the model of color qualia.
3. The model of DNA as topological quantum computer led to the proposal that DNA nucleotides are connected to the lipids of the cell membrane by magnetic flux tubes having quark and antiquark at its ends such that the u and d quarks and their antiquarks code for the four nucleotides. The outer lipid layer was also assumed to be connected by flux tubes to the nucleotide in some other cell or in cell itself.
4. The model for DNA as topological quantum computer did not completely specify whether the flux tubes are ordinary flux tubes or wormhole flux tubes with possibly opposite signs of energy assigned with the members of the flux tube pair. Although it is not necessary, one could assume that the quantum numbers of the two parallel flux tubes cancel each other so that wormhole flux tube would be characterized by quantum numbers of quark pairs at its ends. It is not even necessary to assume that the net quantum numbers of the flux tubes vanish. Color confinement however suggests that the color quantum at the opposite ends of the flux tube are of opposite sign.
 - (a) The absence of a flux tube between lipid layers was interpreted as an isolation from external world during the topological quantum computation. The emergence of the flux tube connection means halting of topological quantum computation. The flux tube connection with the external world corresponds to sensory perception at the level of DNA nucleotide in consistency with the idea that DNA plays the role of the brain of cell [K64]. The total color quantum numbers at the ends of the flux tubes were assumed to sum up to zero. This means that the fusion of the flux tubes ending to the interior and exterior cell membrane to single one creates a flux tube state not localized inside cell and that the interior of cell carries net quantum numbers. The attractive interpretation is that this process represents the generation of quale of single nucleotide.
 - (b) The formation of the flux tube connection between lipid layers would involve the transformation of both quark-antiquark pairs to an intermediate state. There would be no kinematic constraints on the process nor to the mass scales of quarks. A possible mechanism for the separation of the two quark-antiquark pairs associated with the lipids from the system is double reconnection of flux tubes which leads to a situation in which the quark-antiquark pairs associated with the lipid layers are connected by short flux loops and separated to a disjoint state and there is a long wormhole flux tube connecting the nucleotides possibly belonging to different cells.
 - (c) The state of two quark pairs need not have vanishing quantum numbers and one possibility is that the quantum numbers of this state code for qualia. If the total numbers of flux tubes are vanishing also the net quantum numbers of the resulting long flux tube connecting two different cells provide equivalent coding. A stronger condition is that this state has vanishing net quantum numbers and in this case the ends of the long flux tube would carry opposite quantum numbers. The end of flux tube at DNA nucleotide would characterize the quale.
5. Two identification of primary qualia are therefore possible.
 - (a) If the flux tubes have vanishing net quantum numbers, the primary sensory quale can be assigned to single receptor cell and the flow of the quantum numbers corresponds to the extension of the system with vanishing net quantum numbers in two-cell system.

- (b) If the net quantum numbers of the flux tube need not vanish, the resulting two cell system carries non-vanishing quantum numbers as the pair of quark-antiquark pairs removes net quantum numbers out of the system.
6. If the net quantum numbers for the flux tubes vanish always, the specialization of the sensory receptor membrane to produce a specific quale would correspond to an assignment of specific quantum numbers at the DNA ends of the wormhole flux tubes attached to the lipid layers of the cell membrane. The simplest possibility that one can imagine is that the outer lipid layer is connected to the conjugate DNA nucleotide inside same cell nucleus. This option would however assign vanishing net quantum number increments to the cell as whole and is therefore unacceptable.
 7. The formation of a temporary flux tube connection with another cell is necessary during the generation of quale and the question is what kind of cell is in question. The connection of the receptor to cells along the sensory pathway are expected to be present along the entire sensory pathway from DNA nucleotide to a nucleotide in the conjugate strand of second neuron to DNA nucleotide of the third neuron.... If Josephson photons are able to regenerate the quale in second neuron this would make it possible to replicate the quale along entire sensory pathway. The problem is that Josephson radiation has polarization orthogonal to axons and must propagate along the axon whereas the flux tube connection must be orthogonal to axon. Hence the temporary flux tube connection is most naturally between receptor cells and would mean horizontal integration of receptor cells to a larger structure. A holistic process in directions parallel and orthogonal to the sensory pathway would be in question. Of course, the flux tube could be also curved and connect the receptor to the next neuron along the sensory pathway.
 8. The specialization of the neuron to sensory receptor would require in the framework of positive energy ontology that -as far as qualia assignable to the electro-weak quantum numbers are considered - all DNA nucleotides are identical by the corresponds of nucleotides with quarks and antiquarks. This cannot be the case. In zero energy ontology and for wormhole flux tubes it is however enough to assume that the net electroweak quantum numbers for the quark antiquark pairs assignable to the DNA wormhole contact are same for all nucleotides. This condition is easy to satisfy. It must be however emphasized that there is no reason to require that all nucleotides involved generate same quale and at the level of neurons sensory maps assigning different qualia to different nucleotides and lipids allowing DNA to sensorily perceive the external world are possible.

The model should be consistent with the assignment of the fundamental bio-rhythms with the *CDs* of electron and quarks.

1. Quark color should be free in long enough scales and cellular length scales are required at least. The QCD in question should therefore have long enough confinement length scales. The first possibility is provided by almost vacuum extremals with a long confinement scale also at the flux tubes. Large \hbar for the cell membrane space-time sheet seems to be unavoidable and suggests that color is free in much longer length scale than cell length scale.
2. Since the length of the flux tubes connecting DNA and cell membrane is roughly 1 micrometer and by a factor of order 10^7 longer than the d quark Compton length, it seems that the value of Planck constant must be of this order for the flux tubes. This however scales up the time scale of d quark *CD* by a factor of 10^{14} to about 10^4 years! The millisecond and 160 ms time scales are much more attractive. This forces to ask what happens to the quark-anti-quark pairs at the ends of the tubes.
3. The only possibility seems to be that the reconnection process involves a phase transition in which the closed flux tube structure containing the two quark pairs assignable to the wormhole contacts at lipid layers is formed and leaks to the page of the Big Book with pages partially labeled by the values of Planck constant. This page would correspond to the standard value of Planck constant so that the corresponding d quark *CDs* would have a duration of millisecond. The reconnection leading to the ordinary situation would take place after millisecond time scale. The standard physics interpretation would be as a quantum fluctuation having this duration.

This sequence of quark sub- CDs could define what might be called memetic codon representation of the nerve pulse sequence.

4. One can also consider the possibility is that near vacuum extremals give rise to a copy of hadron physics for which the quarks associated with the flux tubes are light. The Gaussian Mersennes corresponding to $k = 151, 157, 163, 167$ define excellent p-adic time scales for quarks and light variants of weak gauge bosons. Quark mass 5 MeV would with $k = 120$ would be replaced with $k = 163$ (167) one would have mass 1.77 eV (.44 eV). Small scaling of both masses gives 2 eV and .5 eV which correspond to basic metabolic quanta in TGD framework. For quark mass of 2 MeV with $k = 123$ $k = 163$ (167) one would give masses .8 eV (.05 eV). The latter scale correspond to Josephson energy assignable with the membrane potential in the ordinary phase.

In this case a phase transition transforming almost vacuum extremal to ordinary one takes place. What this would mean that the vacuum extremal property would hold true below much shorter p-adic length scale. In zero energy ontology the scaling up of quark masses is in principle possible. This option looks however too artificial.

Overall view about the representation of qualia as colors of the pixels at cell membrane

This picture leads to the following overall view about qualia. There are two options depending on whether single quark-antiquark pair or two of them labels the qualia. In the following only the simpler option with single quark-antiquark pair is discussed.

1. All possible pairings of spin and electroweak isospin (or em charge) define 16 basic combinations if one assumes color singletness. If arbitrary color is allowed, there is a nine-fold increase of quantum numbers decomposable to color singlet and octet qualia and further into 3×15 qualia with vanishing increments of color quantum numbers and 6×16 qualia with non-vanishing increments of color quantum numbers. The qualia with vanishing increments for electroweak quantum numbers could correspond to visual colors. If electroweak quantum numbers of the quark-anti-quark pair vanish, one has 3×7 *resp.* 6×8 combinations of colorless *resp.* colored qualia.
2. There is a huge number of various combinations of these fundamental qualia if one assumes that each nucleotide defines its own quale and fundamental qualia would be analogous to constant functions and more general qualia to general functions having values in the space with $9 \times 16 - 1$ points. Only a very small fraction of all possible qualia could be realized in living matter unless the neurons in brain provide representations of body parts or of external world in terms of qualia assignable to lipid-nucleotide pairs. The passive DNA strand would be ideal in this respect.
3. The basic classification of qualia is as color qualia, electro-weak quale, and spin quale and products of these qualia. Also combinations of color qualia and and electroweak and spin quale are possible and could define exotic sensory qualia perhaps not yet realized in the evolution. Synesthesia is usually explained in terms of sensory leakage between sensory pathways and this explanation makes sense also in TGD framework if there exists a feedback from the brain to the sensory organ. Synesthesia cannot however correspond to the product qualia: for "quantum synesthesia" cross association works in both directions and this distinguishes it from the ordinary synesthesia.
4. The idea about brain and genome as holograms encourages to ask whether neurons or equivalently DNA could correspond to sensory maps with individual lipids representing qualia combinations assignable to the points of the perceptive field. In this framework quantum synesthesia would correspond to the binding of qualia of single nucleotide (or lipid) of neuron cell membrane as a sensory representation of the external world. DNA is indeed a holographic representation of the body (gene expression of course restricts the representation to a part of organism). Perhaps it is this kind of representation also at the level of sensory experience so that all neurons could be little sensory copies of body parts as holographic quantum homunculi. In particular, in the associative areas of the cortex neurons would be quantum synesthetes experiencing the world in terms of composite qualia.

5. The number of flux tube connections generated by sensory input would code for the intensity of the quale. Josephson radiation would do the same at the level of communications to the magnetic body. Also the temporal pattern of the sequence of quale mental images matters. In the case of hearing this would code for the rhythmic aspects and pitch of the sound.

About detailed identification of the quantum correlates of 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 [K56]. Black-white vision would mean a restriction to the $SU(2)$ subgroup of color group. The model for the cell membrane as a nearly vacuum extremal assigns the peak frequencies corresponding to fundamental colors with biologically important ions. Josephson radiation could induce artificially the same color qualia in other neurons and this might provide a manner to communicate the qualia to the brain where they could be re-experienced at neuronal level. Some organisms are able to perceive also the polarization of light. This requires receptors sensitive to polarization. The spin of quark pair would naturally code for polarization quale.
2. Also tastes and odours define qualia with "colors". Certainly the increments of electroweak numbers are involved but since these qualia do not have any directional flavor, spin is probably not involved. This would give 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 [J48] would conform with this picture.
3. Hearing seems to represent a rather "colorless" quale so that electroweak isospin suggests again itself. If we had a need to hear transversely polarized sound also spin would be involved. Cilia are involved also with hair cells acting as sensory receptors in the auditory system and vestibular system. In the case of hearing the receptor itself does not fire but induces a firing of the higher level neuron. The temporal pattern of qualia mental images could define the pitch of the sound whereas the intensity would correspond to the number of flux tube connections generated.

The modulation of Josephson frequencies -rather than Josephson frequencies as such- would code for the pitch and the total intensity of the Josephson radiation for the intensity of the sound and in fact any quale. Pitch represents non-local information and the qualia subselves should be negentropically entangled in time direction. If not, the experience corresponds to a sequence of sound pulses with no well-defined pitch and responsible for the rhythmic aspects of music. Right brain sings-left brain talks metaphor would suggest that right and left brain have different kind of specializations already at the level of sensory receptors.

4. Somato-sensory system gives rise to tactile qualia like pain, touch, temperature, proprioception (body position). There are several kinds of receptors: nociceptors, mechanoreceptors, thermoreceptors, etc... Many of these qualia have also emotional coloring and it might be that the character of entanglement involved (negentropic/entropic defines the emotional color of the quale. If this is the case, one might consider a pure quale of touch as something analogous to hearing quale. One can argue that directionality is basic aspect of some of these qualia -say sense of touch- so that spin could be involved besides electroweak quantum numbers. The distribution of these qualia for the receptor neuron might distinguish between different tactile qualia.

5.4 Constraints on the fermionic realization of genetic code from the model for color qualia

The original model for DNA as topological quantum computer assigns to DNA nucleotides quarks at ends of flux tubes or quark pairs at the ends of wormhole flux tubes. This is only the realization that

came first to my mind in TGD Universe where dark variants of quarks can define QCD like physics even in cellular length scales. One can actually imagine several realizations of the genetic code and the first realization is far from being the simplest one. It is enough to have four different particles or many-particle quantum states to build at least formally a map from A,T,C, G to four states. It is obvious that the number of possible formal realizations is limited only by the imagination of the theoretician. Additional conditions are required to fix the model.

5.4.1 Fermionic representation

Consider first the fermionic representations in the general case without specifying what fermions are.

1. The original proposal was that DNA nucleotides correspond to flux tubes with quark q and antiquark \bar{q} at the ends of the parallel flux sheets extremely near to each other. Second option relies on wormhole magnetic flux tubes in which case quark pair $q\bar{q}$ is at both ends. Quarks u , d and their antiquarks would code for A,T,C,G. The spin of quarks is not taken into account at all in this coding: why not restrict the consideration to single quark. The total quark charge at given end of flux tube pair vanishes and flux tube ends carry opposite quark charges.

The nice feature of this option is that one could understand the generation of color qualia in the model of sensory receptor in simple manner to be discussed below. Even if one accepts the arguments supporting the view that dark quarks in cell scale are natural outcome of the hierarchy of Planck constants, one could argue that the presence of both quarks and antiquarks does not conform with matter antimatter asymmetry (not that one can however identify the analog of matter antimatter asymmetry at DNA level).

2. Spin states for fermion pairs assigned with two parallel magnetic flux tubes with the magnetic field generated by spin provide much simpler representation for nucleotides. Similar fermion pair would reside at the second end of flux tube pair.
 - (a) It is essential that rotational symmetry is broken and reduces to rotational symmetry around the direction of flux tubes so that spin singlet and spin 0 state of triplet mix to form states for which each fermion is in spin eigenstate. The states must be antisymmetric under exchange of the protons and spin 1/0 states are antisymmetric/symmetric in spatial degrees of freedom (wave functions located to the ends of flux tubes). The states with definite spin for given flux tube are mixtures of $s=1$ states with vanishing spin projection and $s=0$ state.
 - (b) It is not quite clear whether one should treat fermion pairs as identical bosons with 3+1 spin states since in TGD framework one considers disjoint partonic 2-surfaces and the situation is not that of QFT in M^4 . This interpretation would require total symmetry of the states under permutations of bosonic states defined by the 3+1 spin states. Coding by spin requires that each nucleotide corresponds to a state with a well defined spin. In field theory language the state would be obtained by applying bosonic oscillator operators generating states of given spin localized to a given nucleotide position.
 - (c) The classical correlate for the permutations of coordinates of fermions has interpretation as braiding for the flux tubes of the flux tube pair. In the similar manner the permutation of the flux tube pairs associated with nucleotides has interpretation as braiding of the 3-braids formed from flux tube pairs. Braiding therefore gives a representation of spin analogous to the well-known orientation entanglement relation invented by Dirac and providing geometric representation of spin 1/2 property.

5.4.2 Various options for the fermionic representation of A,T,C,G

Fermionic representations allows several options since fermion can be electron, u or d quark, or proton. Wormhole magnetic fields would not be needed in this case.

1. The problem of electron and proton options is that it does not allow realization of color qualia. There is also the well-known problem related to the stability of DNA caused by the phosphate charge of -2 units per nucleotide. Somehow this charge should be screened. In any case, the

charge -2 should correspond to the electron pair at the DNA end of the flux tube for electron option. For proton option the charge would be screened completely. One could of course consider also the large \hbar color excitations of ordinary protons instead of quark at its nucleotide ends. This option would however require the modification of quark wave functions inside proton and this option will not be discussed here.

2. Quark option would give rise to both color and allow also to reduce the electronic charge of -2 units by $4/3$ units to $-2/3$ units in the case of u quark pair. This would help to stabilize DNA. In the case of d quarks the charge would increase to $-10/3$ units and is not favored by stability argument. Flux tube pairs assigned to single nucleotide define diquarks with spin 1 or spin 0.
 - (a) Diquarks behave as identical bosons with $3+1$ spin states and 3×3 color states. The states with well defined symmetry properties in spin degrees of freedom have such properties in spatial degrees of freedom. This means that one obtains a superposition of flux tube pairs with are either braided or unbraided. Triplet/singlet state is symmetric/antisymmetric and total asymmetry could be guaranteed by assuming symmetry/antisymmetry in spatial degrees of freedom and antisymmetry/symmetry in color degrees of freedom. This would give anti-triplet/6-plet in color degrees of freedom. Spatial symmetry would favor antitriplet and diquark would behave like antiquark with respect to color. Let us assume antitriplet state for definiteness.
 - (b) DNA codon corresponds to three-di-quark state. This state must be totally symmetric under the exchange of bosons. One can have total symmetry in both spatial and color degrees of freedom or total antisymmetry/symmetry in spatial and total antisymmetry/symmetry in color degrees of freedom. The first option gives 10-dimensional color multiplet and the second one color singlet. Braiding is maximal and symmetric/antisymmetric in these case. One can consider also mixed symmetries. In this case one has color octet which is antisymmetric with respect to the first nucleotide pair and symmetric with respect to first nucleotide pair and third nucleotide. The braiding of the first two nucleotides must be antisymmetric and the braiding of this pair with third nucleotide. The conclusion would be that color multiplets correspond to well defined braidings and one would therefore have directed connection with topological quantum computation. Color octet is especially interesting concerning the representation of color qualia.

The challenge of all these options (note that the representability of color selects quark option) is to find a good justification for why the assignment of A,T,C,G to quark states or spin states is unique dynamically. Stability argument is expected to help here.

5.4.3 Realization of color qualia for quark option

Consider now how one could understand the generation of qualia for quark option.

1. The generation of qualia involves interaction with external world giving rise to a sensory percept. In the case of visual colors it should correspond to a measurement of quark color and should give rise to eigenstages of color at the ends of flux tubes at DNA nucleotides for a nucleus or cell of photoreceptor. A modification of capacitor model is needed. Color polarization is still essential but now polarization in nucleus or cell scale is transformed in the generation of color quale to a polarization in longer length scale by the reconnection of flux tubes so that their ends attach to "external world". The nucleus/cell becomes color and state function reduction selects well defined quantum numbers. It is natural to assume that the entanglement in other degrees of freedom after color measurement is negentropic.
2. Does the "external world" correspond to another cell or to the inner lipid layers of the cell membrane containing the nucleus. In the first case flux tubes would end to another cell. If the nuclei of receptor cells are integrate to a larger structure by magnetic flux sheets traversing through them one can also consider the possibility that the polarization in the scale of cell nucleus (recall that the nucleus has also double lipid layer) is transformed to a polarization in cell scale so that similar process in cell scale gives rise to qualia.

3. The entire receptor unit must have net color charge before the state function reduction. This requires that there are flux tubes connecting the receptor unit to a unit representing "external world and having vanishing color charge. If second cell is the "external world" these flux tubes must go through the pair of lipid layers of both cell membrane and end up to the nucleus of cell in the environment. If external world correspond to the complement of nucleus inside cell the inner layers of cell membrane represents external world. Cell membrane indeed serves as sensory receptor in cell length scale. One can of course have sensory qualia in various length scales so that both options are probably correct and a kind of fractal hierarchy is very natural giving rise also to our qualia at some higher level. Living matter as conscious hologram metaphor suggests a fractal hierarchy of qualia.

After state function reduction reducing the entanglement the flux tubes split and the receptor becomes un-entangled with external world and has vanishing color charges. At the level of conscious experience this means that there can be only memory about the quale experience. The sensation of quale lasts with respect to subjective time as long as the negentropic entanglement prevails. There is an obvious analogy with Orch OR proposal of Hameroff and Penrose in which also conscious experience ends with state function reduction.

4. Consider now how the color qualia are generated.
 - (a) There must be two flux tube states. In the first state there are two flux tube beginning from cell nucleus A and ending to the inner lipid layer a_1 and flux tube beginning from the outer lipid layer a_2 and ending cell nucleus B. Both flux tubes have vanishing net color so that cells have vanishing net colors. This could be regarded as the resting state of the receptor. The lipids in layers a_1 and a_2 are connected by another short flux tube. Same for b_1 and b_2 .
 - (b) The second flux tube state corresponds to long flux tubes connecting the nuclei of cells A and B. The ends carry opposite color charges. In this case the net color of both A and B is non-vanishing. This state would be an outcome of a reconnection process in which the flux tubes from A to a_1 and B to a_2 re-connect with the short flux tube connecting lipid layers a_1 and a_2 .
 - (c) When these flux tubes carry opposite colors numbers at their ends, the cell possess net color charge and can represent color quale. Or rather, creation of this kind of flux tube connections would give rise to the color charging of the receptor cell with external world carrying opposite color charge.

One can argue that this mechanism is not quite in spirit with color capacitor model for sensory receptor. Polarization is still essential but now polarization in receptor scale is transformed to polarization in longer length scale by the reconnection of flux tubes. The analog of di-electric breakdown however still applies in the sense that its analog induces large polarization. Several mechanisms generating larger polarization are of course possible. One can ask how essential the electromagnetic polarization of cell membrane is for the generation of qualia at cell level. Note also that biomolecules are quite generally polar molecules.

The unexpected prediction of the model is that braiding would correlate directly with qualia. This would mean also a connection between quantum computation and qualia. This condition emerges from Fermi/Bose-Einstein statistics correlating braiding with symmetric properties of color states and spin states. Quite generally, the correlation of braiding with the symmetries of wave functions as functions of points of braid end points would allow to have direct geometric correlate between induced entanglement and braiding as naive intuitive expectations have suggested.

This model is not consistent with the naive expectation that the quale is generated after state function reduction. Rather, the beginning of sensation of quale means beginning of negentropic entanglement and fusion with external world and state function usually associated with the quantum measurement would mean the end of the sensation and separation from the external world! Maybe one can say that state function reduction means that experience is replaced with a memory "I had the sensation of quale"! Krishnamurti would certainly agree!

5.5 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 identifications 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 [K10, K11] providing interpretation for the basic scales of cell in terms of the p-adic length scale hypothesis and Gaussian Mersennes.

5.5.1 Background

The model for nerve pulse is discussed in detail in [K56]. TGD inspired model for high T_c superconductivity involving dark electrons with large \hbar in an essential manner is a prerequisite for the model and is discussed in [K10, K11]. The basic philosophy behind the model discussed in detail in 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 Hodgkin-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 [I61] 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 Hodgkin-Huxley model.

5.5.2 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. According to [J10] 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 [K56].

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 1 kHz soliton sequence. The velocity of 1 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 1 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 since 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 [K6]. 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 [L9]. 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 dark scaled up variants of ordinary W^\pm bosons is a natural manner to achieve this if new nuclear physics is indeed present. A lot of unknown is involved but model builder assuming that dark matter is responsible for the special properties of living matter must tolerate this.

5.5.3 The function of neural transmitters

TGD leads to a general view about the functions of membrane oscillations, nerve pulse and neural transmitters. 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 are coded 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.

5.5.4 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 with size scale of 5 Angstrom ($p \simeq 2^k$ labels space-time sheets whose scale is given by $L(k) = 2^{(151-k)/2}L(151)$, where $L(151) \simeq 10$ nm corresponds to cell membrane thickness) 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 (topological light rays) 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 [K48] becomes precisely defined.

The model of DNA as topological quantum computer [K19] 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. The entire sensory pathway from sensory receptor to brain would define linear representations of nerve pulse patterns and this might explain why the lengths of sensory pathways are maximized. 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.

5.6 Model for EEG

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

Also long range weak and color forces play a key role. Long range weak forces 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 far from vacuum extremals with large Planck constant classical Z^0 fields are very weak and long range color forces strong. In this phase color forces 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 extending over a wide frequency range

beginning from visible photon frequencies 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. The fractal hierarchy of EEGs is described in two chapters of the book "TGD and EEG" [K17, K59].

5.6.1 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 cyclotron radiation also the frequencies $mf_J \pm nf_c$ appear in the spectrum.
2. In standard model $f_J = ZeV/\hbar$ would be 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 corresponds 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 the 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 [L9].
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 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. 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.

5.6.2 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 correspond 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 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.

5.6.3 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 competition 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/m follows 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 sense. 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 $10^7 r - 10^8 r$ can be justified. A possible justification is based on the observation that for $r_1 = 10^8 r$ 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 $r_1 = 10^8 r$ 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.

5.6.4 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 increase of the largest Planck constant in the hierarchy of Planck constants associated with the organism would mean increase of the time scales of planned action and memory and therefore evolutionary leap. 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. Also cells and neurons could be classified according the their evolutionary level characterized by the largest Planck constant involved.

The evolution at our level of hierarchy would most naturally correspond to cultural evolution taking mainly place at the level of magnetic bodies responsible for higher levels of collective consciousness. This would explain why we differ so dramatically from our cousins although genomes are virtually identical. Evolution of quantum computer programs associated with DNA would be one aspect of this evolution.

5.6.5 Does memory code exist?

Stuart Hameroff is one of the pioneers of the quantum conscious and quantum biology. Quite recently Hameroff and collaborators publishes a proposal for memory code based on microtubules. The simplest version would identify code words as 6 bit sequences just as in case of genetic code. The bit would be represented by the presence or absence of phosphate. TGD suggests a different interpretation in terms of flux tubes connecting microtubule surface with lipid layer and now the presence of ATP would mean that flux tube is in active state and gives rise to negentropic entanglement (See the article A Proposal for Memory Code [L23]).

In an article in the March 8 issue of the journal PLoS Computational Biology, physicists Travis Craddock and Jack Tuszyński of the University of Alberta, and anesthesiologist Stuart Hameroff of the University of Arizona propose a mechanism for encoding synaptic memory in microtubules, major components of the structural cytoskeleton within neurons. The self-explanatory title of the article is Cytoskeletal Signaling: Is Memory Encoded in Microtubule Lattices by CaMKII Phosphorylation? [J13].

The basic ideas of the model of the model of memory code are following.

1. The hexagonal cylindrical lattice of microtubule suggests the possibility of lattice consisting of bits and probably very many proposals have been made. One such idea is that bit is represented in terms of the two basic conformations of tubulin molecules called α and β . The recent proposal is that bit corresponds to the phosphorylation state of tubulin. Also a proposal that the bits form 6-bit bytes is considered: 64 different bytes are possible which would suggest a connection with the genetic code.
2. The motivation for the identification of byte is that CaMKII enzyme has in the active state insect like structure: 6 + 6 legs and the legs are either phosphorylated or not. This geometry is

indeed very suggestive of connexion with 6 inputs and 6 outputs representing genetic codons representable as sequences of 6 bits. The geometry and electrostatics of CaMKII is complementary to the microtubular hexagonal lattice so that CaMKII could take care of the phosphorylation of microtubulins: 6 tubulins at most would be phosphorylated at one side. The presence of Ca^{+2} or calmodulin flux flowing to the neuron interior during nerve pulse is responsible for self-phosphorylation of CaMKII: one can say that CaMKII takes itself care that it remains permanently phosphorylated. I am not sure whether this stable phosphorylation means complete phosphorylation.

It is however difficult to imagine how Ca^{+2} and calmodulin flux could contain the information about the bit sequence and how this information could be coded in standard manner to phosphorylation pattern of legs. The only possibility which looks natural is that phosphorylation is a random process and only the fraction of phosphorylated legs depends on Ca^{+2} and calmodulin fluxes. Another possibility would be that the subsequence process of phosphorylation MT by completely phosphorylated CaMKII manages to do it selectively but it is very difficult to imagine how the information about codon could be transferred to the phosphorylation state of MT.

For these reasons my cautious conclusion is that phosphorylation/its absence cannot represent bit. What has been however found is a mechanism of phosphorylation of MTs, and the question is what could be the function of this phosphorylation. Could this phosphorylation be related to memory but in different manner? The 6+6 structure of CaMKII certainly suggests that the analog of genetic code based on 6 bits might be present but realized in some other manner. The presence of ATP would make a bit active and a rather natural expectation is that typically all bits are either inactive or active. This would give a direction connection with negentropic entanglement. The negative energy signal from future would naturally transform ATP to ADP and mean transfer of mental image made possible by negentropic entanglement to geometric now. The original mental image representing memory would be destroyed in accordance with no-cloning theorem.

5.7 Bio-photons

MEs (massless extremals) can be carriers of light like vacuum currents generating coherent light. Bio-photons [I26, I35, I62] were the first proposed identification for this coherent light in living matter [K48]. In absence of material about bio-photons I did not develop these ideas in any quantitative detail. Situation has changed with the development of web and recently I learned from Lian Sidoroff about home page containing online articles of Fritz-Albert Popp and colleagues about bio-photons and related phenomena. I am grateful for Lian also for very useful discussions and keen questions helping me to become and stay conscious about the many poorly understood aspects of the 'great vision'. This homepage is recommended also to the reader and the data used below mostly derive from the articles therein [J37].

5.7.1 What bio-photons are?

The web articles [J37] provide the basic facts about bio-photons and in the following I summarize my novice view about bio-photons.

Bio-photons have frequencies in the range 200-800 nm (at least). The intensity of bio-photons is extremely low: from one photon to few hundred photons/ cm^2s , which is 20 orders of magnitude weaker than common fluorescence of photophosphorence. There is evidence for coherent radiation also at longer wave length scales. A far from thermal equilibrium situation is in question: the intensity of photons is about 10^{10} times higher than that associated with the thermal visible photons at body temperature. The spectral density $f(\nu)$ defined as the counterpart of Boltzmann weight is essentially constant. This means that the effective temperature increases linearly with frequency. The experimental work of Popp and colleagues provides support for the view that bio-photons are indeed coherent light rather than some waste radiation resulting as a by-product of biological processes [J37]. Poisson statistics for the number of photons in coherent state ($p_n = \exp(-\alpha)\alpha^n/n!$) is the basic signature for the coherent light and it is found that photon counts obey this distribution.

Since $\tau \sim 1$ nanoseconds is the characteristic time constant for em emissions and absorptions at visible wave lengths, one can argue that the length scale $L = c\tau \sim 10$ cm defines the length scale below which it is not sensible to speak about localized photon and thus bio-systems must be treated

as macroscopic quantum systems as far as coherent photons are considered. The timescale means also that 10^9 reactions per second can in principle catalyzed by absorption and emission of single photon in single cell: the typical number of reactions is 10^5 per second inside single cell [J37]. If bio-photons Bose-Einstein condense at magnetic mirrors (ME-magnetic flux tube pairs), extremely sharp control of biological reactions could be indeed achieved. Of course, if Bose-Einstein condensed bio-photons are most important for bio-control, one cannot exclude the interpretation of the observed bio-photons as somekind of leakage radiation from living matter (of course, these bio-photons might serve communication purposes).

Even the wave length of the visible photons, which is somewhat below the cell size, implies that molecules see classical em field like boat sees the sea. One could argue that photons as CP_2 type extremals are essentially pointlike. One the other hand, if MEs are classical correlates for photons or if the classical interaction of atoms and molecules with MEs is additional aspect of their interaction with em fields, this is not the case. The situation is not conceptually completely clear in this respect.

Interference effects provide also support for the notion of macroscopic coherent states. Popp proposes that in a healthy organism constructive interference tends to occur inside cells for bio-photons whereas destructive interference takes place outside [I63, I62]. Or stating it differently, cells are able to store visible bio-photons inside them. For healthy cells the bio-photon emission and well as delayed luminescence have been found to increase as a function of cell density up to some critical density and to decrease after that. For cancer cells the intensity increases indefinitely and nonlinearly [I63]. This supports the view that in cancer cell population bio-photons leak out and do not properly participate to the bio-control.

Bio-photon emission is a signature of living matter in the sense that the presence of oxidative process accompanies always the emission. This is true also for the delayed luminescence resulting as a delayed response to electromagnetic or some other perturbation. The dependence of the delayed luminescence on temperature suggests that the activation energy for the process controlling photoluminescence is roughly .53 eV [I19]: this is rather near to the energy .49 eV stored in the ATP molecule. The experiments involving the insertion of inert molecules to DNA indicate that DNA is a source of bio-photons [I31], [J37]. The spectrum of bio-photons and delayed luminescence correlates strongly with various biological processes. For this reason bio-photons have several applications to bio-search, food quality control, cancer research, pharmacology and heal prophylaxis.

5.7.2 Some phenomena related to bio-photons

There are several interesting and theoretically challenging phenomena involving bio-photons.

1. Delayed luminescence [I69, I60] results after an exposure to an external perturbation, which can be light or ultrasound. Delayed luminescence accompanies also biological processes like cell mitosis. The intensity of the coherent light varies from few photons to 10^5 photons/ cm^2s . The characteristic feature of the delayed luminescence is hyperbolic ($I(t) \propto 1/(1 + \lambda t)$) decay instead of the exponential one expected if incoming light just scatters from the system. The intensity involves oscillatory modulations with respect to a variable u which depends logarithmically on time coordinate ($u = \log(1 + \lambda t)$). As a function of cell density delayed luminescence increases up to some critical cell density for a healthy cell population and begins to decrease after that. For cancer cell population there is no such critical cell density.
2. Some animal populations can 'see' each other. For instance, when populations of dinoflagellates become to optical contact they begin to flicker synchronously [I19] (also fireflies in mangrove trees in Thailand flicker in a synchronous manner). In TGD framework this could be interpreted as evidence for magnetic mirror bridges connecting the populations such that the MEs associated with visible light propagate along them from population to another one. The bridges could also contain ELF em waves serves as synchronizers in the time scale in which flickering occurs.
3. Bacteria absorb bio-photons from nutrition media in a way that the absorption is highest for some critical cell density [I63]. Female inbred daphnia in the same developmental stage and about the same size do not display the increasing bio-photon emission with increasing number [I63]. Rather, a typical interference pattern of emission is observed showing maxima and minima of the bio-photon intensity at definite average distances between the animals. This could be seen

as evidence for the hypothesis that the pattern of coherent light from DNA serves as kind of hologram representing 4-D template for the self-organization.

5.7.3 General TGD based model for coherent bio-photons

MEs with light like vacuum currents indeed generate coherent photons so that bio-photons indeed have a place in TGD Universe. ATP energy about .49 eV and near to the rough estimate .53 eV for the activation energy deduced by studying the temperature dependence of the delayed luminescence [I19]. This encourages to think that the MEs are closely related with the process transforming ADP to ATP serving as energy batteries (see [K33] for the TGD based model of ATP). This assumption conforms also with the fact that coherent light is associated with the oxidative process.

Bio-photons and MEs

The empirical data are consistent with the assumption that the MEs are associated with DNA (at least) and are perhaps responsible for the electromagnetic expression of the genetic information below cellular length scales (and corresponding scaled up dark length scales since there is no reason to exclude the dark variants of MEs).

MEs can carry Bose-Einstein condensates of parallel photons and the observed coherent photons represent leakage of the coherent light from cells. Both positive and negative energy MEs are possible and most naturally they are created in a pairwise manner: pairs (which do not form bound states) with a vanishing net energy and momenta are especially interesting since classical conservation laws do not pose any constraints on their creation and annihilation by p-adic-to-real transition. The buy now-pay later energy production by feeding negative energy to the environment might be closely related with the generation of pairs of MEs which vanishing net energy. It must be emphasized that also magnetic mirrors with positive and negative energies might be in question.

Bio-photons as a signature of dark matter hierarchy

Dark matter hierarchy allows perhaps the most plausible interpretation of bio-photons and is also in spirit with the general ideas about quantum holograms. The model of EEG (actually hierarchy of them) based on dark matter hierarchy [K17] assumes that the basic structures assignable to cell have fractal scaled up variants at higher levels of dark matter hierarchy. These higher level structures could generate dark photons with energies in the range corresponding to visible photons.

At the k_d^{th} level of the hierarchy predicted by Mersenne hypothesis the wavelength of photon is scaled up by a factor 2^{k_d} with possible values of k_d fixed by the Mersenne hypothesis [K17] so that communications using "visible dark" light become possible in arbitrarily long length scales. The model for cell membrane as a sensory receptor leads to the identification of these photons in terms of dark Josephson radiation and EEG and biophotons have identification in terms of decay products of dark Josephson photons.

MEs would have lengths of order wave length (which are below cell size for visible light), and there would be a constant distribution of MEs with respect to the direction and length of ME in the scaled up length scale interval corresponding to wavelengths of visible light. The scaled up wavelengths would correspond to the distances between source and receiver of bio-photons and $k_d \equiv 0$ would correspond to intracellular bio-photons assignable to MEs connecting sub-cellular structures having distance distribution which is more or less constant. The higher level contributions would tend to smooth out the wavelength distribution even if this is not strictly the case.

The general vision about quantum control of motor actions and sensory representations is consistent with the interpretation of positive energy MEs as space-time correlates for the emission of photons responsible for communications and negative energy MEs as correlates for phase conjugate photons involved with generalized motor control. In this framework bio-photons could result from the de-coherence of $k_d > 0$ dark photons and also as a leakage of $k_d = 0$ photons from cell interior. The synchronous flickering of dinoflagellates suggests $k_d > 0$ bio-photons are indeed present.

About the anatomy of dark MEs

MEs at the k_d^{th} level of dark matter hierarchy correspond to $r = 2^{k_d}$ -fold covering of M^4 , which are analogs of multi-sheeted Riemann surfaces (note that the meaning of "sheet" in this context is

different from that in the context of many-sheeted space-time). Each sheet of the covering corresponds to scaled up variant of the space-time sheet associated with ordinary photon with r -fold size scale and classical energy E/r . This allows to interpret the formula $E = \hbar(k)f = r\hbar_0 f$ at space-time level.

r -fold MEs could be generated by r -sheeted magnetic flux sheets containing Bose-Einstein condensates of bosonic ions in quantum coherent manner such that each sheet is responsible for one sheet of r -fold ME.

The decay to ordinary photons can occur in two manners.

1. In de-coherence a downwards scaling of the structure by a factor $1/r$ and collapse to a single sheeted structure with energy E representing ordinary photon occurs. Since frequency is replaced with rf and \hbar by \hbar_0 , energy does not change.
2. The multi-sheeted structure could also decay to r single sheeted structures with energy E/r .

Constraint to the intensity of the vacuum current

The decomposition of dark MEs to r ordinary MEs cannot correspond to the generation of coherent photons by vacuum current since the frequencies involved would be much lower than the frequencies $\sim 10^{14}$ Hz associated with the visible light. Thus one can restrict the consideration to $k_d = 0$ case. This process might however also occur as the experimental findings of Gariaev [I34] about laser light induced radio-wave emission to be discussed in the next section indicate.

The source of photons at the second end of ME is responsible for the Bose-Einstein condensate of photons associated with ME. These photons are not observed unless some kind of leakage occurs at the receiving end of ME: suppose that this does not happen. Physical intuition suggests that the light-like vacuum currents associated with MEs generate coherent states of ordinary photons and that these photons leak out and give rise to the observed bio-photons. MEs lose their energy in the process and become eventually vacuum extremals.

These assumptions allow to deduce a constraint to the intensity of the vacuum current associated with ME.

The interaction Lagrangian of the vacuum current with the vector potential of the quantized photon field is given by

$$L_{int} = e \int d^4x j \cdot A \quad (5.7.1)$$

where the indices of the second quantized vector potential and vacuum current have been dropped away for simplicity and the units $\hbar = c = 1$ are used and e denotes the electromagnetic coupling.

This interaction term describes an infinite number of harmonic oscillators coupled to an external oscillatory force. In each Fourier mode initial vacuum state is transformed to a coherent state which is an eigenstate of the corresponding annihilation operator. By standard calculations [B5] one can deduce the expression for the effective classical vector potential defined by the eigenvalues of the annihilation operators is given by

$$\begin{aligned} A(x, t) &= \frac{ie}{(2\pi)^3} \int d^3k \frac{1}{2\omega(k)} \exp[-ik \cdot x - i\omega(k)t] j(k, \omega(k)) \ , \\ \omega(k) &= |k| \ . \end{aligned} \quad (5.7.2)$$

The eigenvalues $\alpha(\epsilon, k)$ for the annihilation operator $a(\epsilon, k)$ associated with polarization ϵ is given by the expression

$$\alpha(\epsilon, k) = \frac{ie}{2(2\pi)^3 \omega(k)} \epsilon \cdot j(k, \omega(k)) \ . \quad (5.7.3)$$

$\alpha(k)$ indeed has the dimension length to $3/2$ as it should be on basis of the commutation relations in the continuous momentum basis. If finite quantization volume with a discrete momentum basis is used, $\alpha(k)$ contains additional $1/\sqrt{V}$ factor guaranteeing that the eigenvalues are dimensionless.

The eigenvalues characterizing the coherent states are proportional to the massless Fourier components of the vacuum current so that the intensities of bio-photons determining the values of the parameters $\alpha(k)$ allow to deduce the on mass shell Fourier components of the light like vacuum current. Of course, the coherent field of photons is superposition of several interfering contributions coming from MEs with light like currents and only the sum of these contributions appears in the detected field.

Sucking force in TGD framework

The mechanism by which sun flowers turn towards Sun as well as the attraction between cells are not very well well-understood processes. Popp and Chang introduce as an explanation an interaction which they call sucking force [I63]. The notion is inspired by the assumed analogy with the vacuum cleaner which is a particular kind of a pump. The pressure gradient along the tube of the vacuum cleaner generates airflow towards the tube. Since pumping is always done when dissipative processes are present, a process involving essentially the dynamics of quantum jumps is in question and the force does not have counterpart at the level of the irreversible classical dynamics.

In case of em fields radiation pressure gradient replaces the ordinary pressure gradient. The counterpart of the tube of vacuum cleaner is naturally a ME along which Bose-Einstein condensed photons propagate and are absorbed at the second end of the tube, most naturally cell in case of visible photons. The pumping implies an attractive force between living systems connected by MEs. This force would be present at all levels of the length scale hierarchy. The force is only between systems having common characteristic frequencies so that they can be connected by MEs. For instance, this force could explain why tRNA carrying aminoacids finds the corresponding mRNA in the translation of DNA to proteins.

The sucked MEs can propagate along larger ME serving as an em bridge to the receiving system and the absorption most naturally corresponds to the annihilation with MEs of opposite energy. Both negative and positive energy MEs can be sucked. The sucking of negative energy MEs makes possible very flexible buy now-pay later type energy consumption: the user (say DNA) generates pairs of positive and negative energy MEs and utilizes the positive energy MEs, whereas the negative energy MEs are received by the payer, most naturally mitochondria where they annihilate with the positive energy MEs produced by ATP process.

5.7.4 The interpretation of biophotons and EEG as decay products of dark Josephson radiation

The foregoing considerations have been classical in the sense that MEs have been taken as a model for biophotons. The model of EEG [K17] leads to the prediction that cell membranes act as Josephson junctions generating Josephson radiation. If the cell membrane is assumed to be almost vacuum extremal which brings in classical Z^0 field proportional to em field and raises the energy scale of Josephson junction from .07 eV for neuron to UV range. The electromagnetic charge of ion must be replaced with effective charge which is non-vanishing also for neutral atoms and molecules.

The energies of dark photons involved are in visible and UV range for most ions in the range of resting potentials just as the energies of bio-photons. The model also predicts correctly the peak frequencies of maximal sensitivity for the four kinds of photoreceptors. The frequencies are inversely proportional to the value of Planck constant characterizing the cell membrane. Quite generally, the value of Planck constant characterizes the evolutionary level of neuron.

Both EEG photons and biophotons can be identified as decay products of dark Josephson photons producing either a bunch of EEG photons or single biophoton. The frequency modulation of Josephson frequencies provides a general coding of sensory percepts and other information in terms of Josephson radiation communicating this data to the magnetic body. This modulation could also explain the observed periodic modulations.

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Chapter 6

TGD inspired view about remote mental interactions and paranormal

6.1 Introduction

The latest TGD inspired articles related to quantum biology, quantum mind, and remote mental interactions were published in JNLRMI around 2003. Several new ideas related to basic TGD, TGD inspired quantum biology and theory of consciousness have emerged during the subsequent 8 years. The article *Evolution of TGD* [L24] provides a short summary about the development of idea. The general vision is that both biology, consciousness, and remote mental interactions and related phenomena labelled as paranormal are predicted to share the same basic mechanisms, and that the proposed vision provides basic concepts and the language allowing to speculate and build simple models. One cannot of course take the proposed models too seriously at the level of details.

My original intention was to write just single article trying to give a summary about the progress of quantum TGD first and after that I will discuss the implications for quantum TGD based view about biology, consciousness and remote mental interactions and related mysteries. It however turned out that book would provide a more concise a more appropriate manner to represent the overall view. One cannot of course take the proposed models too seriously at the level of details.

This is the the first part of an article devoted to remote mental interactions. In the first part of the article I will summarize the new ideas that have emerged since 2003, summarize basic questions and basic ideas, and summarize what parapsychological phenomena are at general level. The is also a more detailed representation at my homepage [K94] as a chapter of a book.

In the second part of the article I will discuss some applications of the basic vision. The notion of conscious hologram is discussed from the point of view of remote mental interactions. The notion of magnetic body is in decisive role as it is also in the understanding of quantum biology in TGD framework.

TGD inspired model for OBEs relying on the notion of magnetic body is summarized. The idea is that OBEs could correspond to sensory experiences assignable to magnetic body rather than real body. Also the connections with the work of other researchers, such as Shnoll, Persinger, and Tiller are discussed briefly. The challenge of testing the vision is also considered.

6.2 Brief summary of the basic vision around 2003 compared with the recent situation

To get perspective it is perhaps good to briefly summarize the basic vision about TGD inspired model for biology and consciousness as it was around 2003 according to the articles published in JNLRMI. The recent view about TGD inspired theory of consciousness is described in the chapter of the book "TGD Inspired Theory of Consciousness" [K40]. The general vision was that both biology, consciousness, and remote mental interactions and related phenomena labelled as paranormal are predicted to share the same basic mechanisms, and that the proposed vision provides basic concepts and the language

allowing to speculate and build simple models. One cannot of course take the proposed models too seriously at the level of details.

Several new ideas and concepts have emerged since 2003.

The most important ones are following.

1. ZEO giving justification for notions like negative energy photons propagating to the geometric past and the notion of causal diamond (CD) providing imbedding space correlate for the notion of self and predicting a hierarchy of fundamental time scales and predicting a connection between biology and elementary particle physics.
2. Hierarchy of Planck constants [K20] giving rise to phases behaving as dark matter and suggesting the identification of living matter as ordinary matter controlled by dark matter in this sense.
3. The identification of ATP as a correlate of negentropic entanglement and information theoretic interpretation of metabolism [K33].

6.2.1 TGD inspired theory of consciousness

The article *TGD inspired theory of consciousness and biosystems as macroscopic quantum system* [L5] describes the basic assumptions and ideas TGD inspired theory of consciousness and of quantum biology. The basic vision is essentially now although some simplification has taken place and the picture has become more detailed.

1. TGD inspired theory of consciousness can be regarded as an extension of quantum measurement theory by raising the observer from a status of something external to the Universe able to only induce state function reductions (in von Neumann's view) to something described by quantum physics. The crucial almost paradox like problem is the conflict between the determinism of Schrödinger equation and non-determinism of state function reduction. Similar closely related problems relate to the relationship between experienced time and the geometric time of physicist. Whatever the theory of consciousness is, it must solve these problems.
2. Quantum jump as a moment consciousness, self as sequence of quantum jumps somehow integrating to a flow of consciousness, self hierarchy, and the identification of subselves as mental images of self, represent the basic identifications. It seems possible to reduce self hierarchy to a hierarchy of quantum jumps: higher levels of self hierarchy would be analogous to bound states of elementary particles and self hierarchy would relate closely to the corresponding hierarchy at the level of physics.
3. Quantum classical correspondence requires space-time correlates for selves. Space-time sheets are natural correlates of selves at space-time level. At imbedding space level so called causal diamonds (CD s) introduced after 2003 in the context of zero energy ontology define this correlates. At the level of "world of classical worlds" (WCW) the correlate is sub- WCW assignable to the CD .

The notion of many-sheeted space-time forces to modify the notion of sub-system. Flux tubes connecting space-time sheets are natural correlates for entanglement. It is possible for space-time sheets without flux tube connections to contain topologically condensed space-time sheets which are connected by flux tubes although space-time sheets. This would correspond to a situation in which two selves are un-entangled but possess subselves which are entangled. The notion of finite length scale resolution is essential for this definition to make sense. This leads to the idea about sharing of mental images by quantum entanglement producing what might be called stereo consciousness.

4. The possibility of quantum jumps and state function reductions occurring in quantum parallel manner is also something new and also relates to the many-sheeted space-time: see the article *Biosystems as macroscopic quantum systems* [L1]. The quantum jumps taking place at the scales of subselves and their subselves could give rise to the experience of a flow of subjective time. One must be however very cautious with this concept: it is not possible to be conscious about not being conscious so that continuous flow of subjective time might be an illusion perhaps created by the model of self as a continuous narrative. At the fundamental level there might not be

continuous narrative. Already dreams represent states of consciousness in which this narrative is only piecewise continuous.

5. The identification of quantum jump as relating entire deterministic *quantum histories* as analogs of solutions of Schrödinger equation solves the problems related to the conflict of non-determinism of state function reduction and determinism of Schrödinger equation and classical field equations which in TGD framework define an exact part of quantum theory. Quantum measurement theory involves also the notion of classical variables. These can be identified as zero modes which by definition do not contribute to the metric of WCW and are therefore not quantum fluctuating variables. The entanglement between zero modes and quantum fluctuating degrees of freedom must be fundamental element of state function reduction and also sensory perception and conscious choice.
6. p-Adic physics as physics of cognition and intentionality [K46] is a central element of this picture and forces a generalization of number concept. Reals and p-adic numbers characterized by prime $p = 2, 3, 5, \dots$ are completions of rationals and one can glue reals and p-adic numbers and their extensions along rationals and common algebraics to form a book like structure. The notion of adèle - well-known to mathematicians - seems to catch quite well this vision [K90].
7. *Negentropy Maximization Principle* (NMP) [K42] defines the basic variational principle of TGD inspired theory of consciousness and states that the gain of conscious information in quantum jump is maximal. There are variants of NMP depending on what one means with quantum theory.
 - (a) For the ordinary definition of entanglement entropy this means that the two systems involved become un-entangled. Interpreting the density matrix as fundamental observable this gives standard quantum measurement theory.
 - (b) The introduction of hyper-finite factors of type II_1 strongly suggested by the fact that WCW spinors correspond to this kind of von Neumann algebras leads to a further modification of measurement theory since state function reduction to a one-dimensional ray of Hilbert space is not possible in general but always happens to an infinite-dimensional sub-space (in the ordinary sense of the word). The state spaces can of course contain factors of type I for which ordinary measurement theory applies.
 - (c) For rational or even algebraic entanglement coefficients the entanglement entropy can be defined using p-adic norm for some p-adic prime p and can be negative and always is for certain primes p . Entanglement would carry genuine information and is expected to be stable under NMP. This leads to the vision about negentropic entanglement as a basic characteristic of living systems.

At space-time level one can also say that the - in general discrete- intersections of real and p-adic partonic 2-surfaces consisting of rational (or more generally, points in some extension of rationals) defined cognitive representations in the intersection of cognition and matter. This discretization would directly correspond to the fact that all cognitive representations have finite resolution and are necessarily discrete: computation represents a basic example of this. At more abstract level the partonic 2-surfaces represented by algebraic equations making sense both in real and p-adic sense can be said to belong to the intersection of matter and cognition and represent living systems. Quite surprisingly, the art of algebraic geometry which typically involves counting the numbers of rational points of algebraic surfaces would directly relate to fundamental biology!

The basic implication of this vision is the necessity to re-consider the existing views about the relationship between subject and geometric time. I summarized the ideas about time as they were around 2003 in the article *Time, space-time, and consciousness* [L6]. There were several poorly understood issues and some of these issues are still far from well understood.

1. What is the precise relationship between geometric time and experienced time? How the experience about continuous flow of time emerges? (Is it an illusion: one cannot be conscious about being not conscious, dark moments of visual perception). What induces the arrow of psychological time inducing the apparent arrow of geometric time? Why the contents of sensory

experience are restricted to so narrow a time interval whereas the contents of memory come from much larger space-time region. Note that the interpretation of the correlate of self as 4-D space-time regions provides a new vision about memory.

2. In the article *TGD inspired theory of consciousness* time-like entanglement and signals proceeding in the reversed direction of time was suggested to provide the basic mechanism of memory, intentional action, and (remote) metabolism. Libet's paradoxical findings about strange time delays of consciousness provide the basic support for this vision. The challenge is to give a more precise mathematical content for the notion of negative energy signal propagating backwards in time. Phase conjugate laser wave was proposed as its physical analog. The basic question is to understand how the arrow of geometric time emerges so that one can use these terms.

In TGD framework the notion of many-sheeted space-time challenges the notion of subsystem. One must also give a more precise mathematical content to the notions of U-process, state function reduction, and state preparation.

1. Quantum jump should consist of unitary process characterized by a unitary matrix U followed by a state function reduction in turn followed by state preparation. State function reduction should be a cascade like process proceeding from top to bottom as a splitting of systems to pairs of unentangled subsystems until negentropic or bound state character of entanglement does not allow splitting anymore [K42]. The identification of the unitary process U and U -matrix remained however open questions at that time. ZEO leads to a rather detailed minimal vision about what happens in quantum jump [K5].
2. What happens in quantum measurement? Non-quantum fluctuating zero modes of "world of classical worlds" (WCW) correspond to classical degrees of freedom in TGD and are excellent candidates for classical variables of quantum measurement - such as direction of the point of some "meter". With these zero modes quantum fluctuating degrees of freedom must entangle before state function reduction and measurement must induce state function reduction eliminating entanglement unless it is negentropic. Does state function reduction follow from macroscopic character of zero modes in the sense that there would be analogy with spontaneous magnetization which also selects single direction of magnetization rather than their quantum superposition.

And what is the role of cognition interpreted in terms of p-adic space-time sheets? Is p-adic-real algebraic entanglement carrying negentropy involved? At what level the state function reduction inducing a sequence of state function reductions in the sequence of entangled systems does take place: does the primary reduction take place at the level of cognition?

Their answers to these questions are still more or less guess work.

6.2.2 TGD inspired quantum biology

Many ideas about basic mechanisms of quantum biology already existed around 2003. Mention only the notion of magnetic body and the hypothesis that living matter resides in the intersection of real and p-adic worlds implying that negentropic entanglement is a fundamental characteristic of living matter.

The assumption that living matter is ordinary matter controlled by dark matter - identified as a hierarchy of macroscopic quantum phases labeled by the value of Planck constant coming as integer multiples of ordinary Planck constant - has allowed to find a more detailed formulation for these intuitive ideas. The alert reader has perhaps noticed that the hierarchy of Planck constants and negentropic entanglement seem to provide two different manners to realize macroscopic quantum coherence. Are these two realizations independent of each other and if not, how do they relate to each other? This remains an open question to high extent.

1. High T_c super-conductivity was assumed to play a key role in living matter but the precise mechanism of super-conductivity was poorly understood. For the views at that time see the articles *Biosystems as macroscopic quantum systems* [L1] and *Quantum model for sensory receptor* [L4]. A detailed model for high T_c bio-super-conductivity was however lacking. The hierarchy of Planck constants allows to construct this kind of model [K10, K11] applying also in the case of

ordinary condensed matter systems. Rather remarkably, dark electrons at magnetic flux tubes play a key role in this model. Also negentropic entanglement could stabilize Cooper pairs.

Another new element not present at the time of writing of these articles is the new physics model of cell membrane as almost vacuum extremal of Kähler action [K26] motivated by quantum criticality and the expectation that large values of Planck constant correspond to almost vacuum extremals if one accepts the TGD based explanation for the hierarchy of Planck constants as a result of dynamics rather than something fundamental. It must be emphasized that the existing high precision determinations of Planck constant do not exclude the hierarchy since they do not detect dark matter. This leads to a picture about cell membrane as an analog of computer monitor with lipids representing pixels to which one can attach various qualia. These qualia need not however correspond ours which are assigned to sensory receptors.

2. In the article *Manysheeted DNA* [L2] several ideas related to DNA were discussed.
 - (a) Homeostasis in mansheeted space-time roughly states that supra currents at super-conducting space-time sheets determine the dynamical equilibria also at the space-time sheets containing ordinary matter. The strange findings about the behavior of cell membrane ionic currents support this hypothesis (they are quantal and flow even in absence of metabolic energy feed suggesting that Josephson currents are in question).
 - (b) Quantum spin glass degeneracy generalizing ordinary 3-D spin glass degeneracy to 4-D one meaning that strict determinism breaks down to piecewise one. Hence not only quantum states but also quantum jump sequences and therefore conscious experiences should have space-time correlates. These correlates would relate to conscious experience like written text to conscious thoughts and would provide a kind of feedback essential for symbolic memory. 4-D spin glass degeneracy provides also a justification for the hierarchy of Planck constants.
 - (c) A further key idea was healing by time reversal. The idea is that the reversal of the arrow of geometric time implies that second law holds in opposite direction of geometric time so that basically entropic process looks like negentropic one. Also the notion of magnetic mirror, topological self-referentiality, the identification of information molecules as quantum links in quantum web, the idea about molecular recognition mechanisms, the connection between metabolism and generation of quantum coherent states, scaling law of homeopathy were further ideas discussed in the article.

The developments since 2003 have enriched this picture with several new ideas.

- (a) ZEO and the notion of CD allow to assign the arrow of geometric time directly to the zero energy states rather than their dynamics. Dark matter as a hierarchy of phases with large value of Planck constant can be identified as controller of ordinary matter in living systems, and negentropic entanglement assumed to have ATP as a correlate allow to a more detailed articulation of these ideas.
 - (b) The idea about DNA as topological quantum computer [K19] with braids realized as magnetic flux tubes connecting DNA nucleotides with lipids of cell membrane is another key idea and means that DNA becomes the hardware of quantum computations with software represented by the braidings of flux tubes.
3. The article Macrotemporal quantum coherence, quantum spin glass degeneracy, and number theoretic information concept [L8] described the vision about living matter as a macroscopic quantum system. The notion of negentropic entanglement and the idea about life as islands of rationality in the oceans of real and p -adic continua was described already in this article.
 4. The article *Biosystems as conscious holograms* [L7] develops the idea about living matter as conscious hologram. One of the key mechanisms was time mirror mechanism finding a justification in ZEO. A model of remote mental interactions and an model inspired by the findings of William Tiller was proposed with key role played by the notion of magnetic body able to receive information from and control even in-animate matter. ZEO provides first principle justification for the time mirror mechanism.

The vision was applied to develop a model of biophotons. The model of cell membrane as almost vacuum extremal, which emerged later, led to a radical proposal: biophotons are nothing but large \hbar EEG photons which have suffered an energy conserving phase transition reducing the value of Planck constant to ordinary one.

5. The article *Quantum model for nerve pulse, EEG, and ZEG* [L3] describes a TGD inspired view about nerve pulse and EEG. I would not speak about *ZEG* in the title now since the status of Z^0 radiation fields is still uncertain (classical Z^0 fields are however in an essential role in the model of cell membrane and sensory receptor).

Electronic super-conductivity and possibly super-conducting states assignable to biologically important ions are key elements of the model but the model of electronic super-conductivity was not convincing: it was assumed that super-conducting space-time sheets are at very low temperature. The model of electronic super-conductivity was not too convincing at that time and considerable progress has taken place with the advent of the hierarchy of Planck constants [K10, K11].

In case of biologically important ions it had already become clear that TGD inspired nuclear physics [L9] allows fermionic nuclei with given charge to have bosonic companions with the same charge and therefore same chemistry. This would make possible to assign Bose-Einstein condensates and super-conductivity even to atoms which are chemically equivalent with fermionic atoms.

EEG and its possible variants were identified as communications and control tools mediating sensory information to the magnetic body and allowing magnetic body to quantum control biological body. This means the presence of a completely new level in biological information processing. Again the hierarchy of Planck constants plays a key role in making possible for ELF photons with extremely small energy to have energies which are above thermal energy and thus have biological effects and carry information [K17, K59].

The aim of this article is to describe in some detail the recent view about remote mental interactions. Also connections with the work of other researchers are summarized.

6.3 Basic questions and basic ideas

The basic ideas of TGD inspired model for remote mental interactions and related phenomena such as OBEs and near death experiences are summarized in the chapters *Quantum model for paranormal phenomena* [K57] and *TGD based model for OBEs* [K74] of the book "TGD Inspired Theory of Consciousness". Also the chapter *Bio-systems as conscious holograms* [K8] contains a summary of a model for how conscious hologram might allow to understand remote mental interactions, and TGD based view about the work of William Tiller related to intentional imprinting. The chapter contains also a section about biophotons: there could be a connection with remote mental interactions since biophotons could result from the transformation of large \hbar dark photons by a phase transition reducing the value of Planck constant, which in turn would be essential for communications between biological body and magnetic body.

I have not worked with this topic during last years, and I apologize for my very restricted views. The most important new ideas relate to the notion of magnetic body, ZEO, negentropic entanglement, and dark matter hierarchy. It would be interesting to deduce explicitly the implications of new ideas that have emerged since 2003 but the following discussion is just a commentary.

6.3.1 Basic questions

The general idea is that remote mental interactions are by no means paranormal in the sense that they would be in conflict with well-established laws of physics, as skeptics want to see them. Our personal magnetic bodies apply remote mental interactions to receive communications from biological body and to control it routine. Remote mental interactions having living matter as a target would correspond to a situation in which the personal magnetic body of operator is able to receive information from the biological body of target or control it. Becoming possessed would be one manner to say this. Hypnosis would represent the basic example of this. The target could be also water perhaps containing some

organic matter as in Tiller's experiments. Also psychokinesis acting on inanimate targets such as computers can be considered but in this case the mechanisms of remote mental interaction cannot be quite same as in the case of biological targets.

The basic question is why the remote mental interactions having living target are so rare if they apply same mechanisms as living matter in general. A possible reason is that living matter has developed an immune system preventing the situation in which the organism becomes possessed. This would be very similar to what has taken place in the evolution of computers. The restriction of communication windows to narrow frequency ranges depending on species and even individual, and the counterparts of passwords realized as temporal field patterns could make this kind of immune system possible. Cyclotron frequencies would be central here and hierarchy of Planck constant would allow arbitrary low frequencies with energies below thermal energies at physiological temperature range. The first guess is that passwords using genetic code so that communications restricted to those occurring between the members of the same species become possible. The challenge is to invent plausible physical realizations for the passwords. One possible proposal inspired by the experiments of Gariaev and collaborators would realize the values of bit as two orthogonal photon polarization directions. Another realization would be in terms of a collection of frequencies interacting resonantly with the target DNA and inducing gene expression: no explicit knowledge of address of the target would be needed.

Second basis problem in many remote mental interactions such as the intentional effect on random number generator is "Who knows how?". How the mere intent can be transformed to action without any knowledge about the details of the action? The attempt to understand how neuro-feedback affect the behavior of single neuron leads to the same question.

1. Magnetic mirrors make possible also feedback and this feedback could make possible learning. For instance, in psychokinesis (especially so in micro PK), this learning would be crucial and analogous to that what occurs when we learn to drive a car. In healing this kind of feedback might help to find the healing frequency by trial and error.
2. It is quite possible that also multibrained and -bodied higher level collective selves actively participate in the process as a third party such that the remote mental interactions would act as a relay states. I have suggested similar explanation for Sheldrake's findings about learning at the level of species and Tiller's findings about the "transfer of intent". This could make possible coherent amplification effects (TEM, prayer groups) and could make available information resources of all brains involved with the group. This could for instance explain the ability of a remote viewer to see an object on basis of data which need not have any meaning for her.
3. A fast amplitude modulation of alpha waves introducing higher harmonics to the carrier wave is a good candidate for mediating communication between brains and higher level multibrained selves. Mesoscopic 'features' in brain involve precisely this kind of amplitude modulation and might represent just this kind of messages. Interestingly, also speech is produced by a fast amplitude modulation of 10 Hz basic vibration frequency of speech organs (assignable to electron CD as a fundamental frequency) and kHz (quarks) frequency is a special frequency from the point of view of hearing.

Third key question relates to the metabolic aspects of remote mental interactions. One expects that negentropic entanglement between operator and target is involved. The hypothesis about the presence of ATP molecule at the magnetic flux tube connecting operator and target as a prerequisite for negentropic entanglement would reduce the energetics of remote mental interactions to basic metabolism. This allows to make quite strong conclusions about the character of these interactions. Here one must however remember that earlier model assumed much more general mechanism of metabolism involving transfer of particles to larger space-time sheets liberating or using zero point kinetic energy in this manner. It could be part of $ATP \leftrightarrow ADP$ mechanism or completely independent mechanism utilized by the prebiotic metabolism. It could be also involved with the remote mental interactions for which targets are in-animate.

Fourth question relates to mechanisms and here time mirror mechanism involving sending of negative energy photons to geometric past is the natural candidate for both intentional action, remote metabolism, and memory. Also its counterpart involving sending of positive energy signals to future

can be considered. It must be emphasized that the reflection need not always occur. The negative energy photon could be just absorbed without any signal generated and this leads to ask what happens in the case of memory.

6.3.2 Key ideas of the TGD inspired model of remote mental interactions

During years a rather concrete TGD inspired model of remote mental interactions has developed.

1. The basic notions of the TGD inspired model are magnetic body as an intentional agent controlling biological body and receiving data from living body or even "dead" matter system with massless extremals (MEs) mediating these communications, zero energy ontology and the related notion of causal diamond (CD) serving as an imbedding space correlate of self and assigning to elementary particles fundamental macroscopic time and length scales as those of CD , the hierarchy of Planck constants making possible macroscopic quantum phases and zoom-ups of quantum systems, and the vision about living matter as something residing in the intersection of real and p -adic worlds and the closely related notion of negentropic entanglement crucial for the functioning of living matter and conscious intelligence in TGD Universe. Note that this means that life corresponds to number theoretical quantum criticality in a well-defined sense.
2. Zero energy ontology means a radical departure from standard physics. The creation of zero energy states from vacuum is possible and means that in principle (just in principle!) the claims of parapsychologists about ectoplasm and of yogis about the possibility to create of matter from nothing are consistent with the basic conservation laws of physics. In TGD inspired biology this process could take place routinely. Causal diamond is the imbedding space correlate for the zero energy state. Positive and negative energy parts of the state reside at its boundaries. p -Adic length scale hypothesis and number theoretical vision suggest that the proper time distance between the tips of CD comes as powers of two. For electron and quarks playing key role in the model of DNA as topological quantum computer this temporal distance would correspond .1 seconds and 1 millisecond respectively suggesting a direct connection between elementary particle physics and basic bio-rhythms.

The translates and Lorentz transforms of CD s are also CD s and one can assign to CD s a moduli space further expanded by the introduction of the hierarchy of Planck constants. One expects that this moduli space is crucial for understanding of the geometric qualia [K58]. The communications between subselves would be naturally based on resonance. CD s are characterized by resonance frequencies which in the rest system of CD come as harmonics of the fundamental frequency determined by the proper time distance. This would allow a universal coding of geometric data using frequencies. Both MEs and CD s could be regarded as being analogous to music instruments and this in fact explains basic facts about music experience. These resonance frequencies should play a key role in biology and also in remote mental interactions- even those in which target consists of "dead" matter since fundamental biorhythms characterize also elementary particles in TGD Universe.

3. p -Adic physics as physics of cognition and intentionality is an essential element of approach. Intentions are represented as p -adic space-time sheets. In the intersection of real and p -adic worlds these space-time sheets have a mathematical representation making sense also in real context so that one can say that these surfaces are in the intersection of real and p -adic worlds and the phase transitions transforming surfaces belonging to different number fields are possible. This makes possible transformation of intentions to actions and their reversals possible in the intersection of real and p -adic worlds. U -matrix indeed makes sense also for transformation representing the transformation of say p -adic space-time surface to a real one and is coded only by data assignable to the rational and common algebraic points of real and p -adic variants of partonic 2-surface [K42]. Note that zero energy ontology makes possible also the transformation of intentions to actions as p -adic-to-real phase transitions without breaking of the conservation laws.
4. Negentropic entanglement, which can be both space-like and time-like in zero energy ontology, makes possible quantum superposition of macroscopically different configurations of the target system correlated with the states of operator system. The operator should be able to achieve

the negentropic entanglement and intentionally increase the amplitude of the desired outcome in this superposition. Negentropic entanglement need not involve binding energy and I have proposed this as a deeper level explanation for the nebulous notion of high energy phosphate bond crucial for metabolism in living matter. Quite generally, negentropic entanglement would make possible for the operator to transfer metabolic energy and momentum to the target. Remote healing involves often positive emotions like compassion and love suggesting that negentropic entanglement accompanies healing process. The hierarchy of values of Planck constant would make possible this process in long time and length scales.

5. Addressing of the target is key problem in remote mental interactions. Here password consisting of a collection of frequencies interacting resonantly with the DNA of living target and inducing remote gene expression dictated by the frequencies is one possibility. Gariaev's findings that scattering of red laser beam from DNA generates broad band of frequencies, which are biologically active, could be interpreted in this model. The photons would correspond to the same energy but wide range of frequencies corresponding to different values of Planck constant. These frequencies would define the address of the target, eventually some part of DNA inducing gene expression. The interaction would be by the superposition of the electric field of incoming radiation with the electric field of flux tube inducing the analog of Becker's healing current in turn loading metabolic resources and generating negentropic entanglement and also gene expression.
6. The notion of hologram is often used as a useful metaphor: Gariaev talks about DNA hologram and I have talked about conscious hologram. This notion obviously requires more detailed definition to be testable. What hologram does is that scattering of laser beam from it is effectively scattering from target. Magnetic flux tubes make TGD Universe an Indra's net: could it be that the scattering from object behaving like bio-hologram could actually take place from the target which it represents! Photons would travel from object to the target along flux tubes, scatter, and arrive along flux tubes and leave the object. The object, which actually acts as a relay station, would define pseudo-hologram. Also frequency coding of the address could be combined with this picture if the lengths of flux tubes are multiples of wavelength (proportional for Planck constant).

6.3.3 Some examples of remote mental interactions interpreted in TGD framework

Some examples about remote mental interactions with living target are in order.

1. In telepathy the communications from biological body of target would be based on EEG and its scaled analogs. Also ECG could be involved. In TGD Universe even electromagnetic field might be replaced with electroweak and color field below some scale in scale hierarchy defined by Planck constants.
2. In hypnosis magnetic body of operator would control the biological body of the target, which would be "possessed" and behave like a part of the biological body of operator.
3. It would be also possible to share sensory percepts and memories of the living target. The mechanism would be time mirror mechanism applying also to ordinary memory and sensory perception.

In the case of in-animate targets the modelling is not so straightforward. One could however assume that also now negentropic entanglement is involved and that the ATP of the operator is used. Note however the possibility of the more general mechanism at the end of the target.

1. In psychokinesis with inanimate target negentropic entanglement would be mediated by flux tubes containing ATP assignable to the operator. The metabolic energy of ATP of operator is transferred to the target. The increase in the rate of metabolism could therefore serve as a signature.
2. In the remote mental interaction with computer the intention is to affect the pattern of random numbers and the mere transfer of metabolic energy is not enough since the effect must also

have a correct sign. The net effect is the change of the distribution of random numbers from expected and Tiller observes strange periodicities in the distribution. It seems that remote mental interaction must be able to affect the probabilities of the outcome so that they are not identical as randomness would require. What could be the mechanism? Direct entanglement with the representation of bits is not plausible. While writing this article it occurred to me that there might be a connection with the model for Shnoll effect [K4] which I developed for a couple of years ago and based on a deformation of probability distributions based on p-adic mathematics and quantum groups. What is remarkable is that the parameters characterizing statistical distributions vary slowly with periodicities assignable to the gravitational fields in solar system. Could it be that also the statistical effects of intentional action could be characterized by the same mathematics leading to purely number theoretical predictions? This will be discussed in more detail below.

3. In the intentional imprinting of Tiller creation of flux tubes connecting the magnetic body of operator and non-living target would take place. Intentional action induces changes such as change of pH and this could rely energetically on the use of ATP. Magnetic fields should be important and cyclotron frequencies might be important. When a sequence of random bits is used, periodicities with cyclotron frequencies are suggestive supporting the hypothesis involving magnetic flux tubes and Shnoll effect.
4. What could be the mechanism in the case of remote viewing? Magnetic body should receive from the target extrasensory input generating sensory percepts or more abstract cognitive mental images such abstract shape. Could the signal arrive from the target to the magnetic body of operator and therefrom to the biological body - maybe brain - of the operator to create genuine sensory percept? To have a genuine sensory percept backprojection to sensory organs is necessary and in TGD based model for sensory qualia the back projections to sensory organs are in a central role: the virtual world sensory input from brain and possibly from magnetic body to sensory organs used to build standardized mental images. Or is there any creation of sensory percept?
5. In the case of precognition the situation is not at all clear. In ZEO based vision the simplest view is that the "upper" light-like boundary of CD corresponds to the seat of sensory percepts realized as mental images. Memories would correspond to information arriving from the geometric past inside CD . Precognition would mean receiving information from the geometric future of CD . Is this possible? How this would be realized. The vision about generalized Feynman diagrams suggests that given CD surrounds a vertex of generalized Feynman diagram in certain scale and that larger CD s are present and precognition would involve time reversed signals at the level of next CD . There presence of larger CD and longer time scale would mean that prophets are indeed "messengers of Gods".

Why we do not remember the geometric future. Is the reason that the contents of conscious experience is about the boundary of CD which performs the state function reduction.

6.4 Parapsychological phenomena

In this section various parapsychological phenomena are discussed in the general framework introduced in the previous section.

6.4.1 Extrasensory perception, precognition, and other parapsychic effects

The general model for paranormal effects relies on same basic ideas as the model of quantum biology.

1. The transformation of p-adic [K46] space-time sheets makes possible the transformation of intentions to actions. Since p-adic space-time sheets have literally infinite size in real sense, distance does not matter. The set of points in the intersection of p-adic and corresponding real space-time sheet obeying same algebraic equations consists of rational and possibly also algebraic points common to real and p-adic variants of imbedding space.

Parapsychological phenomena involve the transfer of information and negentropic entanglement makes possible genuine information at quantum level as also breaking of the second law of

thermodynamics in the time scale of CD in question. Hence remote mental interactions should involve the generation of negentropic entanglement irrespective of whether the target is living system or consists of "dead" matter.

2. The idea about field body serving effectively as an intentional agent is second element of the model. The topological light rays representing negative energy signals propagating into geometric past created by a transformation of p-adic space-time sheet to a real one might be said to represent the "desire" inducing neural activities in the brain of geometric past. This mechanism provides not only a model for how magnetic body uses biological body as a motor instrument but also for PK.

MEs acting as bridges between different organisms would mediate em oscillations allow a directed transmission of smaller MEs behaving effectively as particles moving with light velocity. These MEs could be both real and p-adic and -using the terminology of Qigong practice- would represent qi (action) and yi (intention) respectively. An essential element would be resonance: sender and receiver in should be accompanied by MEs characterized by the same fundamental frequency: only these MEs could resonantly connect healer and healee. Healer must have ability to continuously vary the healing frequency.

MEs would naturally correspond to pairs of positive and negative energy space-time sheets. They would be attached to magnetic flux tubes and magnetic mirrors consisting of two flux sheets would make possible sensory-motor loop.

3. Zero energy ontology justifies the notion of negative energy signals and brings in also CD s as correlates of selves and natural fundamental targets of remote mental interactions. Zero energy ontology and the new view about time allows to assume that sensory qualia are at the level of sensory organ (objections such as phantom leg phenomenon can be circumvented) and that symbolic representations of objects of perceptive field and their attributes reside in brain.

Sensory input generates sensory representations based on real space-time sheets possibly accompanied by p-adic cognitive space-time sheets. Field body can share these mental images by quantum entanglement and also receive sensory information as classical signals involving using frequency coding and coding by temporal patters. These latter representations would correspond to cognitive and emotional aspects associated with the sensory input. One could even say that higher level sensory representations are somatosensory experiences of field body. The intersection points of real and p-adic space-time sheet would determine the physical cognitive representation and would be always discrete. The analogy with the discreteness of numerics should be noticed. Since this model would apply also to extrasensory perception, the attribute "extrasensory" becomes somewhat misleading attribute.

4. Extrasensory perception could also result from the direct electromagnetic perturbation of the sensory magnetic canvas outside the body and the sounds generated by auroras and meteors might be genuine "extrasensory" perceptions of this kind [K59] . The frequency spectrum for the sounds produced by meteors and detected both sensorily and electronically in in the range 37 – 44 Hz [F1] , which is the range of thalamocortical resonance frequencies associated with sensory representations in magnetic sensory canvas model. The sounds are several orders of magnitude more intense than they should be unless em perturbations propagate to Earth in a channelled manner. Only few meteors generate these sounds. These observations suggest that a resonant amplification of the em perturbations by magnetic mirrors of the sensory canvas channelling the em field to the surface of Earth are in question.
5. One might argue that if memes are not universal, remote cognition is not very useful. If memetic and genetic codes are realized in terms of CD s of quarks and leptons, one would have universality. If DNA double strand provides the relay station through which sensory input and motor output of the magnetic body flows, one would achieve universality of communication and control mechanisms at the level of living matter. An interesting question is whether memes are really species-specific as the morphic fields are in Sheldrake's theory. The ability of shamans to transform at the level of conscious experience to animals suggests that this might not be the case. There is also a famous real life story about a student who spend several days in the experiential world of dog. Various identification phenomena would very probably involve also magnetic

mirrors acting as bridges between say shaman and animal (or possibly multibody collective self defining 'species self') and making possible to share the experience of animal. Same mechanism as in the case of long term memories would be in question but with personal memories being replaced with the experiences of another species.

The fact that p-adic space-time sheets have literally infinite size suggests that cognition and intentionality are cosmic phenomena and that there might be cosmic pool of shared cognitive mental images. Hence memes could be completely universal.

6.4.2 Psychokinesis

One can classify psychokinesis to various types depending on whether the target is living or "dead" and whether the effect on target is a mere transfer of energy and momentum or control action involving information transfer.

Below I briefly discuss an early TGD inspired model of PK, a general model of PK assuming time mirror mechanism of ordinary intentional action but applied by the magnetic body of the operator to a system different from the biological body, and a more specific model for machine-human interactions. Also concrete examples of various kinds of PK effects are discussed.

A possible model for psychokinesis with non-machine targets

In [K86] a mechanism of psychokinesis based on the generation of wormhole magnetic field configurations making possible levitation was proposed. Although this mechanism was yet general it deserves a discussion and reader is recommended to see [K86] for details. Basic mechanism is the levitation of diamagnetic substances in an external magnetic field: the force results when the diamagnetic substance repels external magnetic field from its interior. The force is essentially the gradient of the net magnetic energy inside the volume defined by the object.

The mechanism is purely TGD based and relies on the generation of a pair of space-time sheets having opposite time orientations, and carrying opposite magnetic fields and opposite energy densities, and the subsequent interaction of the second space-time sheet with the object moved in the psychokinesis. Exactly the same mechanism applies in case of MEs (massless extremals) and could be used to generate coherent locomotion of organism resulting as a recoil effect when the second ME is absorbed by the body part. MEs provide a candidate for the mechanism of psychokinesis.

TGD based general view about PK

A general TGD based explanation psychokinesis relies on the same fundamental mechanism as ordinary intentional action, long term memory, and remote metabolism. The model applies more or less as such also to telepathy and could also allow to understand the notion of water memory explaining homeopathic effects.

1. The basic mechanism of PK and retro PK relies on quantum jumps transforming the p-adic space-time sheets representing intentions to real space-time sheets representing desires represented as negative energy signals to the geometric past. These signals modify the output of say random number generator to a non-random one. Magnetic flux quanta would realize the bridges along with the negative energy signals would propagate. The mechanism would favor retro PK if the operator is in active role. Genuine PK is also possible but in this case target would be active sucking metabolic energy provided by the operator.
2. Negative energy signals could consist of dark phase conjugate photons or even massless W bosons since TGD allows scaled up variants of electro-weak gauge bosons with large Planck constant and arbitrarily small mass scales. Dark W bosons are especially interesting since they can induce charged entanglement and purely non-local charge transfer mechanism and have been proposed to play a key role in the generation of the nerve pulse.
3. Magnetic flux quanta are the bridges making possible (presumably) unconscious feedback so that the operator can unconsciously learn how to affect the machine. How intentions can have effect on system whose functioning is unknown to the operator is actually the basic mystery of, not only psychokinesis, but of remote healing and remote mental interaction in general, as also of

the phenomena labelled as instrumental transcommunications (ITC). The learning by feedback, much analogous to that happens when we learn to drive bicycle, would solve this mystery. The effects of group activity could be understood if groups tend to form collective selves so that coherent amplification of the effect occurs.

4. The ability of the PK able person to imagine the desired effect is important and could correspond to the ability to generate p-adic space-time sheets representing the intention. The desire about the action represented by the corresponding real space-time sheet should induce the effect optimally. In personal discussions with a PK-able psychic I indeed learned that he always tried to imagine in every possible detail how he moved the physical object (say a box of matches). The role of imagination is important also in remote healing [J58] . Perhaps the p-adic pseudo constants made possible by the non-determinism of p-adic differential equations should be in a good approximation genuine constants.
5. The optimal targets are initial value sensitive- or more generally-critical.
 - (a) Quantum criticality is the basic characteristic of TGD Universe and the prediction is the existence of a hierarchy of criticalities. Number theoretical criticality would in turn characterize living matter and might be a characteristic of optimal targets.
 - (b) Also quantum criticality in the sense that several values of Planck constant are possible with large values of \hbar assignable to negative energy signals mediating the desire of the PK-able person. PK requires energy and this favors systems, which can utilize standardized metabolic energy quanta liberated in the dropping of particles to larger space-time sheets.
 - (c) Water would be an optimal system from the point of PK and retro PK. Homeopathy might indeed involve PK like aspects. Benveniste's experiments [I28, I29] gave support for the notion of water memory but could not be replicated when the experimenters did not know in which bottles the treated water was. The preservation of water memories represented in terms of many-sheeted lasers for with 1/0 corresponds to a population inverted state/ground state, requires metabolic energy feed and the system might suck this metabolic energy from the biological body of the experimenter [K31] .
6. As noticed, the proposed model is extremely general and seems to apply to almost any paranormal phenomena. For instance, the claimed re-incarnation experiences could be understood in terms of the general mechanism for long term memory. The person who remembers having lived in past could share mental images of a person in the geometric past by time like entanglement (episodal memory), or could be able to communicate with negative energy signals to the brain of a person on geometric past memory recall and thus receive declarative memories. It is quite possible that survival of fittest in our culture has led to an evolution of an immune system preventing sharing of mental images and communications with other brains.

Machine-mind interactions

Machine-mind interactions represent a modern branch of parapsychological research and nowadays methodologically highly advanced. These interactions are studied several groups and individuals: mention only the Princeton Engineering Anomalies Research (PEAR), which is a group directed by Prof. Jahn, the Anomalous Cognition Project of Dick Bierman, and the retropsychokinesis work of Helmut Schmidt. In the sequel some aspects of this work are discussed.

The generation of negentropic time like entanglement between operator and target leading to a superposition of pre-existing and desired zero energy states and a subsequent increase of the amplitude of the desired outcome could be the general mechanism of machine mind interactions. 'Who known how?' is a highly relevant question in the case experiments involving the attempt of operator to affect the function of a machine like computer whose detailed functioning is not known for the operator. This question could have two answers. Either the operator learns to who to affect the outcome by the simple sensory-motor loop provided by MEs or there is third party who knows and corresponds to a higher collective level of consciousness.

1. *Retro psychokinesis with random number generators*

The analysis of experiments [J17, J18, J46] discussed in the [K80] suggests that the geometric past can change in the time scale of a fraction of second. Both the work done at PEAR [J31] and the work of Helmut Schmidt with retro psychokinesis [J57] provide support for the change of the geometric past in much longer time scales. PEAR experiments demonstrate the anomalous effect also in the direction of future. For instance, the experiments of Schmidt done 1992 discussed in *New Scientist* [J24] demonstrate that martial art students were able to affect the visual display determined by pre-recorded random numbers. The probability for this kind of deviations from non-randomness was about 1/1000. Henry Stapp proposed an explanation for this in his paper published in *Phys. Rev. A* [J61] based on nonlinear quantum mechanics.

The change of also geometric past in the quantum jump between quantum histories implies the notion of a four-dimensional physical reality and forces to regard three-dimensionality of reality as illusion created by the 3-dimensionality of our sensory experience (recall the notion of the association sequence). This implies that our geometric past is changing all the subjective time and that communications to the geometric past and future are possible and are consistent with the weak causality violation hypothesis of Schmidt [J57]. What this hypothesis implies that in the newest quantum history generated by RPK all separate records contain the pre-recorded random numbers are altered in the same manner in RPK. Schmidt has tested weak causality hypothesis by using two separate cassette tapes containing the pre-recorded random numbers, one used in the PK experiment and another one kept locked in a safe. The records were indeed found to be identical after the experiment.

The results of Schmidt suggest also classical signalling to the direction of the geometric past. Real space-time sheets with negative time orientation could serve as the geometric correlates for these signals.

2. *The work of Princeton Engineering Anomalies Research group*

The study of anomalies in human-machine anomalies provide a highly sophisticated and controlled manner to study psychokinesis in its various forms. For instance, in the experiments carried out in PEAR group (Princeton Engineering Anomalies Research) [J31] operators try to affect various kinds of electronic, mechanical, acoustical, optical and fluid devices. In unattended calibrations these devices yield random output whereas in the experimental situation operator tries intentionally to affect the output so that non-randomness results. Each input that operator tries to affect consists of 200 bits formed from a random physical signal and operator can have either the intention to increase the number of 1:s (high), the number of 0:s (low) or have no intention at all (baseline). Operators can exert their efforts from a distance of thousands of miles, before or after the the actual operation of the devices. Over the laboratory's 20-year history, thousands of such experiments, involving about 100 millions of trials, have been performed by several hundred operators.

The observed effects can be summarized as the average for the sum of bits which is 100.026 for high and 99.984 for low. The effect is by a factor 3.6 higher than the expected margin of error. Effects are thus quite small, of the order of a few parts in ten thousand on average, but they are statistically repeatable and compound to highly significant deviations from chance expectations. Effects are highly operator specific and there are significant disparities between male and female performances. The random devices respond also to the group activities of large numbers of people and are especially sensitive to the effect of small intimate groups, group rituals, sacred rites, musical and theatrical performances, and charismatic events.

Time mirror mechanism suggests the following model for the machine-human interactions encountered in say PEAR experiments.

1. The effect of intention could be on the generator of random noise, on bit sequence represented in the computer memory, or even on the recorded value of the sum of bits. A possible mechanism in the latter two cases is the reversal of electromagnetically represented bit.
2. The general mechanism of intentional action involves negative energy signals inducing a change in the charge distribution determining the value of bit. Negative energy photon could induce a dropping of ions to a larger space-time sheet. Also the emission of negative energy dark W bosons (appearing in TGD based model of nerve pulse) could induce a change in the net charge. In both cases the sign of charge would correlate with the character of intention and for the first mechanism there would be asymmetry between "high" and "low" (proton, electron).

3. *The work of William Tiller*

[J65] [J65, J66, J67, J70] has performed experiments involving intentional imprinting of targets such as water. The model for the findings of Tiller is discussed in [K8]. The imprinting manifested itself as temporal and spatial oscillations of pH and temperature. The surprising finding was conditioning: also the air around intentionally imprinted device exhibited these oscillations. Also computer could be conditioned. The Fourier transform of the correlation function for bit sequences of random number generator demonstrated peaks at harmonics of $f = 1/T$, $T = 113.778$ min. 2^n -multiple of .1 seconds for $n = 16$ would correspond to $k = 143$ and $T = 109.23$ minutes which is by about 4 per cent too small. The proposed assignment of cyclotron photons with motor action leads to ask whether large \hbar dark cyclotron photons with these frequencies could induce a periodic perturbation of the random bit sequence?

Could Shnoll effect and statistical effects of psychokinesis have common mathematical description?

In the remote mental interaction with computer the intention is to affect the pattern of random numbers and the mere transfer of metabolic energy is not enough since the effect must also have a correct sign. The net effect is the change of the distribution of random numbers from expected and Tiller observes strange periodicities in the distribution. It seems that remote mental interaction must be able to affect the probabilities of the outcome so that they are not identical as randomness would require. What could be the mechanism? Direct entanglement with the representation of bits is not plausible.

1. This brings in mind Shnoll effect [K4] in which probability distribution $p(n)$ for an integer valued observable transforms from expected smooth distribution - say Poisson distribution - to a many-peaked distribution. The distribution could relate to microscopic observable but the modification of distribution seems to depend on gravitational field created by solar system so that astrophysical and microscopic dynamics couple at the level of probability distributions. I have proposed a mathematical model involving p-adic numbers and their quantum counterparts as a model for the effect but have not been able to understand this astro-micro correlation. Could it be that Shnoll effect allows to describe also statistical psychokinesis. This would lead to precise number theoretic predictions and the model would be testable.

There is an interesting analogy with quantum computation in TGD framework. Individual bits or bit sequences correspond to outcomes of quantum computations inside CD and their distribution determines the outcome of the computation. Intentional variant Shnoll effect would mean that intentional action can affect this distribution. One could localize this intentional action to a CD containing the CD s defining bits.

It is however far from clear whether this model can be formulated as a modification for the probability for a given value of bit. It might well be that the effect is global rather than local and on the distribution of number of bits with a given value. Indeed, in TGD framework reality is 4-D and the sequence of bits produced by random number generator is what correspond to the event rather than single bit!

2. One can of course consider also a local model. A negentropic entanglement with the macroscopic quantum states of random number generator affecting the environment of system responsible for the random event could be in question and change the situation in such a manner that second value of bit becomes more probable. Could the magnetic fields associated with the flux tubes mediating the negentropic entanglement with RNG and interacting with the target make second bit energetically slightly more favored? Could the negentropic entanglement prevent the normal state function reduction producing the random number and produce the random number as ATP is transformed to ADP so that operator would perform some fraction of state function reductions? How it is possible to have an effect with a correct sign without any precise knowledge about the functioning of RNG?

Telekinesis and electrostatics

In the book "Mind at Large" edited by Tart, Puthoff, and Targ there is an article "An Investigation of Soviet Psychical Research" by Wortz *et al* reporting among other things the research related to

the electrostatic aspects of telekinesis. The article mentions the work done by Vasiliev and associates with Nina Kulagina and the work of Adamenko with Alla Vinogradova, another highly gifted person in telekinesis. Kulagina and Vinogradova are said to have been able to move objects of .1 kg along table. Interestingly, according to the article PK able persons tend to be women. Adamenko has tried to understand the phenomenon theoretically and has proposed that the static charges of objects and electrostatic forces generated by the subject might explain the effects.

Adamenko's work

The objects moved by subject persons were located at a table which was a di-electric cube with of side length of .5 meters in Adamenko's experiments.

1. Vinogradova was able to induce an electric charge in cube and then move objects located at the cube. With biofeedback training also other subjects were able to replicate Vinogradova's feat.
2. To move the object the static friction (friction coefficient between .1 and .3) must be overcome. Adamenko theorizes that there is kind of buoyancy force caused by the flow of air molecules involved and that the electric field somehow induces this force.
3. The reported electric field was 10 kV/cm and corresponds to the voltage at which a di-electric breakdown occurs in a dry air. The reported movement of the air could correspond to a corona wind resulting at strong electric fields.
4. Adamenko assumes that the objects had either static charge or that they were polarizable and developed a dipole moment in the external electric field. The electrostatic interaction with the electric field induced by Vinogradova would have been the cause of the movement.

TGD based model

TGD based model for phenomena is based on the general mechanism of mind-matter interactions allowed by the many-sheeted space-time concept. There are three questions to be answered: How the table and possibly also object were charged?; How the motion of the object was caused?; How the object was lifted from table to circumvent friction force? *How the table and object were charged?*

The charging of the table is certainly crucial for the PK effect. Vinogradova could have emitted "topological lightrays" (MEs), as a matter fact high frequency (microwave) MEs propagating like particles within low frequency (ELF) MEs. Negative energy ELF MEs could have served as correlates for entanglement. Entanglement is however not necessary in this case since conscious telepathy is not involved. Microwave MEs would have induced bridges between the atomic space-time sheets of the object and super-conducting magnetic flux tubes of Earth. The bridges would have made possible ionic and electronic currents between these space-time sheets and led to the charging of the table and possibly of also object. A suitable intentional targeting of MEs would allow to control the charge distributions of the table and object and therefore the pattern of the induced electrostatic fields.

What could have produced the motion of the object?

The interaction of the object with the electrostatic field of the table is a possible explanation for the PK effect. The distribution of the charges of the table and object would allow to control the field pattern and thus the direction of the electrostatic force. This is however not the only mechanism. Ionic currents from the magnetic flux tubes to the atomic space-time sheets of the object produce recoil effect (momentum is conserved only in many-sheeted space-time, not for single space-time sheet), and this could have been the fundamental mechanism of motion (essentially the mechanism of rocket motion). In both cases the subject would have produced only the ME bridges taking care of the control of motion but would not have provided the energy and momentum.

The experiments of Modanese and Podkletnov [H1] provide support for the mechanism. Modanese and Podkletnov studied capacitor at a rather low temperature and at a voltage near the di-electric breakdown voltage. The second electrode was a super-conducting disk. The resulting discharge was large and coherent and accompanied by radiation pulses of unknown type. The pulses induced the motion of the air and kicked test penduli. The force was proportional to the mass of the penduli. The effect caused by the pulses did not weaken with distance. This supports the view that the pulses were TGD counterparts of the Tesla's scalar waves and induced temporary bridges between test penduli

and magnetic flux tubes inducing the flow of ions and the recoil effect. The same mechanism should be at work as a microscopic and incoherent version in the case of lifters.

How to circumvent the friction?: a connection with the physics of lifters

Lifters exhibit the called Biefeld-Brown effect [K76] . Lifters are asymmetric capacitors consisting typically of a wire electrode and planar electrode, are in a voltage slightly above the voltage causing di-electric breakdown. Lifters move in the direction of the smaller electrode. Also the flow of air from the small electrode to the large one is involved. On basis of the experimentation and guide the findings of Juha Hartikka, I ended up with a simple model of lifters. What would happen is that there is an electric discharge in the form of small plasmoids (discharge sparks would be analogous to ball lightnings), whose emission from the small electrode causes the recoil effect. The emission of the scalar wave pulses could induce the motion of the air by Modanese-Podletnov recoil mechanism. Since the table is charged, there should be a strong electric field also in the narrow space between the object and table. Therefore electronic discharges from the object could occur, and lead to a small scale lifter effect lifting the object slightly above the table. This does not require the object to carry a net charge.

Could the remote EEG sensor of Sergeyev be based on the same mechanism as PK?

In the same article also the remote EEG sensor invented by the mathematician Sergeyev claimed to remote sense EEG from a distance of 5 meters is described. Unfortunately, the information related to the invention of Sergeyev is classified. What is however known from the existing literature is that the sensor is surprisingly simple, consisting of a metal disk suspended into water and coated with a semiconductor. The immersion in water is reported to double the effectiveness of the sensor. According to the report, the ordinary EEG sensors can detect EEG only up to a distance of few centimeters since the noise of the environment masks the (Maxwellian) EEG at larger distances. Furthermore, the amplifying effect of water is not consistent with the high value of the di-electric constant of water if ordinary Maxwellian electrostatics is behind the sensor.

Sergeyev's explanation for the functioning of the sensor utilizes bio-plasma hypothesis. The use of the term bio-plasma is remarkable since professional physicists know that plasma state at the temperatures and densities of living matter is not possible in standard physics universe. In TGD framework super-conducting ions leaking from the magnetic flux tubes of the Earth's magnetic field can give rise to what might be called bio-plasma, and Sergeyev's sensor is indeed said to produce bio-plasmagram. Also maser (microwave laser) effect in bio-matter producing ions and electrons flowing into air is mentioned.

All this suggests that EEG MEs containing microwave MEs inducing a leakage of the ions from magnetic flux tubes to the atomic space-time sheets of the metal disk and in this manner generate plasma. The strength of the resulting electric signal would be modulated by the intensity of the net flux of EEG MEs so that information about EEG would indeed result. EEG MEs would not topologically condense at atomic space-time sheets but propagate as bridges connecting the boundaries of the magnetic flux tubes and atomic $k = 151$ (cell membrane thickness) space-time sheets. This would explain the dissipation free propagation. For positive energy MEs the effective phase velocity would be of the same order as the alpha wave phase velocity since these MEs would tend to "stuck" (in quantum sense). The basic sensing mechanism would be very much the same as explaining the generation of nerve pulse. Also Z^0 MEs could be involved and would usually have a very weak interaction with the environment. The ability of water to act as a many-sheeted maser, presumably crucial for the functioning of living matter, could explain why the water amplifies the effectiveness of the sensor.

Also the remote sensing of the pulsating magnetic fields produced by Nina Kalugina and having strength nearly equal to that of the Earth's magnetic field are mentioned in the article. The possible significance of the pulsating magnetic fields for PK is still poorly understood in the TGD framework: the problem is that solutions of field equations representing this kind of field configurations are not known. One might however think that the pulsating magnetic fields carry also supra-currents, and that their presence intensifies the leakage of charged particles to the atomic space-time sheets of the remote sensor device.

6.4.3 Healing as rejuvenation?

The article of Lian Sidorov [J58] and its references give a thorough view about remote healing and viewing. One particular healing method goes under name Qigong [J26]. Qigong is a general term for a large variety of traditional Chinese energy exercises and therapies. Qigong is generally considered as a self-training method or process through Qi (vital energy) and Yi (consciousness or intention) cultivation to achieve the optimal state of both body and mind. The traditional Chinese medicine postulates the existence of Qi, which could be regarded as a kind of subtle energy circulating around the physical body.

The physiological, chemical and electromagnetic effects of both internal and external Qigong have been studied ([J58] contains large number of related references). Also the effects of Qigong healing on cancer has been studied [J26].

Negentropic entanglement as Qi?

In TGD framework the energy associated with MEs and supracurrents flowing along magnetic circuitry could be a natural counterpart of Qi. The positive metabolic energy assignable to negentropic entanglement or negentropic entanglement could be an alternative identification for Qi. If entanglement is entropic it corresponds to bound state entanglement and this entanglement of its negative metabolic energy could be seen as the counterpart of "sick Qi".

Yi could in turn would translate to p-adic cognitive representations representing also intentions, perhaps p-adic variants of MEs or even magnetic mirrors. Internal Qigong refers to self healing whereas external Qigong means directing Qi energy or intention to help others by opening Qi blockages or inducing the sick Qi to get out of body, or helping to achieve Qi balance. The transfer of metabolic energy by ATP-ADP process [K23] would be basically a transfer of negentropic entanglement in TGD framework and Qi blockage could be interpreted as a blockage preventing transfer of this entanglement (of metabolic energy in standard framework) would be basically a transfer of negentropic entanglement in TGD framework and Qi blockage could be interpreted as a blockage preventing transfer of this entanglement (of metabolic energy in standard framework).

Zero energy ontology in principle makes possible the creation of matter from vacuum as zero energy states. This process involves a generation of a new CD serving as a correlate for self carrying positive and negative energy parts of the zero energy state at its future and past boundaries. The standard physics interpretation would be as a quantum fluctuation in a space-time volume dictated by CD . At space-time level space-time sheets within CD would be the correlate. Also the transformation of p-adic space-time sheets to real ones and vice versa in the intersection of real and p-adic worlds becomes possible.

Healing as regeneration of negentropic resources?

De-differentiation of cells taking place in the healing of cancer cells resembles rejuvenation. But what does rejuvenation mean? The first guess is that it corresponds to time reversal and running of biological programs backwards so that the stage before the emergence of disorder is reached. This interpretation is attractive but during the preparation of this article I realized that it does not conform with the most recent view about what the arrow of geometric time is [K5].

To begin with, one must understand how the arrow of psychological time is induced from quantum arrow. This question is not completely understood in TGD framework. There are several arrows of time: quantum arrow of time, arrow of the geometric time of 8-D imbedding space, and the arrow of the geometric time of 4-D space-time sheet of subsystem identifiable psychological time.

1. Quantum arrow of time has a nice explanation: for zero energy states either positive or negative energy states (but not both) can be chosen to have well defined single particle quantum numbers - they are prepared. The simplest manner to identify quantum jump and unitary process U would be as state function reduction taking place alternatively for positive or negative energy part of the state. One would have time-flip flop at imbedding space level: the arrow of 8-D imbedding space geometric time would alternate. This of course sounds weird unless one makes a sharp distinction between different times.
2. What about the arrow of the time at 4-D space-time level? What is clear that observer of space-time as Flatlander does not observe the change of the arrow of imbedding space time but

experiences constant arrow of time reflecting itself as second law. In fact, entropy defines natural time coordinate for Flatlander. This can be understood if quantum average 4-D space-time surfaces associated with subsequent zero energy states effectively combine to form a multiply folded towel like structure. In quantum jump 4-D space-time surface can be said to turn downwards at the upper end of CD , return back to turn upwards at the lower end of CD , and so on. Flatlander would experience the flow of 4-D time as a continual increase of entropy manifesting itself as properties of the space-time sheet with which Flatlander identifies herself. The 4-D arrow of time would not change. Only by observing space-time sheets in different time scales would make possible for the Flatlander to discover that the 8-D imbedding space arrow of time alternates. Phase conjugate laser beams and self assembly in biological systems would represent examples of processes allowing to overcome the restrictions of being Flatlander. During last decades we have been indeed able to overcome these restrictions as the discovery of phase conjugate laser beams demonstrates [D16]. In TGD framework massless extremals (MEs, topological light rays) provide a representation for the phase conjugate laser beams. Also the discovery of Italian physicist Fantappie that living systems are characterized by both entropic and syntropic processes demonstrates the presence of both directions for the arrow of time at imbedding space level [J38, J69].

In this framework healing corresponds to rejuvenation if the age of cell is as entropy defining also a measure for the amount of differentiation that has occurred. By second law aging would be reduction of negentropy resources and healing as rejuvenation would mean the increase of negentropy of the system. This is possible if the notion of negentropic entanglement is accepted. The healing as increase of the negentropy of the system implying rejuvenation should take place in state function reductions and NMP [K42] would make them possible if the notion of number theoretic entanglement entropy is accepted.

How topological light rays and magnetic flux tubes relate to healing?

Massless extremals are excellent candidates for the space-time correlates of communication and control signals and depending on the sign of the energy can propagate in both time directions. Real bosons correspond to wormhole contacts connecting positive (negative) energy MEs whereas virtual bosons are identified the wormhole contacts connecting positive and negative energy MEs. In zero energy ontology it makes sense to speak about quantum jumps transforming p-adic MEs to real ones and about reflection of MEs in time direction so that positive energy ME transforms to negative energy ME or vice versa. Also MEs analogous to virtual particles are possible. They correspond to pairs of MEs with opposite time orientations so that the wormhole throats carry opposite signs of energy. In this case the classical momentum is not anymore light-like and although wormhole throats are massless the boson itself can be interpreted as a virtual off-mass-shell particle.

In quantum optics time reversal is known as a phase conjugation [D16] and is one of the basic notions of holography. MEs act as both quantum holograms and receiving and sending quantum antennae of [K48]). MEs can generate reference waves of coherent photons interacting with other MEs and activating dynamical holograms of coherent light. If the reference wave is phase conjugated, the resulting hologram is time reversed.

What makes this so interesting is that MEs and magnetic flux tubes are the tools of of quantum control in the TGD based view about biosystem as a symbiosis in which MEs control superconducting magnetic flux tubes controlling ordinary matter at atomic space-time sheets via the many-sheeted ionic flow equilibrium. The coherent light pattern emitted by ME resulting from the interaction of ME with the reference wave (its phase conjugate) could act as a control command (time reversed control command) inducing process (time reversed process).

How topological light rays and magnetic flux tubes relate to healing?

1. In the original vision about healing as time reversal for biological programs phase conjugate reference waves would provide a simple and general mechanism of healing by time reversal allowing the living matter to fight against second law. This picture is however inconsistent with the recent view about the arrow of time.
2. In the recent view about the arrow of time topological light rays generate non-local single particle excitations at the flux tubes carrying cyclotron Bose-Einstein condensates and the resulting negentropic entanglement induces healing.

6.4.4 Near death experiences

Near death experiences are rather commonly experienced, say by the victims of various accidents. These experiences are known for centuries but it was the best-selling book "Life after Life" of Raymond Moody which brought these experiences known to the general public [J49].

1. *What NDEs are?*

NDEs seem to possess invariantly the same characteristic features. There are feelings of peace and joy, time speeded up, heightened sense, lost awareness of body, seeing bright light, entering another world, encountering a mystical being or deceased relatives and coming to a point of no return. The experiences seem to proceed in quite universal manner. First comes a loud buzzing or ringing noise and a long dark tunnel. Patient sees his own body from outside and does not feel any pain or agony anymore. Patient meets others and a being of light who shows his life in its entirety as a kind of playback to evaluate. Then comes the point of no return, and although patient feels peace, joy, and love, the patient has to return to continue his life. Often these experiences induce very profound changes in the subsequent life of the patient. The claims of Moody have been supported by subsequent research and hardly anyone, even the most foolhardy skeptic, denies the reality of these experiences.

The latest twist in the development emerged when University of Southampton research team announced the result of a one-year study of NDEs of victims of a heart attack supporting the view that consciousness and mind exist after the brain has ceased to function and the body is clinically dead. The resuscitated patients were various times clinically dead, with no pulse, no respiration and fixed dilated pupils. Independent EEG studies have confirmed that brain's electric activity, and hence brain function (according to standard dogmas of neuro science) ceases in this kind of situation. 11 per cent of patients who survived the heart arrest however recalled emotions and visions during this state. This announcement has created considerable excitement in various consciousness related discussion groups and the question whether some of the basic dogmas of neuroscience are badly wrong has been raised by the neuroscientists themselves.

2. *TGD based view about life after death very concisely*

It is good to summarize the latest TGD based view about consciousness after physical death before comparison with other theories and detailed analysis of NDEs. The view, which is certainly not the only possible one can imagine, is supported by the improved view about psychological time.

The basic notion is that of 4-D body involving both the physical body and the magnetic mirror structures associated with it. 4-D body is gradually carved like an artwork via p-adic-to-real phase transitions representing the progress of front of volition to the geometric future and by the reverse phase transitions deconstructing the 4-D body or its parts. This fractal trial-and-error construction of the 4-D body occurs in various time and length scales. Gradually increasingly stable 4-D body results. The volition is concentrated to the front of the p-adic-to-real phase transition so that the experience of 4-D body for which deconstruction processes occurs only in the time scales short compared to the duration of lifecycle, would be about entire lifecycle and in this sense 'timeless'.

The simplest view assumes that the front of volition does not propagate after the physical death. One could however consider the possibility that the front of volition continues to propagate by transforming p-adic magnetic mirror structures to real ones: volitional life would continue in electromagnetic form. This would make possible the communications of the deceased with living since the resulting real magnetic mirrors could connect the deceased with the living. On the other hand, the repertoire of possible p-adic magnetic mirror structures would be very wide because of the p-adic non-determinism.

Since magnetic mirror structures are fundamental for the field realization of the genetic code, one can quite well consider the possibility that this process induces also the self-organization of the ordinary living matter around the magnetic mirror structures. This would have interpretation as a reincarnation. Buddhas able to resist the temptation to reincarnate would continue their life at the field level. Interestingly, the development of physics from Newtonian physics of the material bodies to Maxwellian physics of fields would mirror the evolution of consciousness from concrete biological life to life at the field level.

3. *Astral plane theories for NDEs*

There are several theories of NDEs. A theory enjoying popularity in New Age circles is based on

the notions of the astral projection and next world stating that we have another body that is vehicle of our consciousness which leaves the body at the moment of death. Although completely respectable as such, this kind of theory is not based on existing or even postulated physics, and is therefore hard to test. The notions of 'higher vibrational level' and 'astral plane' are simply devoid of a physical meaning.

In TGD framework the idea about 'vibrational levels' generalizes in an astonishing concreteness to an entire hierarchy of electromagnetic life forms and electromagnetic bodies whose sizes vary to astronomical length scales [K26, K59]. In this framework the idea about brain as a seat of consciousness is an illusion resulting from the fact that sensory data is mostly about the immediate region around body. Of course, even the idea that consciousness (as opposed to its information contents) can be localized to some part of space-time, is basically wrong in TGD approach.

A possible test for the astral projection theories is a weighing of the body after death to deduce the weight of the astral body (assuming of course that astral planes obey ordinary physics!). If 'astral planes' correspond to the p-adic space-time sheets, this test of course does not make sense. Magnetic mirror structures are obvious candidates for astral body and are real but their separation from body is impossible so that this kind of measurements do not make sense. The notion of 4-D body also suggests that the physical body remain in the geometric past in the physical death wherefrom it can communicate with the living ones via the magnetic mirrors of magnetic body which continues to be generated by p-adic-to-real phase transition.

Extrasensory perception via astral bodies is a second possible test. This test might make sense if extrasensory perception can be generated by patterns of ELF em fields as supposed in the TGD inspired model of qualia. Magnetic mirrors connecting organisms to each other and also to 'nonliving' matter make possible ESPs. Also direct electromagnetic perturbations of the magnetic sensory canvas can give rise to ESPs: in [K36] the possibility that the strange sounds produced by meteors [F1] could correspond to ESPs is discussed.

4. Tunnel experience

The theory of Grof and Halifax [J41] is based on the observation that NDE involves elements which might be assigned to the moment of birth. Perhaps NDE is reliving the moment of birth. The counter argument is that the newly born baby does not see anything unless she is able to perceive extrasensorily. 'Nothing but hallucinations' theories are of course no explanations at all and belong to the same category as 'consciousness as mere illusion' theories. In neuroscience framework also the wake-up reality is seen basically as a hallucination produced by brain and coupled with sensory input to guarantee correspondence with what is out there.

The tunnel is experienced also during epilepsy and migraine, during meditation and relaxed state of mind, and with certain drugs like LSD, phencyclidine and mescaline. It has been suggested that the physiology of brain could explain the properties of near death experiences [J29]. The theory of Cowan [J29] states that the tunnel results from a failure of the inhibition leading to brain induced activity yielding visual experiences. What is however questionable is why person would feel falling into the tunnel, to say nothing about meeting deceased relatives. Blackmore and Troschienko have proposed a theory in which also the motion along tunnel could be understood as a visual illusion [J22].

TGD based explanation for tunnel experience might be simply as a direct visual experience about magnetic flux tube structures resulting from the perturbation of the magnetic sensory canvas outside body. Thus a genuine ESP would be in question. Magnetic field obeys indeed same basic equation as incompressible liquid flow. Both retinas and pineal gland ('third eye' literally since it contains retinal pigments and serves as a genuine third eye in some species [K26]) are magnetic structures. The practically always present vortex in center ('third eye' in my private terminology) could correspond to the magnetic flux tube structure emanating from the pineal gland whereas the very dynamical flow could correspond to the contribution of retinas. If the magnetic mirrors are universal electromagnetic bridges connecting us to other living beings, in particular to our friends and relatives, the meeting of the 4-D bodies of the deceased relatives would happen at the level of fields.

The movement along the tunnel could correspond to the propagation of p-adic-to-real phase transition along this kind of magnetic mirror structure transforming it from p-adic to real: thus the tunnel would be created after the physical death. During lifetime these em bridges would be p-adic and physical death be followed via the transformation of these bridges to real ones.

I cannot resist the temptation of telling about a personal 'tunnel experiences' taking place every-

daily although this might be criticized as highly unscientific. For me science is attempt to identify the regularities of conscious experience and the only conscious experience I have is my own! As I close my eyes in a half-meditative state achieved by writing at computer terminal, I can see a dim flow consisting of points. Typically this flow enters to or emergences from a tunnel. It can be rotating spiral like flow or simple sink or source. Source or sink can be also linear structure. Earlier this experience was not stable and tends to fade away all the time, and after few minutes I was not anymore able to achieve it. Situation has changed quite recently: I can have the experience almost anytime in peaceful state of mind. During the "great experiences" this flow was much more complicated and completely visible and formed a stable background of the ordinary visual experience and of hallucinatory visual images.

There is however no experience of entering into the tunnel in this case so that the tunnel need not be the same as encountered in NDEs.

5. OBE aspect

Blackmore explains OBEs [J21] as resulting from the replacement of ordinary self-center experience of world with bird's eye of view model where brain sees own body from above. Bird's eye of view is only a memory model so that extrasensory perceptions are predicted to be impossible during OBEs. There is however some evidence that patients can report very precise visual perceptions during OBE. It has been indeed argued, that some other senses than vision, namely [K55] [J21] , could create indirectly these perceptions. It is however difficult for even the most hardborn materialist to understand how a clinically dead person could be able to effectively see by hearing, since this feat is impossible for even completely healthy person.

The idea of Blackmore about bird's eye of view is very attractive as such and can be interpreted in TGD framework in quite different manner. Cognitive maps based on the canonical identification map [K25] typically exterior to inside and vice versa. Thus both a p-adic map of the external world realized inside brain and a p-adic map of body and its surrounding realized outside the body are possible and would give models of the external world and self. The inside-to-exterior map could provide a bird's eye of view about body and its immediate surroundings.

Both exterior→interior and interior→exterior maps could contribute to the conscious experience even under the normal wake-up consciousness and the exterior contribution would thus represent genuinely extrasensory contribution to the conscious experience. When the ordinary sensory input and volitional activity ceases as during NDE, the contribution of the model of external world to the conscious experience becomes negligible. The ability to experience tunnel unstably during relaxed wake-up consciousness with eyes closed is consistent with the interpretation that these two components are competing. It is quite possible that during sleep the bird's eye of view component also dominates but that no memories about this period are generated for the simple reason that the brain functions necessary for the generation of the memories are not active.

The notion of magnetic sensory canvas implies that we actually see at ELF frequencies. Same applies to other senses. This implies the possibility of experiences without any sensory input or even without any neuronal activity. The needed ELF MEs acting as sensory projectors would be generated in the dropping of ions from atomic space-time sheets to the magnetic flux tubes of magnetic body carrying field strength .2 Gauss (Earth's magnetic field has nominal value .5 Gauss). If the ion drops in high n cyclotron state the subsequent decay of the state by cyclotron transitions generates a bundle of parallel ELF MEs giving rise to the sensory projection. This representation can be generated by the entire body and would give rise to a three-dimensional vision about body 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.
2. Becker tells in his book "Cross currents" [J15] about a young cancer patient who told that he can see the interior of his own body. The patient could locate the calcium deposit left as tumor vanished. This supports the view that ELF MEs could project from the entire body to the sensory canvas.
3. Also the OBE experiences, for instance those associated with NDEs, could have a similar interpretation. The sensory input from eyes and even the input from neural activity could be 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.

What has been said applies also to other senses. Maybe a personal reminiscence is allowed. As I was younger I often woke-up partially and realized that I hear my own snoring as an outsider: not a pleasant experience! Sometimes I 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 the outcome is a kind of double breathing with time lag.

Sensory canvas hypothesis provides a more concrete view about the situation. p-Adic-to-real phase transition of a p-adic magnetic sensory canvas to real one could also be part of the fundamental volitional process. The magnetic mirrors connecting brain to sensory canvas should be there also in the absence of sensory input. Could it be that the out of body view is always involved but masked by the from the body view and after the physical death only out of body view remains?

The competition between bird's eye of view and sensory view has also EEG correlate. Delta waves in the EEG spectrum are natural EEG correlates for the external part of cognition. The reason is that this part of EEG frequency spectrum has a shape and intensity very similar to that for the so called sferics [F4], which correspond to meteorological electromagnetic perturbations typically associated with thunder storms. Could sferics be the electromagnetic correlates of discarnates?! The degree of the sensory alertness correlates directly with the the ratio of the EEG net intensities in the delta band and in higher EEG bands [F4]. This is consistent with the competition predicted by NMP. Certainly in the NDE experiences studied by the Southampton team only delta band is present in EEG. Note that delta waves dominate also during deep sleep.

Also alpha band is a good candidate for communicating sensory information to higher level selves having magnetic sensory canvas receiving sensory input from several brains simultaneously. It is indeed alpha band in which detectable changes occur in remote vision and remote healing [J58]. Could it be that higher than alpha consciousness somehow transforms to alpha consciousness in physical death and could it be that alpha consciousness relates with the fact the lowest Schumann frequency associated with the perturbations of Earth's magnetic field is in the alpha band? It might be that magnetic transition frequencies are involved with the 'vertical' communications from brain to the sensory canvas whereas Schumann resonances would be involved with the lateral communications between different sensory canvases. The fact that hypnagogic experiences involving also identification with other persons (personal experience) appear in the borderline between wake and sleep when dominating EEG frequencies are around 7.8 Hz supports this view.

6. Life review

Blackmore explains the life review as an effect analogous to the lively episodal memories generated by stimulating temporal lobes. This explanation leaves open what exactly happens in the stimulation of the temporal lobes and what episodal memories are. To say nothing about the systematic review and evaluation.

In TGD framework brain and perceptive field are four-dimensional and it is quite possible that episodal memories are multitime experiences involving input which comes from the moment of the geometric time when the recalled experience happened and happens again at the level of sensory representation but not as real life event since this would involve macroscopic volition and induce miracle life events in the geometric future. The notion of 4-D body makes this idea concrete. In the physical death 4-D body becomes in some sense mature (about possible de-construction processes in shorter time scales). The volitional contribution essential for the illusion that world is 3-dimensional is not anymore present and entire 4-D body is experienced as a whole. Perhaps this is just what life review is.

Since geometric memories are in question, the review is only a narrative since our geometric past changes all the subjective time and the review is about geometric past subjectively now. Life review would be a temporal counterpart of the OBE experience in the sense that one sees one's geometric life history from outside in a 4-dimensional sense. This is possible since p-adic cognitive representations are four-dimensional and four-dimensional bird's eye of view could begin to dominate at the moment of death.

Also genuine subjective memories about time interval equal to the wake-up period of self and of order lifetime could be in question. This requires the occurrence of what might be called a p-adic phase transition to higher level self with much longer subjective memory: this view is in accordance

with the vision about the physical death as a birth to a life in 'other world'. p-Adic phase transition could mean that the p-adic magnetic mirrors after the geometric time after physical death correspond to higher value of p and quite concretely, have lengths which are longer than during the physical life. This makes possible both geometric and subjective memories in much longer time scale.

7. Positive emotions

With the motivation coming from the OBEs associated with the temporal-lobe epilepsy, it has been suggested that brain-stress near NDE episode leads to the release of neuropeptides and neurotransmitters (in particular endogenous endorphins) which are responsible for positive emotional states like joy, peace, and love. Again the question concerns about the deeper mechanism. Presumably these neurochemicals are only correlates for the experiences in which extra-sensory component of the experience begins to dominate. It has been also suggested that the lack of oxygen is what gives rise to the NDE experiences [J21]. The observations of the Southampton team seem to exclude these explanations. Of course, one could claim that some core parts of brain are working even when the patient is clinically dead (no respiration, no heart beat, dilated pupils) and that these functioning parts of brain are able to generate NDE. If so, spiritual experiences would represent the lowest possible levels of consciousness, and even reptiles would have them: perhaps a vulgar skeptic could applaude here but I do not find this idea very convincing.

In TGD framework clinical death naturally implies that extrasensory component of the conscious experience begins to dominate. This picture is consistent with the view about brain as p-adic-real transformer rather than the seat of the entire conscious experience. The dominance of the positive emotions would simply mean that the negative emotions coming from sensory input would be absent.

8. Other worlds

The experiencing of 'other worlds' requires a considerable amount of hand weaving in the standard neuroscience framework. Blackmore claims that imagined worlds are experienced as real because these experiences are the most stable. I believe that Blackmore is right in the sense that mental images (sub-selves) correspond to self-organization patterns which are stable asymptotic states of self-organization. I do not however believe that this is an essential point, and certainly Blackmore's explanation fails if the interpretation of the Southampton team about NDEs is correct.

In TGD framework the other worlds might correspond to the emergence of magnetic mirror structures which correspond to higher value of p-adic prime than during the physical life. They would have much longer lengths and give rise to much longer subjective and geometric memories. Note that the MEs associated with magnetic mirrors are classical representation for light (which brings in mind Tibetan book of death!) so that one could say that the deceased becomes a light being in a well-defined sense. The meeting of the light being might mean an ability to communicate with and sensorily experience the presence of other light beings, natural if the deceased herself has transformed to a light being (but having still 4-D body in the geometric past, this is perhaps why angels have human body!).

Note also that the absence of sensory and corresponding cognitive mental images during NDE is analogous to the empty mind free of mental images which is the goal of the meditation practices. Perhaps soul could be identified as a self having no sub-selves, 'irreducible self' as suggested in [K64].

9. After effects

The after effects induced by the spatio-temporally extended consciousness in which one sees one's own life from outside are often dramatic. It is difficult to reduce these after effects to brain pharmacology.

My own "great experience" had many aspects common to NDEs and induced profound (not at all pleasant!) changes in my own life. In my case the direct experience of the higher levels of reality made possible the realization how magnificent the almost-boring everyday reality really is when seen through sharpened senses, how pathetically narrow the zone of wake-up consciousness is, and how ridiculously little the celebrated big science tells about reality. This realization resulted in a strong conviction that I am on a right track, and has given the courage to work these fifteen years as a ridiculed scientific dissident in a country in which vulgar skepticism is in the role of a scientific state religion and vulgar skeptics have taken the role of the mind police of science.

6.5 Conscious hologram and remote mental interactions

The notion of conscious hologram allows also a unified description of remote mental interactions.

6.5.1 Big vision

The notion of conscious hologram, which is based on the generalization of the notion of Feynman diagram, provides a general view about remote mental interactions.

1. Brain can be seen as a part of a gigantic dynamical and fractal brain consisting actually of the entire universe. The same mechanisms that work at the brain level work also at larger length and time scales. Brains/bodies serve as 'neurons' for the magnetospheric selves receiving information from several brains/bodies. In particular the fusion of the mental images defined by similar structures can give rise to stereo-consciousness, and the notion of species consciousness and even multi-organ consciousness associated with various kinds of organs makes sense.
2. The notions of super-genome and hyper-genome provide a concrete view about how transpersonal levels of self-hierarchy are realized. Super genes are magnetic flux sheets containing sequences of genes like text lines at the page of book. Hyper genes are flux sheets containing sequences of super-genes belonging to different organisms as genetic text lines. This picture conforms nicely with and generalizes Sheldrake's species memory and 'alike likes alike' rule. It also suggest a concrete realization of remote biological mental interaction based on activation of gene expression and nerve pulse activity.

The flux sheets associated with super-genome and hyper-genome have fields strengths of magnetic field of Earth. The correlation of the quality of remote cognition performance with sidereal time [J60] leads to the hypothesis that also the flux quanta of galactic magnetic field couple somehow to living matter.

3. Besides time mirror mechanism charge entanglement realized in terms of W MEs is a basic mechanism of remote mental interaction. The simplest model for the generation of nerve pulse is based on quantum jump leading to a state in which Bose-Einstein condensate of Ca^{++} and/or Mg^{++} becomes exotically ionized and generates charge flow through cell membrane. Quite generally, charge entanglement would be part of the ordinary bio-control realized in terms of Ca^{++} waves. Charged entanglement provides also a mechanism for the sharing of mental images between magnetic body and biological body. There is no reason why this mechanism could not work also at the level of other remote mental interactions than those that we are too familiar with to realize that remote mental interactions are in question. The typical time 13-15 seconds associated with the remote realization of intentions by Qigong masters [J36] could correspond to a typical duration of W entanglement.

The models for bio-photons bio [I26] and Gariaev's findings [I34] suggest a tentative model for how remote mental interactions proceed. Charged entanglement via W MEs makes possible sharing of mental images. After a reduction of entanglement the generation of positive and negative energy MEs occurs and involves time mirror mechanism making possible remote metabolism and communications of declarative memories. In the case of ordinary bio-control magnetic body utilizes the metabolic energy resources of biological body.

4. Association mechanism works also for remote mental interactions and is even in the case of brain based on MEs and magnetic flux tubes with neuronal firing and metabolic activities being side products of the this mechanism.
5. One of the strange findings about remote mental interactions is that remote viewer can receive information about an object for which she knows only coordinates, which as such are meaningless numbers to her. It is also commonly reported that erroneous readings or interpretations of the target tend to propagate to other viewers. These findings suggest that magnetospheric (earthly or galactic magnetosphere could be in question) dynamical multi-brained selves act as kind of relay stations mediating the remote contact between remote viewer and object. If some brain knows the meaning of the coordinates of the target, this is enough to connect remote viewer to the correct target.

Empirical support for the notion of multi-brained collective levels of consciousness comes from the experiments of Mark Germaine [J39]. An operator and a subject person were involved. The stimulation of the subject person consisted of a sequence of identical sounds containing now and then an odd-ball stimulus (now silence). The odd-ball stimulus generated an event related potential (ERP) visible in EEG and reflecting the conscious reaction. The operator was in a second room and by simple toss of coin decided whether to observe the stimuli in the computer monitor or not. The stimuli appeared in the computer monitor one second before they were heard by the subject person.

What was found that when the operator saw the odd ball stimulus from the computer monitor, the ERP was weaker on the average. An 11 Hz periodicity was the major component in the difference profiles.

The simplest explanation is that the brains of both the operator and of the subject person belong to a larger multi-brained self and that the evoked response represented partially the reaction of this self. When this multi-brained self had already seen the stimulus through the operator's eyes, it was not so surprised to hear this stimulus again through the ears of the subject person, and ERP was weaker.

The appearance of the 11 Hz periodicity suggests that this frequency is an important correlate for the entanglement of the subject person's mental images with those of some multi-brained magnetospheric self. The cyclotron frequencies of most bosonic ions in Earth's magnetic field are in alpha band so that the finding is consistent with the vision about a fractal hierarchy of generalized EEGs associated with the dark matter hierarchy [K17]. The notion of hyper-genome provides a detailed model for how transpersonal levels of self hierarchy control the behavior of groups of individuals. The hypothesis could be tested by looking whether the gene expressions of individuals having close personal relationship but not in a direct personal contact correlate.

6.5.2 Sketch for what could happen in a typical remote viewing experiment

Consider a situation in which a system consists of remote viewer A, person B knowing the position of target T and the coordinates XYZ for it. B gives the coordinates XYZ for person C in turn giving them to the remote viewer A. The following simplified sketch assumes that communication channels are permanent and that the intentions involved with the process are realized as p-adic space-time sheets in the brain of A, and very probably involve p-adic MEs as representations of the intentions.

1. Remote viewer A, person B knowing having target-XYZ association as two mental images in his brain, and target T have permanent bridges to a magnetospheric multi-brained self M. Therefore M knows the target-XYZ association via the brain of B.
2. Remote viewer A is a client of the multi-brained self M using the remote sensory services provided by M. A-M contact is more or less permanent: this is what it means to have the ability to remote view. Minimum requirement is the existence of magnetic flux quanta connecting A to M. The sharing of mental images requires generation of entanglement, say charge entanglement by W MEs. This would correspond the most primitive passive mode of remote viewing. W mode allows to share also mental images of primitive living systems like plants, and even those assignable to system regarded usually as in-animate. The reduction of charge entanglement makes possible remote mental interaction since resulting charge non-equilibrium generates currents: generation of nerve pulse and Ca^{++} waves would represent basic example of this kind.
3. One can imagine also active mode of remote viewing and this could be involved with telepathy: in this case M would not be involved. This mode involves intentional action (p-adic MEs are transformed to their real variants) and classical communications with the geometric past/future using neutral negative/positive energy MEs could realize declarative memories/"declarative" precognition as well as motor action based on classical communications using symbolic representations. The model for bio-photons suggests that Z^0 and em MEs are generated after the reduction of charge entanglement. The ability to predict reasonable well the personal future could rely on "declarative pre-cognition". The evolution from bicameral mind to modern consciousness [K65] could have proceeded from a mere sharing of mental images by W MEs to complex classical symbolic communications involving also neutral MEs.
4. Since M cannot be assumed to have anything comparable to a nervous system, A-M communications should rely on sharing of mental images. That is, the intention of A (p-adic space-time

sheet in brain of A perhaps) to remote view and the questions of A about the target would be shared by M. T-M communications could involve classical communication with light velocity generating magnetospheric sensory representation about the target by self-organization. The 13-17 second delay of remote mental interactions [J36] could correspond to the typical duration of charge entanglement. Target could be also "non-living": it is quite possible that magnetospheric selves form sensory representations also about "non-living" matter. The finding that meteor sounds have frequency spectrum in the 40 Hz band of thalamocortical resonance frequencies, rather than in the predicted 20-20.000 Hz band, supports the view that magnetospheric sensory representations at 40 Hz resonance band are associated also with the non-living matter [K34] , [F1] . Also the vision about dark matter hierarchy conforms with the idea about Earth's magnetosphere as a living organism.

5. Remote viewing by the sharing of mental images means that there are no sensory receptors associated with the passive mode of remote viewing: no such receptors have been identified [J32] . Various physiological correlates (say EEG patterns) of remote viewing should be reactions to the shared mental image rather than direct correlates of it. If primary sensory qualia are at the level of sensory organs, remote viewing differs from hallucinations in that there is no feedback to the retinas from cortex responsible for "qualification": this could provide be a clear-cut test. At least in the case of living targets the laws that govern the ordinary sensory perception should hold true for the remote viewing. For instance, the known correlation of the AC performance with the spatial and temporal entropy gradients of the target should hold true for living targets. Even in the case of a non-living target similar correlation holds true if the sensory perception of magnetospheric selves obeys same laws as that of ours: there is some evidence for the correlation of the entropy of non-living target with the AC performance [J32] .

6.5.3 About the physiological correlates of anomalous cognition

In the article "Physiological correlates of Psi cognition" of Charles Tart [J62] some apparently contradictory findings about physiological correlates of anomalous cognition are described besides the experimental findings of Tart. Changes in EEG, galvanic skin response, finger pulse, and basal skin resistance are examples of possible candidates for the physiological correlates of remote mental interactions.

The findings are following.

1. The first class of experiments involves two persons: subject and agent. The agent is subjected to various kinds of stimuli inducing emotional response: sudden sounds, painful stimuli as in the experiments of Targ, etc.. Subject person is typically in a sound proof room and tries to remotely cognize when subject person experiences these stimuli. Various candidates for the physiological correlates are measured. The physiological correlates typically express a heightened arousal. For instance, in the experiments of Tart [J62] galvanic skin response occurred more frequently, and EEG became more complex with more beta waves and fewer alpha, theta, and delta waves.
2. In the second kind of experimental arrangement remote viewing or telepathy is involved but the second person, if present at all, is not subject to any stimuli inducing emotional reaction. Now the physiological correlates tend to be characteristic for a relaxed state of mind. The increase of the basal skin resistance is one such correlate.

At first these findings might seem to be contradictory. The paradox disappears if sharing of mental images is in question and if the mental images induce same emotional response in the subject person as in the agent.

The remotely perceived (possibly sub-conscious) stimulus or remote anticipation of the stimulus induces in the subject person an emotional reaction having as a correlate the reduction of skin resistance. In the experiments of Tart [J62] both the real electrical stimulus experienced by the agent and the electrical stimulus guide by the operator to an electrical resistance instead of the agent, generates the arousal in the subject. This requires that both the operator, agent, and subject belong to the same multi-brained self so that the reaction of the subject can be interpreted as a kind of conditioned reaction of the multi-brained self expressed via the body of the subject.

6.5.4 Local sidereal time, geomagnetic fluctuations, and remote mental interactions

The article of J. Spottiswoode [J60] discusses two strange findings about remote mental interactions.

1. There is a statistical tendency of the anomalous cognition (AC) performance to concentrate in a 2 hour period around 13.30 of the local sidereal time (ST), which is the time measured using as a reference distant stars and thus running at a slightly different rate than the solar time: the lag is $\Delta T = 24/365$ hours ~ 3.7 minutes during 24 hours.
2. The anticorrelation between the level of geomagnetic fluctuations and AC performance has also a maximum during 2-hour period around ~ 13.30 ST.

The fact that AC performance is associated with the same sidereal hour suggests the identification of the galactic magnetosphere as a conscious involved with remote cognition. For interstellar and galactic magnetic fields cyclotron time scales correspond to the time scales of human consciousness so that also these magnetic flux quanta could receive sensory input from biosphere and control it.

Support for the role of magnetospheric consciousness

The so called ap index measures the intensity of the fluctuations of the Earth's magnetic field. If the magnetosphere is a conscious entity, ap index can be interpreted as a measure for the level of arousal of the magnetospheric mind. The negative correlation between ap and AC performance tells that AC is most probable, when the magnetosphere is in a "calm state of mind". This is natural since only in this kind of situation the noise masks minimally the signals from the galactic magnetosphere.

The local magnetic noise produced by the modern high tech environment is much stronger than the geomagnetic noise but this does not matter. If artificial magnetic fields correspond to $k_d = 0$ level of the dark matter hierarchy, they have no effect on higher levels of dark matter hierarchy.

Is there an ELF signal from the special direction masked usually by the geo-magnetic noise?

The obvious question is why the anticorrelation between anomalous cognition effect size and ap index is highest at 13.30 ST? What this finding means that a particular portion of the sky defined by a definite longitude is above the head of a successful anomalous cognizer independently of the time of year. Thus there should be something special in a direction at this longitude.

The simplest explanation for these findings goes as follows.

1. Suppose that there is a higher level conscious entity at the direction 13.30 ST at the galactic magnetic body such that various cyclotron frequencies involved with the communications with this entity correspond to a typical time scale of the anomalous cognition. This conscious entity could have size of galaxy or it could correspond to a flux tube of galactic magnetic body using the cognizer and target as sensory receptors and motor instruments just as our magnetic body might use neurons of our brain or our body parts.
2. Anomalous cognition could involve positive and negative energy signals to this magnetic body and back so that essentially instantaneous AC events would be possible.
3. The information transfer between two kinds of flux tubes is made possible by the topological condensation of the flux tubes of B_E or its dark variant at those of the galactic magnetic field or its dark variant and would be maximal when both are nearly vertical. Also geomagnetic noise would be transferred via wormhole contacts to the flux tubes of the galactic magnetic field and perturb these communications. Both AC and its anticorrelation with geomagnetic noise would be maximal when the flux tubes of magnetic fields in question are approximately parallel. Since the flux tubes of B_E are approximately vertical, this the case when the galactic center is directly above the head. This would explain the special value of sidereal time. One can say that the magnetic flux tubes of the interstellar magnetic field define kind of cosmic umbilic cord which might serve as a correlate for the tunnel experience associated with NDEs.

4. If signals to geometric past and back are involved the time and length scales would be measured using 10^5 years as unit. The signals themselves would be coded using frequencies characterizing time scales of neural consciousness as kinds of ripples to the very slowly oscillating background signal just as perturbations due to nerve pulses interfere with EEG rhythms. Since remote psychokinesis and anomalous cognition should rely on the same mechanism, the first guess for the time scale involved with these signals is as the time lag of 13 to 17 seconds involved with the remote realization of intentions by Qigong masters [J36] : the interpretation as a typical duration of charge entanglement was already proposed. It would not be surprising if the time scale of entanglement would determine also the scale of cyclotron frequencies. This would mean the importance of the frequencies in the range .06 to .08 Hz for anomalous cognition.

The following scenario suggests a possible manner to understand the time scale of remote PK.

1. If protonic cyclotron transitions generate the low frequency MEs in the range $f_1 = .06$ Hz to $f_2 = .1$ Hz, the strength of magnetic field must be in the range 13 to 17 nT (nanotesla). The magnetic flux tubes of an interstellar magnetic field in a direction with a longitude defined by 13.30 ST should be in question.
2. The ends of the magnetic flux quanta attached to structures within the inner magnetosphere co-rotate with Earth. The resulting twisting presumably tends to induce additional noise to the interstellar magnetic field or Earth's magnetic field or both.
3. The strengths of the typical disturbances of Earth's magnetic field are in the range 50-200 nT [J60] . The average strength for a given frequency component for the fluctuating part of the Earth's magnetic field increases at low frequencies. At the alpha band the strength of the Fourier component of fluctuations is about $\sqrt{B^2(f)} \simeq 1 \text{ pT}/\sqrt{\text{Hz}}$ at alpha frequencies. Interestingly, the magnetic perturbation produced by brain at alpha band has a peak, which is slightly above the fluctuations of the Earth's magnetic field. This is perhaps not an accident in light of the expected role of the alpha band in remote mental interactions. The strength for the Fourier component $B^2(f)$ for the fluctuations of $B^2(t)$ [J14] is roughly $\sqrt{B^2(f)} \simeq .1 \text{ nT}/\sqrt{\text{Hz}}$ at $f_2 = .01$ Hz, and about $\sqrt{B^2(f)} \simeq 10 \text{ nT}/\sqrt{\text{Hz}}$ at frequency $f_1 = .06$ Hz.

What puts bells ringing is that the noise level 50-200 nT is by a factor 4 to 15 higher than the required interstellar static magnetic field at the lower limit corresponding to the 17 second period. These findings suggest that magnetic fluctuations tend to mask the positive effect of the interstellar magnetic field on AC. Only when the strength of the fluctuations of the Earth's magnetic field at the cyclotron frequency of the interstellar magnetic field reduces sufficiently below the strength of the interstellar magnetic field, the masking effect is small enough.

What is the origin of the interstellar magnetic field?

The idea about the magnetic umbilic cord connecting distant astrophysical objects to a single quantum coherent whole is sensible in the many-sheeted space-time. The TGD based model for the galaxy formation assumes that the ordinary matter results from the decay of cosmic strings, which are objects carrying extremely strong magnetic fields (magnetic flux tubes and these objects belong to the same solution family of field equations). These cosmic strings form a complex network. For instance, this model explains gamma ray bursters [K67] .

The huge energy production of gamma ray bursters is consistent with their huge distance only if one assumes that the energy is liberated in jets. In TGD framework the gamma ray bursts can be identified as jets resulting in the decay of split cosmic strings giving rise to the ordinary matter. The bursts are indeed known to originate in the regions, where new stars are born. This picture supports the idea about the existence of a fractal magnetic flux tube network connecting different astrophysical objects, and left as a remnant from cosmic strings, when their magnetic energy transformed to the ordinary matter and gave rise to the birth of stars. This network could give rise to galactic nervous systems in turn combining to the central nervous system of the Universe.

Surprisingly, this picture might be consistent with the constraints on the direction and magnitude of the interstellar magnetic field.

1. According to the online lecture of S. Oliver [E4], the measured values of the interstellar magnetic fields depend somewhat on the method with which they are measured (this might be a signal of the many-sheetedness). The interstellar magnetic fields vary in the range $B_u = 1$ mGauss– $B_l = .1$ μ Gauss [E9], which means that both electronic and protonic cyclotron time scales for all interstellar magnetic fields correspond to time scales relevant for human consciousness. The minimal values of k_d are $k_d = 53$ for B_u and $k_d = 66$ for B_l from thermal stability: .1 second time scale of alpha band is mapped to 50 s for B_u and to ~ 3 days for B_l .
2. The synchrotron radiation associated with the diffuse emission from the whole sky but concentrated towards galactic plane corresponds to a field strength $\sim .6$ nT. Zeeman splitting for hydrogen 21 cm line from condensing clouds gives fields in 1-2 nT range. In the plane of the galaxy the field is roughly parallel to spiral arms and its strength is .1-1 nT and too weak to correspond to the proposed magnetic umbilic cord. Also the direction of the spiral arm is different from the direction of the required magnetic umbilic cord.
3. The second guess is that the magnetic umbilic cord is orthogonal to the galactic plane. The direction of the galactic North Pole has the right ascension (identifiable as the sidereal time at the meridian of the rotating observer) RA=12.49 $\delta = 27.4$ degrees: RA is not too far from 13.30 so that this guess might make sense. Taking into account that the rotation axis of is tilted by 23.5 degrees towards Sun this would mean that the direction of the magnetic umbilic cord is with accuracy of 3 degrees in the plane defined by the orbit of Earth around Sun. Interestingly, the magnetic field associated with the solar wind varies in the range .2 – 80 nT and average value is 6 nT.

According to [E9], galactic center carries a dipole like field with a strength of order 100 nT, not too far from 10-30 nT. Also this field has filament like structures (flux tubes), which might extend to long distances [E9]. The flux tubes of this field should intersect the galactic plane orthogonally. If the strength of the magnetic field inside the flux tubes stays constant rather than varying like dipole field strength, these flux tubes could give rise to the magnetic umbilic cords connecting us directly to the center of the galaxy. Galactic center, perhaps the immense black-hole region there, could be an monstrous brain having galaxy sized central nervous system! That the model for magnetospheric consciousness would generalize to the scale of entire galaxy would conform with the fractality of consciousness.

4. According to [E9], supernova remnants are accompanied by radial filament like structures carrying magnetic field in 1-10 nT and it seems that supernova wind might carry this field around galaxy: very natural if flux tubes carry the field. According to [E4], for individual sources such as supernova remnants like Cas A Minor, the field strength is 10-30 nT. This corresponds to the interval 5.6 to 17 seconds. That the field strength is of the same order of magnitude as the dipole field at the galactic center conforms with the idea about magnetic nervous system of galaxy connecting the center of the galaxy to the stars. This magnetic field would be easy to observe in case of supernovae because super nova explosion has packed magnetic flux tubes to a very dense bundle.

Connections with other effects?

There might be fascinating connections with other strange findings.

1. In Comorosan effect [K86], [I23] the irradiation of a bio-matter with a laser irradiation lasting for a multiple of 5 seconds has anomalous effect on a catalyst action. 5 seconds corresponds to $n = 3$ cyclotron transition for proton in a magnetic field of 10 nT. Comorosan effect occurs also in a non-living matter and suggests that the magnetic umbilic cord serves as a kind of cosmic clock.
2. The strength of the Earth's magnetic field in far-away in the plasma sheet is about 10 nT. Could this cosmic magnetic umbilic cord be connected with the plasma sheet and be in a synchrony with what happens there? Plasma sheet is known to be highly self-organizing structure containing in the velocity distributions of charged particles features like "wings" and "eyes" [F2]. In [K36] I have proposed that plasma sheet defines the "self model" of magnetospheric brain and is thus

in a role analogous to the insula in the human brain. It would rather natural for the cosmic umbilic cord to couple with that part of the magnetospheric brain which corresponds to the highest level in the self hierarchy associated with the magnetic Mother Gaia.

3. Lungs contain magnetic particles giving rise to magnetic field of about 10 nT. The theory of magnetospheric sensory representations inspires the speculation that the moment of physical death is decided by magnetospheric self sending to lungs stopping signal at proton's cyclotron frequency associated with 10 nT magnetic field.

6.5.5 Could magnetic flux tubes make possible effective holograms?

What conscious holograms really are? Are they genuine holograms or are they holograms only in the sense that the scattering of light beams from them is very much like scattering on ordinary holograms - that is like scattering from the original object. Could one imagine mechanism making possible scattering from the original object effectively represented by the hologram like structure?

To proceed notice that there is rather general belief that just some objects possessed by the patient is enough for healer- in some sense this object are holograms of the patient. Usually this belief is of course regarded as primitive pars pro toto magic. This belief might however have some justification in terms of negentropic entanglement expected to be fundamental aspect of remote mental interactions. In principle negentropic quantum entanglement can take place via arbitrary number of relay stations and magnetic flux tubes connecting the entangled objects would be the quantum correlate for it. Negentropic entanglement would serve as a correlate for attention, experience of understanding, etc., and it would correlate closely with metabolism: generation of ATP and associated high energy phosphate bond would generate negentropically entangled electron Cooper pair or add electron to negentropically entangled existing many-electron system and its decay to ADP would liberate metabolic energy quantum and destroy the negentropic entanglement.

Negentropic entanglement could actually mean that objects of the external world - say living beings - can act like parts of our biological body. There is a wide variety of psychological experiments which show how illusory is our view about what our body is. Quantum entanglement of object with its target having magnetic flux tubes as geometric correlates making object a relay station. The object - call it O - would only serve as a relay station connected to say person, call it P , possesses the object. The light scattering from the O could actually transform to dark photons and travel along flux tubes to P , where it is scattered back- say from DNA- and returns back along flux tubes and leaves O . Effectively this is like scattering from a hologram of P represented by object O . The flux tube connection would make various objects in our vicinity effective holograms. This is something that one actually expects since attention- both visual and auditory - has flux tubes connecting perceiver to the target of attention as correlates.

One can consider two options since the radiation to object could transform to positive or negative energy photons. In the first case scattering could be seen as ordinary scattering from P . Negative energy photons would however represent signals traveling to the geometric past (analogs of phase conjugate laser beams) and scatter back from P as positive energy photons traveling to O . TGD based models of memory as communications with the geometric past and intentional action as a process in which negative energy signal to geometric past initiates neural activities (Libet's findings about active aspects of consciousness) involve similar mechanism. Also the remote metabolism based on sending of negative energy signals to a energy storage (analogous to population inverted laser) relies on the same mechanism.

Peter Gariaev's experiments irradiating DNA with red laser beam generate broad of radio waves, which in TGD Universe could correspond to photons with same energy but with large Planck constant. These photons have biological effects on organisms of the same species and even on closely related species. TGD based proposal is that the scattered laser beam defines a collection of frequencies serving as addresses for parts of DNA activating gene expression.

If this represents a basic mechanism of genetic expression, one can quite well imagine that an organism- call it A - whose DNA is somehow damaged, could utilize the healthy DNA of another organism - call it B - by sending to it the counterpart of laser beam which scatters and generates the superposition of dark photon beams serving as an address activating the DNA of A . A would effectively use the DNA of B and B would effectively become part of A 's biological body. This mechanism could explain why the mere presence of healthy organisms of the species can induce the healing of organism

which is not healthy. It could be the basic mechanism of healing: patient could remotely use the healthy DNA of the healer to generate signals activating her own genes.

Some further comments and questions are in order.

1. The relay station mechanism could universal in biology. The transformation of ordinary photons to dark photons at flux tubes defining the magnetic body of DNA is assumed in the model explaining the photos taken by Peter Gariaev and his group about DNA sample showing the presence of what looks like macroscopic flux tube structures [K1].
2. The mechanism could also explain phantom DNA as real DNA connected by flux tubes to the chamber that contained the original DNA. The laser beam arriving to the empty chamber would travel along flux tubes to the place, where the removed DNA is, scatter and return back. This would create the scattering pattern assigned with the phantom DNA.
3. One can even ask whether the basic mechanism of homeopathy relies on relay station mechanism. Homeopathically treated water would be a collection of flux tube connections to the molecules, which were present in the first stage of the preparation process of the homeopathic remedy. Since the dark photons travel with light velocity, the times for travel of photons would be so small that the scattering of incoming light via the relay station mechanism would almost instantaneous so that the original molecules would be effectively present.
4. For instance, the de-differentiation of cells which looks to my rather mysterious phenomenon, means rejuvenation. Could one imagine that the genetic programs are replaced with those in geometric past and similar mechanism is at work. Could the rejuvenation mechanism involve scattering of the counterpart of phase conjugate laser light from non-differentiated healthy cells of the geometric past? If so, one should try to achieve the same effect directly at the level of cells. One could try to induce de-differentiation of the cells of the owner of the object serving as a relay station in the same manner. Healing of say cancer cells by de-differentiating them to omnipotent state. In the experiments involving Becker's DC current just this happened. In this microscopic situation might be can demonstrate the effect really convincingly.

The knowledge about OBEs [J6] like NDEs (and often part of NDEs) relies mostly on reports about subjective experiences and the experimental testing of theoretical models is difficult if possible at all. OBEs can be generated nowadays by electrical stimulation of brain and this gives hopes about laboratory testing. On the other hand, TGD based view about life and consciousness introduces the notions of magnetic body and dark matter and about dark matter only its existence is known. Therefore the theory is unavoidably very speculative and OBEs might pose the badly needed constraints on imagination. The following contains a brief summary about what OBEs are describe very briefly a model for them with possible answers to some basic questions about OBEs. A more detailed treatment of OBEs in TGD framework can be found in [K74].

6.6 TGD inspired model for OBEs

It is good to develop the model for OBEs by first summarizing what OBEs are and then listing the basic TGD specific ingredients of the model and then proceed by making questions (I hope that reader does not feel them to be leading).

6.6.1 OBEs, autoscopy, heautoscopy, and other strange experiences

Phenomenological characterization

The phenomenological characterization of OBEs [J6] has been discussed in [J50]. A precise definition of OBE is to have sensation of being outside the body. Autoscopy experience involves a also a sensation of seeing a mirror double of the body or part of it or at least experiencing its presence. There is a form of AS in which some internal organs are perceived. In one form form of AS only the presence of double is experienced. AS experiences are often accompanied by physical difficulties such as migraine episodes and epilepsy.

Heautoscopy refers to an experience of meeting one's alter ego, doppelganger. The main differences to AS is that in AS the double is mirror image and that alter ego is experienced to have also duplicated features of psychological self.

OBEs are classified to parasomatic and asomatic experiences according to whether the person experiences of having body or not. In aparasomatic experience a detachment from both the physical and parasomatic body is experienced. Blackmore suggest that OBE starts when sensory input from the body ceases while person remains conscious [J20] . This brings in mind the notion of subtle body of spiritual practices identified as the body experienced during lucid dreaming [J71] . The notions of guardian angle and ba-ka double of ancient Egypt, could relate to the double body too.

There is also a classification of OBEs to asensory, naturalistic and supernaturalistic ones. Asensory experience lacks sensory percepts about environment, naturalistic one involves perception of familiar surroundings, and supernaturalistic other-worldly realms like heaven or visits to other planets and contacts with aliens.

One can distinguish between natural and enforced OBEs. Natural OBEs are triggered by exhaustion, illness, traumatic events, NDEs, meditation, etc.. Enforced experiences can result from intoxication, anesthesia, hypnosis, etc..

OBEs induced by electric stimulation

Relatively recently OBEs and AS experiences have been produced by an electric stimulation of the angular gyrus [J52] . Angular gyrus is located in the parietal lobe, near the superior edge of the temporal lobe, and is involved in processes related to verbal communication and cognition and also with the transformation of written language to internal monologue. The experience developed to a full fledged OBE as the intensity of electric stimulation was increased. The electric stimulation induced responses in vestibular and sensory-motor systems, two of three systems which govern body balance.

According to experimenters, OBE and AS frequently involves what they call pathological sensations of position, movement and perceived completeness of one's own body. These include vestibular sensations such as floating, flying, elevation and rotation, visual body-part illusions (illusory shortening, transformation or movement of an extremity) and the experiences of seeing one's body only partially during OBE or AS. Authors believe that these experiments yield neurological evidence about the common neurological mechanism behind OBEs and AS experiences.

[J50] [J7] has criticized the interpretation of experiments.

1. Only single subject person was studied. She suffered from temporal lobe epilepsy and the epileptic region was at distance of about 2 cm from angular gyrus. Hence one can ask whether genuine OBEs were in question and whether the results generalize to healthy persons.
2. The OBE was not typical. For instance, body was seen only partially and the conscious attempt of the subject person to examine it more closely led to its disappearance. The environment was not perceived.
3. The claimed localization of the spot inducing OBEs to angular gyrus might be an illusion. Some researchers have represented results in which the OBE is induced in a different manner. Interestingly, the experience is associated with the generation of 4 Hz theta wave, which corresponds to the dominating EEG band during sleep.
4. The reductionistic conclusion that OBEs can be reduced to neuropathology and are thus "only" hallucinations is not justified. What has been shown is that electric stimulation of angular gyrus helps to induce the OBE and this leaves a lot of room for theorizing.

Explanations of OBEs and related experiences

The explanations for OBEs can be divided to two classes.

1. Something is assumed to leave the body.
This something could be something physical or non-physical ("astral"). In some cases people who have had OBE share reported of having perceived objects that were actually there and having experienced events and dialogue that truly happened. Charles Tart has documented the case of Miss Z [J63] who in controlled experiments was able to deliver the randomly selected

five digit number which was in a position which could be seen only from the position out of her body. Telepathy would be an alternative explanation for this.

2. Nothing leaves the body.

Parapsychological explanations involve remote sensing and hallucinations. Psychological explanations regard OBEs as basically hallucinations. The observation that electrical stimulation generates both AS and OBE could be seen as a support for this interpretation. Of course, one can ask what hallucinations really are. Furthermore, the reports about seeing internal organs during AS experience [J15] are not easily explainable as hallucinations.

TGD based model does not fit into either category. The model involves the notion of magnetic body serving as the third person receiving visual stimulus from the body and reflecting it back to the brain where it is processed. In this model the conflict between hallucinatory character of AS and OBEs and a real perception of body from outside is only apparent. The basic mechanism allows to develop also a more detailed model for dreams, hallucinations, third person aspect of wake-up consciousness, and directed attention.

6.6.2 Questions

In the following the model is developed by posing questions about OBEs.

Where the information processing giving meaning to what is seen is carried out?

Seeing is much more than just receiving the photons on retina, since a lot of information processing is needed to give meaning to what is seen. This essentially involves a decomposition of visual input to recognized objects having relations to each other and to the past of perceiver. This applies also to the visual percepts during OBEs. The most natural candidate for the system processing the visual stimulus and giving it meaning is the brain of the subject person.

Sharing of mental images allows to consider an alternative interpretation based on telepathy. The sensory organs in other bodies receive the visual stimulus and other brains do the information processing. For instance, "unconscious" victim of accident could share the fused mental images of people around the place of accident. This would explain the case of Miss Z studied by Tart [J63] as telepathy.

Are OBEs "only" hallucinations?

In TGD framework the first possibility is that the sensory stimulus is always artificial and comes from brain to eyes and other sensory organs by back projection. OBE would be a dream like cognitive representation, simulation rather than a real percept. REM is expected to always accompany OBEs in this case.

There is an objection against this idea. If person is unconscious or has NDE, it is questionable whether she is able to construct such high level cognitive representation as the representation of the state of her own body as seen by outsider is, and even transform it to a sensory representation. One can also ask what hallucinations really are. In TGD framework hallucinations must be generated by an artificial sensory stimulus so that hallucinations and genuine OBEs might involve the same basic mechanism.

Does OBE originate from an actual sensory stimulus?

The well-known fact that body parts indeed contain holograms about other body parts [I39] (see the discussion in [K31]) and the TGD view about the relationship between dark and living matter [K16] allows to consider seriously the possibility that OBE originates from an actual sensory stimulus.

The dark photon laser beams emanating from the body would be received by a magnetic body containing dark matter at some level in the hierarchy of magnetic bodies and would be reflected back to the receiving sensory organs along MEs possibly parallel to magnetic flux tubes rather than space-time sheets along which ordinary visual input arrives.

It is quite possible that several magnetic bodies in the hierarchy are involved. The magnetic bodies involved need not always correspond to a personal magnetic body and could receive input from

several biological bodies and remote vision and telepathy might involve signals from brain reflected to a second brain via multi-brain magnetic body. Magnetic bodies could be associated also with "dead" matter.

In this picture the case of Miss Z could be understood in two alternative manners. A dark photon beam possibly created by the visual representation of the random number (does "dead" matter generate sufficiently intense beams of this kind?) and reflected by personal magnetic body could be in question. Alternatively, the magnetic body involved could receive the information about random number from the brain of the experimenter and reflect it to the brain of the subject person.

Why does electrical stimulation induce OBEs?

Electrical stimulation of angular gyrus induces OBEs just as the stimulation of neurons of temporal lobe induces long term sensory memories. In neurological "brain only" approach the interpretation would be that the responses in the vestibular and somatosensory system induce the AS and OBE as hallucinations. In TGD framework the response in vestibular and somatosensory system would be interpreted as a response to an actual experience of being in a detached position and orientation, and brain would process genuine sensory data about being in detached position.

One might think that the temporal ordering between the experiences and these responses would allow to decide which causes what. In TGD framework negative energy signals propagating backwards in the geometric time are however a basic element of brain functioning and this criterion need not be apply.

One imagine two mechanism generating OBEs.

1. The mechanism inducing visual OBE and related experiences could simply turn off the ordinary sensory input so that only the dark photon beams from the magnetic body and reflected back from biological body would contribute to the visual stimulus. This would occur automatically during dreams and NDE experiences.
2. The sensory input from the magnetic body could be amplified. Time mirror mechanism could be responsible for this amplification [K81]. During epilepsy strong electric fields generated by brain during epilepsy induce starvation of neurons and the electrical stimulation of angular gyrus could have the same effect. Starving neurons would generate a beam of phase conjugate (negative energy) dark photons received by magnetic body in order to get metabolic energy. The magnetic body would be in a state analogous to a population inverted (possibly many-sheeted) laser defining a hologram like representation of the body. The receipt of negative energy photons would induce a cascade like induced return to the ground state and amplify the dark photon beam arriving from magnetic body so that it would not be masked by the ordinary visual input anymore and would give rise to a percept.

6.6.3 Dark matter hierarchy, zero energy ontology, negentropic entanglement, OBEs

Dark matter hierarchy, zero energy ontology, and the notion of negentropic entanglement lead to new insights also about OBEs.

Basic ingredients of the TGD inspired model

The model of OBEs involves several ingredients that are specific to TGD.

1. Magnetic bodies and field bodies are excellent candidates for the "third person" seeing the ordinary body. Magnetic body could receive a visual stimulus from ordinary body and reflect it back as a visual stimulus during OBE processed by the brain of the subject person. Thus body would see itself from the perspective of the magnetic body. Also dreams and hallucinations might involve the same mechanism. In the case of hearing sounds created by subject person could be reflected back to her ears or more plausibly, microwave hearing [I48] could be involved.
2. Topological light rays ("massless extremals", MEs) are an element of TGD having no counterpart in Maxwell's ED and play a key role in TGD inspired theory of consciousness. The interpretation

of MEs has remained somewhat obscure. The development of TGD based model for dark matter residing at magnetic flux tubes and characterized by large value of Planck constant implying quantum coherence in even macroscopic length and time scales changed the situation in this respect. The model for dark matter as macroscopically quantum coherent phase is discussed briefly in this book in chapter [K50] and more extensively in the book "Genes, Memes, Qualia, and Semitrance" [K16]. MEs can be identified as space-time correlates of Bose-Einstein condensates ("laser beams") of dark photons. It is however still unclear whether ordinary laser beams actually correspond to dark photon Bose-Einstein condensates and become visible only in de-coherence to ordinary photons. Negative energy MEs can be identified as correlates for phase conjugate laser beams of dark photons. The so called time mirror mechanism is universal building block of basic biological and brain functions [K81].

3. Bio-systems as conscious holograms is one of the key ideas of TGD approach [K8]. Bio-holograms [I39] suggest themselves as primary sensory stimuli quite generally. Biological body could generate dark photon "laser beams" received by magnetic bodies and reflected back to retina or perhaps to pineal gland [J47], the "third eye". This would explain AS as well as the images of internal organs [J15]. Also other systems, at least living systems, could be seen from the perspective of the magnetic body. Remote vision hypothesis testable by using living targets not visible in ordinary sense. This would give also rise to telepathy if reflection occurs from magnetic bodies of another person.
4. In TGD framework sensory organs are identified as seats of primary sensory experience and brain only constructs symbolic representations about percept, in particular identifies objects of perceptive field. This does not exclude a considerable back projection to sensory organs modifying the sensory input. Dreaming involves back projection to sensory organs inducing artificial sensory experiences as simulation. One possibility is that dreams and hallucinations represent direct back projection to sensory organs along neural pathways. An alternative view is that the projection involves dark photon beams generated by brain and reflected back from the magnetic body. If OBEs are hallucinations, the visual sensory memories of the subject person about herself could serve as building blocks to generate simulation about what person looks like when seen from outside.
5. Sharing and fusion of mental images is one of the basic notions of TGD inspired theory of consciousness [K81, K8]. One can ask whether OBE involves sharing of the visual experience of other persons involved about subject person. If this were the case, the presence of other persons would be necessary to have OBE. Sharing of mental images would explain the case of Miss Z as telepathy.

Dark matter hierarchy

The identification of dark matter as a hierarchy of quantum phases labeled by the values of Planck constant [K20] provides additional insights about OBE experiences. Planck constant is quantized and can have arbitrarily large values and since Compton length and other analogous quantum lengths and times scale as Planck constant, this means macroscopic and macro-temporal quantum coherence and a reduced rate of dissipation.

Also the magnetic body controlling biological body (actually onion-like hierarchy of them) is assumed to carry dark matter and (forgetting ontological delicacies) dark matter could be seen as the agent responsible for the quantum control of ordinary matter in living systems. The value of Planck constant becomes also a measure for the evolutionary level of the living system and great leaps in evolution can be identified as transitions increasing the maximum value of \hbar in "personal" hierarchy of magnetic bodies [K17].

Zero energy ontology and causal diamonds

Zero energy ontology is second new element of quantum TGD and states that all physical states have vanishing net values of conserved quantum numbers. Zero energy ontology provides a firm justification for the notion of negative energy signals consisting of (say) phase conjugate photons propagating to the geometric past. These negative energy signals are crucial element of the time mirror mechanism

playing a central role in the general mechanism for intentional action, remote metabolism, and long term memory.

Causal diamond (CD) defined roughly as the intersection of future and past directed lightcones serves as an imbedding space correlate for zero energy state. Space-time sheets representing zero energy states are inside CD and the future *resp.* past boundaries of CD carry positive *resp.* negative energy parts of zero energy states.

What is important from the point of view of consciousness theory is that CD s serve as imbedding space correlates of selves and sub- CD s as those for sub-selves (mental images). Sub- CD s are very much analogous to music instruments in the sense that the frequencies which come as harmonics of the fundamental frequency defined by the proper time distance between tips of CD (coming as powers of two) resonate with the geometry of CD and put it to "ring". Sub- CD s could be seen as an analog of radio receiver as far as sensory representations are considered and sending antenna as far as the motor control of biological body is involved. This allows to communicate sensory data from brain to sub- CD s at magnetic body CD in a highly selective manner. MEs (massless extremals) mediating the communications between magnetic body and biological body are also very much like strings of a music instrument. This picture generalizes the earlier music metaphor applied to axonal pathways.

A more precise definition of CD is as the Cartesian product of the intersection of future and past directed light-cone with CP_2 . The hierarchy of Planck constants brings in additional structure. There is identification of preferred $M^2 \subset M^4$ defining a preferred time direction (rest system/quantization axis for energy) and spin quantization axis. The preferred geodesically trivial sphere $S^2 \subset CP_2$ and the selection of point assigned with CP_2 at the future and past boundaries of CD gives rise to a selection of quantization axes of color isospin and hyper charge.

Sensory representations are a key element of the consciousness theory and the moduli space of CD s characterizing what kind of CD s are possible brings in new representational resources.

1. The moduli space of sub- CD s involves the position for the either tip of the sub- CD and the naive expectation is that this position could code for the position of the perceptive field. If so the representation would be very concrete and since the size of CD is already for electron with .1 lightseconds the representations is realized automatically in astrophysical scale.
2. The moduli space of sub- CD s assignable to the mental images with another tip fixed could represent geometric qualia. Without any further restrictions this space corresponds to proper time constant hyperboloid of future light cone. The values of time parameter come in powers of two. One can however quite well consider the possibility that only a discrete lattice of the hyperboloid is realized- at least in the intersection of real and p-adic worlds.
3. A Lorentz boost for sub- CD induces scaling of frequency and scaling of the object in the direction of the boost. Therefore boost coded to the fundamental frequency of CD could code for various shapes of a figure obtained by scaling. Boost of sub- CD leaving the other tip of sub- CD invariant could also code for the velocity of object. Also the velocity of the object of the perceptive field could be coded to the shape of sub- CD by performing corresponding Lorentz boosts to it [K58] .
4. The moduli space of CD s contains also the choice of quantization axes of energy (preferred rest system) and spin as well as the choice of quantization axes of color isospin and hyper-charge identifiable as flag manifold $SU(3)/U(1) \times U(1)$. Mathematician Barbara Shipman has proposed that this flag manifold is involved with the representation of geometric data in honeybee dance [A26] and I have proposed a model for what might be involved [K26] .

The moduli space of CD s is thus highly relevant for the representation of the geometric data associated with the objects of the perceptive field and the this data would be communicated using MEs with harmonics of the fundamental frequency of sub- CD so that sub- CD would act like radio receiver. This includes the position of the real object codable to the position of sub- CD s at magnetic body, the velocity of the object of the perceptive field codable to the Lorentz boost changing the shape of sub- CD and represented as scaling of the frequency assigned with the stationary object. Also the shape of perceptive field would represent this kind of geometric data. This picture supports the interpretation of sub- CD s as spotlights of attention giving information about many-sheeted space-time inside the regions defined by the sub- CD s. It would seem that sub- CD s are dynamical objects

created, destroyed, and shifted in quantum jumps. This picture is also consistent with the explanation for the arrow of psychological time based on zero energy ontology [K80].

Negentropic entanglement

The third new element is the notion of negentropic entanglement making sense when entanglement probabilities are rational or even algebraic numbers. Negentropic entanglement makes sense in the "intersection of real and p-adic worlds" consisting of partonic surfaces whose mathematical representations make sense both in real sense and p-adically. Negentropic entanglement is possible also between different number fields in accordance with the idea that cognition corresponds to p-adic number fields and cognitive representations are realized in the interections of realities and p-adicities. Living matter is identified as matter in the intersection between real and p-adic worlds. This view together with zero energy ontology allows precise definition for the idea that intentional acts transform p-adic space-time sheets to real ones and for the reversal of this transformation [K42].

It is natural to assume that negentropic entanglement is what makes living matter living and is involved with the sharing of mental images and with the formation of sensory representations by entanglement. Negentropic entanglement can be also time-like. MEs are excellent candidates for mediating this kind of entanglement whereas magnetic flux tubes would naturally mediate space-like negentropic entanglement. The sequence of negentropic entanglements would have as its upper ends sub-CDs at highest layer of the magnetic body and sensory organs as its lower ends. Even sensory organ could have negentropic entanglement with the real object of the perceptive field and this might be crucial element in the construction of the sensory representations. For instance, the deduction of distance of the object of perceptive field might rely on interferometry using the dark variants of visible photons with wave length which is is of the order of the distance to the object.

6.6.4 A model for OBEs

In the following a more detailed model for various aspects of OBEs is developed.

OBEs and general view about remote mental interactions

A general model for the remote mental interactions follows from a model for the living matter by assuming that also other biological bodies can serve as targets for the control action of the magnetic body or communicate sensory information to the magnetic body. The notion of negentropic entanglement favors biological systems as targets but it is of course an open question whether also "dead" matter could have negentropic entanglement with its magnetic body. Ordinary intentional action would represent a particular case of remote mental interaction in this framework.

Consider now OBEs in this general framework.

1. During OBE experiences the mental images constructed by brain about biological body could be absent due to the absence of the metabolic energy feed to the appropriate parts of brain taking care of the construction of cognitive mental images about biological body and communications of them to the magnetic body. The simplest representation would be in terms of bit sequences with bit 1/0 represented in terms of population inverted state/ground state of many-sheeted laser. Negative energy signals to the geometric past would be used to read these signals by inducing partial reduction of the population in inverted states. In absence of metabolic energy feed 1:s would gradually transform to 0:s. It is however essential that time-like negentropic entanglement is involved besides classical communications. This would make it possible to share the mental images.
2. In absence of these cognitive mental images to the magnetic body, magnetic body would not anymore provide strict cognitive representations of biological body and virtual world experiences would result. Since only magnetic body would contribute to the bodily experience, the low rate of dissipation due to large value of \hbar would explain the pleasant experience about the absence of the sensory noise.
3. This general picture could also explain why OBEs seem to correlate with neural disorders such as epilepsy and disorders relating to perturbed body image. During this kind of disorders the

feedback provided by the sensory and cognitive input would be lacking from the brain regions suffering the neural disorder and magnetic body would be solely responsible for the body image. The lacking strict correspondence between the conformations of magnetic body and biological body would mean that the experience is hallucination from the point of view of biological body. At the imbedding space level the "conformations" of the magnetic body could be rather abstract and represented in terms of positions and other moduli of sub-*CDs*.

In the sequel an attempt to answer basic questions about OBES on basis of this vision is made.

Do bio-photons result from the de-coherence of dark photon beams?

Bio-holography provides support for the body as a hologram (more precisely, dark photon 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 [I39] (for a TGD based model see [K8, K31]). This suggests 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): this of course need not correspond to a conscious vision at our level of self hierarchy.

The biological function of bio-photons [I26] is poorly understood, and they are an excellent candidate for ordinary photons resulting when dark photon beam de-coheres. TGD based model of bio-photons can be found in [K33] and the identification as dark photons is discussed in [K16]. The findings of Peter Gariaev about the effects of visible laser light on DNA [I34] and so called phantom DNA effect [I33] provide a further support for the biological importance of biophotons (see the discussions in [K16, K33]).

What is the mechanism of out-of-body hearing?

Mechanism could be even more general and work also in the case of other qualia. In particular, hearing might involve similar reflection of sound waves at larger space-time sheets from the magnetic body and heard as "other-worldly" sounds.

A more plausible option is that the auditory sensation is generated by dark microwave photons reflected back from magnetic body. Microwave [K55] [I48] is indeed a well-known but poorly understood phenomenon and the generation of microwaves by plants after sunset correlates also with taos hum [I70] (see the discussion in [K34]) which does not generate any response in microphones but reflects the features of the acoustic environment.

The auditory and visual hallucinations of schizophrenic persons would represent in this framework a genuine sensory input. The notion of bicameral mind introduced by Jaynes [J45] discussed in TGD framework in [K65] would fit also nicely with this picture. The "god" controlling the behavior of bicameral by giving explicit commands would correspond to some magnetic body, not necessarily that of the subject person, but a magnetic body receiving input from several brains in the social group and representing collective consciousness.

Where are the sensory receptors giving rise to the primary sensory experience?

The simplest guess is that the visual stimulus from the magnetic body is received by eyes. The fact that REM accompanies visual dreaming supports this view in the case of dreams. The receiving sensory organ could be also pineal gland [K12, K59], "third eye", the seat of the soul according to Descartes [J47]. Pineal gland is known to contain retinal pigments and its counterpart in more primitive animals is known to function as a genuine eye. A simple test in the case of artificial OBEs is to look whether the electric stimulation of OBEs generates also REM.

If OBE hearing is indeed microwave hearing, the identification of the primary sensory receptors is not obvious, although their existence cannot be denied.

The insect olfaction relies on infrared light as discovered by Callahan [I22] (see the discussion in [K26]). One might therefore wonder whether also humans possess olfactory receptors sensitive to IR light, and whether the emission of dark IR photons reflected from magnetic body could play some role in olfaction and in the generation of olfactory hallucinations. One can even ask, whether the molecular recognition mechanism underlying chemical senses relies on IR light. It is known that human nose contains so called vomeronasal organ [J1] sensitive to odors having sexual or social meaning but that these odors do not give rise to a conscious experience.

It is known that blind persons can learn to "see" when their skin is stimulated by electromagnetic fields representing the environment. Perhaps dark photon beams could induce also tactile sensations. Quite generally, the earlier proposal that information in all sensory modalities can be transformed to field patterns represented by MEs could sharpen to the hypothesis that the information in various sensory modalities allows a representation as dark photon beams inducing corresponding sensory qualia in the interaction with appropriate sensory receptors.

What is the mechanism causing the kinesthetic sensations during OBEs?

The model should also explain sensations of lifting, flying experiences, and the experiences of being in translational or rotational motion. The motion of the magnetic body with respect to the physical body should induce this kind of sensations. The basic idea is simple: generalize the mechanism allowing to hear the motion of a sound source. Generalizing from sound waves to dark photon beams, the sensation in question would be basically due to the Doppler shift of the dark photon beams travelling between biological body and the moving magnetic body. The change of the dynamical hologram resulting in the interference of a bodily reference beam and Doppler shifted reflected beam in quantum jumps could be responsible for the sensation.

This model could also resolve an objection against the hypothesis that sensory receptors experience the primary qualia. The objection is based on train illusion. When you sit on a train and look at second train which starts to move, you can have an illusion that it is your train that moves. The illusion is not a mere belief but involves a sensation of acceleration in the entire body. There are two options.

1. The sensation is a response to various bodily activities induced by the belief of being in an accelerated motion.
2. The sensation is caused by a primary sensory input induced by the acceleration. This sensory input must be produced artificially in the case of train illusion.

Consider first a genuine accelerated motion of the biological body. One could argue that in absence of visual, auditory or other sensory information about being in accelerated motion, there is no belief about being in accelerated motion so that acceleration is not perceived at all for option a). This makes option a) implausible. For option b) the acceleration of the biological body with respect to the object defining the rest system is directly perceived. The Doppler shift of the dark photon beams radiated from biological body and reflected back from the rest system would induce the sensation. Reflection could occur either from the rest system or a magnetic body associated with it.

One can imagine two mechanisms creating an illusory acceleration for option b).

1. If the fixation of the attention to the moving train means the presence of dark photon laser beams connecting biological body and train or a magnetic body associated with it, the Doppler shift of dark photon beams could induce the sensation of acceleration.
2. Directed attention could cause a personal magnetic body to mimic the motion of train so that the relevant part of it deforms in the direction of moving train to keep the distance to the moving train fixed. This would induce train illusion by the same mechanism as in case 1).

For both mechanisms the reflection of dark photon beams becomes the fundamental mechanism of directed attention. Attention would mean a formation very concrete bonds between subject and object or a representation of object at the personal magnetic body: the rays connecting the eyes of cartoon characters would represent a very profound idea about consciousness. Both views about attention mean a clear-cut deviation from the prevailing neuro-scientific thinking according to which the experienced world is virtual and completely detached from the real world.

Cliff illusion might be an appropriate name for the disgusting feeling in stomach which one feels on the brink of a precipice. Sensory imagination about falling down is in question and could be induced by the deformation of the personal magnetic body such that it mimics free fall.

The floating sensations and strange deformations of personal body during OBEs could also correspond to the deformation dynamics of the magnetic body which could be also caused by external influences. If the size of the magnetic body is measured using Earth radius as a natural unit and if the personal magnetic body co-rotates with Earth, the variation of the effect of the solar wind could

induce periodic deformations of the magnetic body as in the case of Earth's magnetic field. This could reflect itself as diurnal alterations in the shape of the body experienced during OBEs: a contraction during day time and an elongation during night time. Sunspot maxima induce magnetic storms and these could have strong effects on the shape of the body perceived during OBEs.

What is the mechanism making possible to see internal organs?

Becker tells in his book "Cross currents" [J15] 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. The simplest explanation is that magnetic body at some level of hierarchy reflects the dark photons emitted by the internal organs.

Usually this does not occur and one should understand why the emission occurred in the case of the cancer patient. There is evidence that bio-photons leak out from non-healthy organs [I26] : this might mean that organs send more intense dark photon beams reflected at the magnetic body.

Time mirror mechanism involving time reflection instead of ordinary reflection suggests itself as an alternative explanation. The cells suffering starvation generated phase conjugate dark photon beams in order to get metabolic energy. This in turn induced a cascade like emission of positive energy dark photon beams from the magnetic body instead of mere time reflection.

6.6.5 The role of the magnetic body in the case of other brain functions

During the construction of the model of OBEs it became clear that the reflection of dark photon beams from the magnetic body could serve as a building block of several ordinary brain functions. It has been already found that dark photon beams could define a fundamental mechanism of directed attention.

Dreams and hallucinations and magnetic body

The reflection of dark photon beams from the magnetic body could be involved also with dreams and hallucinations so that the neurological similarity of AS experiences and OBEs does not mean that both are hallucinatory. The "subtle body" assigned by many spiritual traditions with the dreaming state (for a nice summary see [J71]) would correspond to the magnetic body. In this case mental images constructed in brain would induce dark photon beams sent to magnetic body and reflected back. The mechanism would also naturally explain autoscopic and heautosopic experiences, in particular the ability to see internal organs.

The relationship of EMDR experiences to OBEs

Near-death experiences are not the only manner to get convinced about life after death. So called eye-movement desensitization and reprocessing (EMDR) discovered by Francine Shapiro [J23] induces what could be interpreted as after-death communications (see the discussion in [K57]). The experiences of subject persons are claimed to be induced by this therapy in a highly reliable manner: according to [J23] 98 per cent of patients willing to participate the therapy had after death communication experience. It does not matter what the religious convictions of the subject person are and the experiences are actually rather easy to induce. It does not matter if the loss is traumatic or not or whether it is recent or occurred for decades in past.

The experiences resemble near death experiences (light tunnels, beautiful landscapes) and involve spiritual contact with the deceased. The EMDR technique involves getting the patient to move his or her eyes in a particular rhythmic fashion while at the same time attending to a particular aspect of the traumatic memory. How EMRD works is poorly understood as yet: possibly the fact that the shifting of eyes leads to increased brain processing is of importance. Notice that rapid eye movements REM are also involved with dreams.

A possible explanation is that EMDR experiences involves visual communication using dark photon beams and/or their phase conjugates with the 4-D magnetic bodies of the deceased ones located possibly in the geometric recent or past via the magnetic mirrors associated with them. Essentially the same mechanism as involved with long term episodal memories could be in question: the only difference would be that the magnetic mirrors now mediate information not from own 4-D body from the 4-D body of the deceased.

Third person aspect of conscious experience

Our conscious experience involves so called third person aspect giving a symbolic bird's eye of view about ourselves. Magnetic body could take the role of the third person. At the fundamental level this representation could be based on sensory stimuli originating from body and reflected back to sensory organs. It would be completely masked by the ordinary sensory input in wake-up state but distilled by brain from the dominating sensory input and coded to a cognitive representation to minimize the amount of irrelevant information. A strong interference of this kind of sensory representation with ordinary sensory input would be obviously highly undesirable. The third person aspect could be present always and be based on the reflection of dark photons along MEs parallel to magnetic flux tubes.

Feedback to primary sensory organs via reflection from magnetic body

One objection against the hypothesis that primary sensory organs are seats of sensory qualia is that that sensory stimuli are only the raw material sculptured into actual sensory perceptions and that directed attention chooses what aspects of sensory stimulus are amplified and which neglected. I have proposed that there is a feedback by projections to the primary sensory organs from brain generating artificial sensory stimuli modifying the primary sensory input. This feedback could be realized also as a reflection of artificial dark photon beams generated by brain from the magnetic body and received as such by eyes or received by brain and channelled to eyes via MEs parallel to visual pathways.

Does imagination involve feedback via magnetic body?

One can wonder, whether also imagination could involve reflection of dark photon beams from the magnetic body. In TGD framework the hypothesis that sensory qualia are generated at primary sensory organs and brain constructs only symbolic representations about experiences circumvents the basic objections such as the experience of phantom leg. In this framework imagination and cognition can be identified as symbol generating activities which are not initiated at sensory organs but at some higher level of the hierarchy starting from sensory organs and ending at the associative areas of cortex.

Imagination could however involve also transformation of symbolic representations to dark photon beams reflected back from the magnetic body. This input would not contribute to sensory input but might be abstracted from the sensory input and might serve as a kind of feedback. In absence of ordinary sensory stimuli the input from the magnetic body would dominate and imagined mental images would transform to dreams or hallucinations.

Sensory memories and magnetic body

In some exceptional cases often associated with a serious damage in cognitive areas of brain the feedback from the magnetic body could give rise to a genuine sensory representation making possible direct sensory memories. Examples are autistic persons with ability to remember visual scenes music pieces in every detail and also reproduce them.

One explanation is sharing of sensory mental images of geometric past. An alternative explanation is that the information about sensory memory is communicated from the geometric past in symbolic form and transformed to a dark photon beam reflected back from the magnetic body. The fact that angular gyrus is involved with the translation of written language to internal speech and the abstraction of meaning of visual metaphors supports the view that a transformation of linguistic statements to concrete images projected to the magnetic body occurs in this process.

I have proposed a mechanism [K58] explaining synesthesia. The association of different sensory modalities could also occur via a transformation of sensory input in given modality to dark photon beam reflected from magnetic body and generating a sensation in another modality. Synesthetes are also known to be capable of amazing sensory memory feats [J30] and I have proposed an explanation based on time mirror mechanism [K58]. Also in this case neurons in certain region of left brain hemisphere suffer starvation which should be lethal by standard wisdom.

As a matter fact, the starvation mechanism seems to be a very general mechanism: Callahan has found evidence that insects find more easily the plants suffering from under nutrition [I21] (see the discussion in [K30]). Even the fasting common in spiritual practices could be seen as a method to get body entangled with magnetic bodies by using time mirror mechanism.

6.7 Connection to the work of researchers in forefront

Here some examples about the work of other researchers possibly relevant for understanding remote mental interactions in TGD framework is discussed briefly.

6.7.1 Simon Shnoll

Shnoll and collaborators [E1, E6, E5, E2, E8, E3] have discovered strange repeating patterns of random fluctuations of physical observables such as the number n of nuclear decays in a given time interval. Periodically occurring peaks for the distribution of the number $N(n)$ of measurements producing n events in a series of measurements as a function of n is observed instead of a single peak. The positions of the peaks are not random and the patterns depend on position and time varying periodically in time scales possibly assignable to Earth-Sun and Earth-Moon gravitational interaction.

These observations suggest a modification of the expected probability distributions but it is very difficult to imagine any physical mechanism in the standard physics framework. Rather, a universal deformation of predicted probability distributions would be in question requiring something analogous to the transition from classical physics to quantum physics [K4].

The hint about the nature of the modification comes from the TGD inspired quantum measurement theory proposing a description of the notion of finite measurement resolution in terms of inclusions of so called hyper-finite factors of type II₁ (HFFs) and closely related quantum groups. Also p-adic physics -another key element of TGD- is expected to be involved. A modification of a given probability distribution $P(n|\lambda_i)$ for a positive integer valued variable n characterized by rational-valued parameters λ_i is obtained by replacing n and the integers characterizing λ_i with so called quantum integers depending on the quantum phase $q_m = \exp(i2\pi/m)$. Quantum integer n_q must be defined as the product of quantum counterparts p_q of the primes p appearing in the prime decomposition of n . One has $p_q = \sin(2\pi p/m)/\sin(2\pi/m)$ for $p \neq P$ and $p_q = P$ for $p = P$. m must satisfy $m \geq 3$, $m \neq p$, and $m \neq 2p$.

The quantum counterparts of positive integers can be negative. Therefore quantum distribution is defined first as p-adic valued distribution and then mapped by so called canonical identification I to a real distribution by the map taking p-adic -1 to P and powers P^n to P^{-n} and other quantum primes to themselves and requiring that the mean value of n is for distribution and its quantum variant. The map I satisfies $I(\sum P_n) = \sum I(P_n)$. The resulting distribution has peaks located periodically with periods coming as powers of P . Also periodicities with peaks corresponding to $n = n^+n^-$, $n_q^+ > 0$ with fixed $n_q^- < 0$, are predicted. These predictions are universal and easily testable. The prime P and integer m characterizing the quantum variant of distribution can be identified from data. The shapes of the distributions obtained are qualitatively consistent with the findings of Shnoll but detailed tests are required to see whether the number theoretic predictions are correct.

The periodic dependence of the distributions would be most naturally assignable to the gravitational interaction of Earth with Sun and Moon and therefore to the periodic variation of Earth-Sun and Earth-Moon distances. The TGD inspired proposal is that the p-adic prime P and integer m characterizing the quantum distribution are determined by a process analogous to a state function reduction and their most probably values depend on the deviation of the distance R through the formulas $\Delta p/p \simeq k_p \Delta R/R$ and $\Delta m/m \simeq k_m \Delta R/R$. The p-adic primes assignable to elementary particles are very large unlike the primes which could characterize the empirical distributions. The hierarchy of Planck constants allows the gravitational Planck constant assignable to the space-time sheets mediating gravitational interactions to have gigantic values and this allows p-adicity with small values of the p-adic prime P . A Possible Explanation for Shnoll Effect [K4]

What makes Shnoll effect so interesting is that it involves interaction of very long length scales with microscopic scales - even nuclear physics length scale as in the experiments of Shnoll. Similar situation prevails machine-mind interaction involving intention to affect sequences of random numbers generated by microscopic systems via quantum transitions. The proposed model suggests a mathematical description of the statistical distributions modified by the intentional action but leaves the interaction mechanism open. A possible mechanism could be a realization intentions as actions via a mapping taking p-adic space-time sheets representing them in long length scales to real space-time sheets in short length scales. In the recent case the field patterns would represent space-time sheets carrying classical fields inducing the desired effect at microscopic level on particles that have topological sum contacts to these sheets. Classically gauge forces would be in question and at quantum level

modifications of various reactions rates caused by these fields.

This map would be carried out by the quantum counterpart of canonical identification or its variant [K72]. The map would be characterized by resolution defined by power p^N of prime p . For powers of p^n , $n > N$. the map would be continuous from p-adics to reals and for $n < N$ it would be discontinuous and would correspond to the identification of reals and p-adic numbers via common rationals. I have discussed this kind of option based on ordinary canonical identification - actually one of the first ideas related to p-adic physics - in [K89, K90]. The main objection was that this map is not general coordinate invariant. This could however make sense since cognition breaks General Coordinate Invariance via a selection of a preferred coordinate system and bringing in the number theoretic anatomy of coordinate variables. I have also proposed [K41] that the generation of cognitive representations and realization of intentional actions using canonical identification and its inverse could define the analog of T-duality of string theories, which also maps long and short scales to each other.

A more concrete model for the intentional action is obtained if one requires consistency with the model based on time mirror mechanism as a key element of intentional action. Canonical identification maps p-adic space-time sheet representing the intention and having the size of CD assignable to intentional agent and characterized by a typical macroscopic time scale (actually astrophysical since already electron corresponds to Earth sized CD with time scale of .1 seconds) to a much smaller space-time sheet representing a flux tube connection and possible accompanying massless extremal connecting the biological body of the operator and and target. The classical fields carried by these space-time sheets would induce the microscopic effect realizing the intention.

6.7.2 Michael Persinger

Anyone - atheist or believer - wanting to learn about Persinger's work and the basic insights of neurotheology should listen the extremely inspiring talk *God and the Brain - The Persinger 'God Helmet', The Brain, and visions of God* by Todd Murphy [J5]. Persinger's work (for references to the articles by Persinger and collaborators see the Wikipedia article about God helmet) suggests that the temporal pattern of the modulation of magnetic field strength (FM would be in question for slow variations) is important. We do not however know the "code". Also the strength of the magnetic field can be important. Note that the effects of very weak ELF em fields on vertebrate brain take place in amplitude windows [K17].

The modulation of magnetic field would probably induce FM of cyclotron frequencies. The model for hearing suggests this kind of modulation as a manner to represents the frequencies of the sound wave. Also phase information is very important: time reversed speech sounds very different as normal speech but has the same power spectrum. Modulations would be slow in the time scales defined by the audible frequency range. .1 seconds would represent lower limit for the variation rate of modulation. Audible frequencies above 20 Hz.

The article TGD Based View about Classical Fields in Relation to Consciousness Theory and Quantum Biology contains a section considering a model for the findings of Persinger and collaborators using "God helmet". The spiritual experiences induced by "God helmet" could be interpreted as subjective experiences generated when the personal magnetic body receives an additional layer. For instance, manic-depressive bipolar cycle might be understood as a cycle in which euphoric period means the emergence of a new layer appears to the magnetic body and depressive period means its disappearance. I have also commented other findings of Persinger. God helmet might provide a technical tool to test the notion of magnetic body.

6.7.3 William Tiller

William Tiller in Stanford University has carried out impressive experimental work with what he calls intention imprinted electronic devices (IIED), and his results challenge that standard assumption that the intentions of experimenter do not affect the experimental apparatus [J65, J66, J67] .

Experimental arrangement

The goal was to try to imprint a specific intention into a simple, low tech electronic device so as to influence the companion, specific, well-designed, target experiment. The intentional imprinting was

attempted in a meditative state. The intentionally imprinted device, IIED, was sent to a laboratory located at distance of about 1500 miles where colleagues had set up the experiment. The device was placed about 6 inches from a continuously running and computer-monitored target experiment and switched on (total electrical power rate was less than 1 microwatt). Over a time period of about 1-4 months the recorded results from the target experiment changed in the directions of the specific intention and the change eventually reached the selected magnitude of the specific intention. Also an identical, but not intention imprinted device was used and the results were compared in order to achieve more objective measurements about the effects of human consciousness on electric devices.

The targets used were purified water, some bio-molecules, and larvae of flies. These targets were either unshielded or shielded from radiation. For the latter purpose they were closed inside a grounded Faraday cage (FC), which screened rather effectively the radiation coming at microwave frequencies whereas for ultra low frequency (ULF) fields the screening is virtually absent (skin depth behaves as $1/\sqrt{\pi\sigma f}$ at low frequencies and $f = 2\pi\sigma$ (in units $\hbar = c = 1$) defines kind of critical frequency above which screening occurs effectively). The targets could be affected by control device (CD) or by identical IIED generating microwave radiation. Radiation was generated either at single frequency (7.3 MHz) or at three frequencies (5.0, 8.0 and 9.3 MHz) [J70] .

In the case of purified water the spatial distributions of physical parameters like pH, temperature, and conductivity were measured as a function time. In the case of bio-molecules the possible effect on thermodynamical activity, which measures the thermodynamical energy of single molecule, was measured. In the case of fly larvae the effect on the larval development time was studied. The results from various arrangements were compared with control targets (no FC, no CD, no IIED).

I have discussed a TGD based model for Tiller's findings the chapter Biosystems as conscious holograms. [K8]. The basis idea is that a connection between the magnetic body of operator and target is formed and the intentional imprinting involves magnetic fields and possibly also corresponding cyclotron frequencies. If one accepts the canonical identification as a map taking intention represented by p-adic space-time sheet to action represented by real space-time sheet in much shorter scale then the space-time sheets create would be microscopic space-time sheets carrying magnetic fields giving rise to the cyclotron frequencies.

The basic experimental results were two-fold. First of all intended effects were achieved. Secondly, the "conditioning" of the laboratory resulted as an unexpected effect and continued even after the removal of the target and IIED.

Direct effects of the intentional action

1. IIED imprinted by intention to increase/decrease the pH of water gradually induced a shift in the pH of purified water to the intended value, increased the in vitro thermodynamic activity of bio-molecules, and a reduction of larval development time.
2. For bio-molecules and larvae four simultaneous side-by-side treatments were tested: i) an unshielded sample, ii) a shielded sample, iii) a shielded sample with an "on" control device, iv) a shielded sample with an "on" IIED. Just the shielding of em radiation affected the thermodynamic activity of the bio-molecules, and just adding less than about 1 microwatt of microwave radiation via control device reduced the thermodynamical activity and lengthened the developmental time. Thus the microwave radiation acted as a stressor having entropic effect. When the control device was replaced with IIED, the degradation caused by microwave radiation was overcome.

"Conditioning" of the laboratory

Quite unexpected phenomena arose from a repeated conduct of IIED in a given laboratory space. By simply continuing to use IIED in the laboratory space, it became "conditioned in some very fundamental way". Three signatures heralded the onset of the "conditioning" process.

1. Oscillations of air and water temperature, and of pH and electrical conductivity of water with large amplitudes with the periods of oscillations in 10-100 minute range developed. The amplitudes of pH- and temperature oscillations was $\sim \Delta pH = .1$ pH-unit and $\Delta T \sim 1 - 3$ K units respectively. Even more remarkably, the oscillations were sustained in the locale even after the

removal of the IIED suggesting kind of phantom effect analogous to phantom DNA effect. Oscillation amplitude had peaks at the harmonics of fundamental frequency $f_l = 1/T_l$, $T_l = 36.6$ minutes with three lowest harmonics being very clearly visible [J67]. Also $T_l = 51.2$ minutes appears as fundamental period in some experiments. The ratio of these periods is 1.4 and rather near to $\sqrt{2} = 1.41$, which might relate to p-adic length scale hypothesis.

2. When an pH-increasing IIED with intention to increase pH by one unit was turned on in an almost unconditioned space located several hundred feet away from a strongly conditioned space, a well-defined pattern of pH-oscillations in an unconditioned space emerged. This pattern was accompanied by a highly correlated pattern of oscillations in strongly conditioned space. This kind of highly correlated oscillations were not observed in several unconditioned spaces - also located several hundred feet away.
3. The targets were subject to the action of a vertically aligned magnetic field in the range of $10^{-2} - 5 \times 10^{-2}$ Tesla, such that the direction of the field could be reversed. In an unconditioned space the change of the direction of the magnetic field did not affect the pH. In the strongly conditioned space the effect on pH was different for the opposite directions of the applied field and the difference in pH values was about .6 units. One can say, that the target had become sensitive to the effects of external magnetic fields.

TGD based model for intentional imprinting

The model obtained by combining the model for Shnoll effect based on the canonical identification as a map taking intentions to actions with time mirror mechanism would suggest that intentional imprinting generates flux tubes between the target and magnetic body (MB) of operator and also those between target and biological body (BB) of the operator. These flux tubes would correspond to the images of p-adic space-time sheets representing the intention and having astrophysical size scale (or the order of the size of CD associated with operator). These flux tubes would connect BB and MB also to the nearby environment of IIED. The fact that nearby environment remains intentionally imprinted when target and IIED are moved away could explain why the effect remains as oscillations even when IIED is removed and why synchronous oscillations take place.

Negative energy signals would tend to generate negentropic effects eliminating the entropic effects if microwave radiation. This could explain why IIED reduces the entropic effects caused by microwave radiation. Cyclotron frequencies define natural candidates for the time scales involved. The magnetic fields in question would be of order 10-100 pT. The mechanism of compensation of the effects of cyclotron photons remains open. The simplest possibility is that microwave photons generated by IIED correspond to large \hbar phase conjugate photons with energies in the range of energies of microwave photons. The effects of negative energy large \hbar photons, which have suffered phase transition to ordinary positive energy microwave photons could induce the negentropic effects.

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Chapter 7

How to test TGD based vision about living matter and remote mental interactions?

7.1 Introduction

The proposed theory of living systems and remote mental interactions involves large number of general ideas which represent something new and one should be able to invent tests. Since the basic mechanisms of remote mental interactions are same as those of TGD inspired model of living matter, there is no special reason to restrict the tests to remote mental interactions. The emphasis is on new physics predicted by TGD. The following is an attempt to list the most important ideas and imagine possible tests. Most tests are tests of the proposed new physics suggested to be crucial for living matter. I do not possess the required background to propose any detailed experimental protocols and my hope is that I would be able to represent the basic ideas so clearly that others could invent manners to test them.

Chi (life energy) and Yin (intent) provide a good example about what is involved. Usually one just tries to find correlates chi and intent by using various kinds of detectors [J27]. The detector for a given speculative effect could be physical detector measuring fields, particle currents etc., chemical methods could be used to detect the effects, biological materials and even human body could serve as a detector. If one takes TGD seriously, one can reduce the test for chi and intent to a tests for its new physics correlates. The general vision also suggests optimal choices of targets of remote mental interactions.

While preparing this chapter I learned about two articles providing reviews about empirical testing of notions of chi and intent. The first article by Kevin Chen - titled *An analytic review of studies on measuring effects of external Qi in China* [J27] - summarizes the various methods of measuring external Chi (EQ). Second article is by Lian Sidorov and Kevin Chen and titled *Biophysical Mechanisms of Genetic Regulation: Is There a Link to Mind-Body Healing?* [J59]. The main message of the article is that intent has a direct effect on DNA and that electromagnetic fields play an important role in both communication and energy metabolism. It would be interesting to combine existing general ideas with the experimental input discussed in these articles.

7.2 Zero energy ontology

Zero energy ontology (ZEO) is one of the cornerstones of TGD and has become part of TGD during last six years. Zero energy states are identified as superpositions of pairs of positive and negative energy states assigned with the future and past boundaries of causal diamonds (CDs) and correspond in ordinary ontology to physical events with positive and negative energy parts of the state identified as counterparts for the initial and final states of the event. Effective 2-dimensionality allows a further reduction to the level of partonic 2-surfaces: also their 4-D tangent space data matter. Symmetry considerations lead to a beautiful view about generalizations S-matrix to U-matrix having as its rows

orthogonal M-matrices which in turn are expressible as products of square root of density matrices and unitary S-matrix. One can say that quantum theory is "complex" square root of thermodynamics.

Therefore one should try to find tests for ZEO.

7.2.1 The hierarchy of CDs

The basic assumption is that the sizes of CDs come as integer multiples of CP_2 scale R and for prime multiples of R correspond to secondary p-adic length scales $L_{p,2} = L_{p,1}\sqrt{p}$, $L_{p,1} = R\sqrt{p}$, where R denotes CP_2 scale. For electron with $p = M_{127} = 2^{127} - 1$ one has $T_{p_2} = .1$ seconds and defines a fundamental bio-rhythm. This time scale should have preferred role in physics. More generally the secondary p-adic time scales assignable to elementary particles should define time scales relevant to macroscopic physics. The corresponding size scale can be assigned to the magnetic body of the elementary particle. Also it should be possible to assign to quark mass scales special biological time scales as has been indeed done [K6]. h predictions could be tested.

7.2.2 Generalization of standard conservation laws in ZEO

ZEO together with sub-manifold geometry provides a new view about conservation laws and resolves the problem posed by the fact that gravitational interactions do not seem to respect energy conservation in cosmological time scales. Conservation laws holds true only in the scale associated with given CD, not universally (this would allow only single infinitely large CD).

Superconducting coherent states involve quantum superposition of states with different numbers of Cooper pairs and therefore break the super-selection rule associated with fermion number in ordinary ontology. In ZEO they could be understood without giving up the superselection rule associated with fermion number.

Experimental tests should try to prove that quantum number conservation is a length scale dependent notion. For instance, creation of matter from vacuum is possible in ZEO, and one might hope that its occurrence could be in some scale for CDs artificially.

7.2.3 Breaking of second law in standard form

In standard physics second law states that all systems are entropic but a system can reduce its entropy by feeding its entropy to the environment. Negentropic entanglement carries genuine information and life can be seen as islands of negentropy in the sea of entropy. This forces to generalized second law. The proposed generalization [L22] [K42] can be characterized as maximally pessimistic.

The generation of negentropic entanglement is assumed to be accompanied by generation of compensating entropic entanglement. The modified form of second law is suggested by the mechanism of directed attention based on negentropic entanglement assignable to magnetic flux tube connecting self and target. Negentropic entanglement prevails during the attention but disappears after state function reduction giving rise to entropy at the level of ensemble. Second law would hold true above time scale assignable to the duration of negentropic entanglement.

There are also other reasons to reconsider second law. The breaking of second law in standard form since the arrow of geometric time can change locally. Living systems are indeed accompanied by syntropic effects as realized by Italian quantum physicist Fantappie [J38, J28]. These effects could be understood as entropic effects but with a reversed arrow of geometric time. The mechanism would be based on negative energy signals. Phase conjugate laser waves are known to obey second law in reversed direction of geometric time. Cooling effects due to the absorption of negative energy signals inducing the breaking of the standard form of the second law are predicted to be possible. One can also imagine a spontaneous excitation of atoms generating radiation in the return to ground state in a situation when there is a target able to receive negative energy signals emitted in spontaneous excitation.

Standard form of second law assumes that quantum coherence is absent in the scales in which it is applied. Both the hierarchy of Planck constants and negentropic entanglement however make possible macroscopic quantum coherence characterized by the scale involved and the natural guess is that the time scale associated with causal diamond in question defines the scale above which one can expect second law to hold. There is evidence for the breaking of second law in time scale of .1 seconds [D9].

7.2.4 Negative energy signals

Zero energy ontology allows to assign to zero energy states an arrow of time naturally since one can require that states have well defined single particle quantum numbers at either upper or lower boundary of CD . Also the spontaneous change of the arrow of geometric time is possible. The simplest possible description for U-process is that U-matrix relates to each other these two kinds of states and state function reductions occur alternately at upper and lower boundaries of CD meaning reduction to single particle states with well defined quantum numbers. The precise correlates for the generation of geometric arrow of time are not completely understood.

Negative energy signals to geometric past would serve as counterparts for time reversed states in the case of radiation and phase conjugate laser waves are natural counterparts for them. The signal property requires a dissipative process proceeding in preferred time direction and this kind of process has been assigned to sub-CDs and should proceed as state function reduction sequence in preferred direction of time determined by the quantum arrow of time for the zero energy state. This process would be essential for the experience of flow of time in preferred direction and for generation of arrow of geometric time as explain in previous chapter and also in [K5]. For phase conjugate laser beams the reversed time direction for dissipation is observed.

Negative energy signals make possible remote metabolism as sucking of energy from remote energy source provided resonance conditions for transitions are satisfied. The counterpart of population inverted laser could serve as ideal source and the the negative energy signal could serve as a control switch inducing phase transition like process taking the excited atom like systems to ground state (induce emission). This process should occur in living matter. Anomalous excitation of atomic state by absorbing energy by remote metabolism and subsequent generation of radiation could also serve as a signature. It could also lead to cooling effects breaking second law.

Negative energy signals would also make possible realization of intentional action by initiating the activity already in geometric past. This would be very desirable in rapidly changing circumstances. The time anomalies of Libet for active aspect of consciousness could be interpreted in terms of time mirror mechanism [J46] and further experiments in longer time scales might be perhaps carried out.

Negative energy signals could be also essential for the mechanism of long term memory. They would induce a breakdown for a system analogous to population reversed laser via induced emission meaning generation of strong positive energy signal [K60].

7.3 p-Adic physics

7.3.1 p-Adic length scale hypothesis and Mersenne hypothesis in living matter

p-Adic length scale hypothesis states that favored primary p-adic length scales proportional to square root of p-adic prime correspond to primes which are near powers of two: $p \simeq 2^k$. Favored secondary p-adic length scales would correspond to favored CD sizes coming as octaves. Mersenne primes are in special position. This leads to rather specific predictions in the case of living matter since the length scale from 10 nm to 5 μm contains as many as four Gaussian Mersennes which correspond to ordinary primes with $k = 151, 157, 163, 167$. This can be seen as a mathematical miracle and it is interesting that it associated with the biologically most interesting length scale range. This leads to Mersenne hypothesis [K6] stating that in living matter the p-adic length scales associated with both ordinary and Gaussian Mersennes are important. Besides this the hypothesis states that those values of Planck constant come as proportional to

$$r = 2^{k_i - k_j} ,$$

where k_i and k_j are primes characterizing two Mersenne primes. This predicts a large number of preferred time and length scales which might be relevant in living matter. Also this hypothesis could be tested.

7.3.2 Negentropic entanglement

Negentropic entanglement is suggested to be a basic characteristic of living matter whereas the hierarchy of Planck constants would make possible macroscopic quantum coherence. Negentropic en-

tanglement and dark matter hierarchy allow to circumvent the basic objection against viability of computation: even technological applications can be dreamed of. At this moment the only support comes from proposed applications to particle physics and from the modelling of living matter and is only indirect. The basic challenge is to learn whether Nature has chosen negentropic entanglement and hierarchy of Planck constants as its tools. The next challenge would be to develop technological tools for handling them.

For instance, phase transitions changing Planck constant from ordinary to larger one would effectively mean disappearance of ordinary matter and this could serve as a signature. Negentropic entanglement makes possible abnormally long duration of entangled period resembling that appearing in Orch Or of Hameroff and Penrose [J42] and anomalously low dissipation could serve as a signature of both negentropic entanglement and of hierarchy of Planck constants.

Negentropic entanglement could be associated with many-particle states at magnetic flux tubes. Either non-local single particle excitations of Bose-Einstein condensates of bosonic states (Cooper pairs of electrons say) or many-fermion states can be considered [K91]. Metabolic energy quantum liberated in $ATP \rightarrow ADP$ would generate the excitation. NMP does not tell whether a transfer of negentropic entanglement from high energy phosphate bond to flux tube takes place or whether the negentropic entanglement is created in the process. Exactly the same process would take place in photosynthesis as a first step and there is evidence for non-local excitations of electrons [I18]. Whether electrons or their Cooper pairs are in question will be known probably very soon. The general prediction is that metabolic energy transfer always takes place via a transfer of dark photon. The decays of these photons to ordinary photons should produce biophotons with energy around .5 eV and IR photons with this energy could have biological effects.

7.3.3 p-Adic-real phase transitions and intentional action and formation of cognitive representations

Canonical identification $\sum x_n p^n \rightarrow \sum x_n p^{-n}$ maps p-adic numbers to real numbers in continuous but non-smooth manner and its inverse is also continuous for p-adic irrationals but two valued for rationals. The original proposal - which was temporarily given up - was that cognitive representations could be mediated by canonical identification mapping real partonic 2-surfaces to their p-adic counterpart. Since p-adic and real numbers have rationals as common the canonical identification maps rational points which correspond to large real scales to small real scales and vice versa. This property is analogous to the T-duality [A2] of string models and I have indeed proposed that T-duality generalizes to map governing formation of cognition representations and realization of intentional action. Intents would correspond in real sense to large scales and p-adically infinitesimal literally to something of size of entire Universe [K41]. Their realizations in real sense would correspond to small size scales.

In Shnoll effect [E1] the expected probability distribution with single peak develops several peaks and the effect depends on periods assignable to solar system. The effect is very general and appears even for atomic nuclei. There exists no standard physics explanation for it.

1. The TGD inspired model of Shnoll effect [K4] as a statistical effect is based on the interpretation of probability distribution having integer valued argument as p-adic valued distribution and the replacement of the parameteres and variables with their images under canonical identification. For electron the magnetic body has size scale of the Earth so that this effect should be mediated by the magnetic body assignable to the CD and could be seen as evidence for these notions.
2. The oscillatory character of the effect with periodicities assignable to solar system inspires the question whether the transformation of intention to action mediated by canonical identification might be involved. If so this mechanism would apply also to experimental situations involving effect of intent on both living and inanimate systems. The prediction is the appearance of characteristic number theoretical signatures in the form of probability distributions.

7.4 Magnetic body as carrier of dark matter

Magnetic body carrying dark matter is certainly a central concept.

7.4.1 Dark matter as a hierarchy of phases with large value of Planck constant

1. Dark matter is identified as a hierarchy of phases with effective value of Planck constant coming as a multiple of ordinary Planck constant. A more stringent hypothesis inspired by spin glass degeneracy is that given multiple of Planck constant correspond to an effective local singular covering of the imbedding space. In biological systems the values of Planck constant could be rather larger: the condition that a photons with given frequency correspond to energies above thermal energy at physiological temperatures allows to estimate \hbar as ratio of thermal energy with the photon energy for ordinary value of \hbar . This dark matter must be distinguished from galactic dark matter (which could be actually magnetic energy) assignable to long flux tubes like structures around which galaxies concentrate like pearls in necklace. The values of Planck constant proposed for flux tubes mediating gravitational interaction between bodies with masses M and m is gigantic: $\hbar > GMm/c$ and can be assigned to dark energy rather than to dark matter.

It is assumed that at partonic 2-surfaces the sheets of multiple covering become completely degenerate and partially degenerate at two kinds of preferred 3-surfaces. n_1 -fold branching occurs both at space-like ends fo space-time surface assignable to CD boundaries and n_2 -fold branching at light-like orbits of wormhole throats at which induced metric changes its signature. At partonic 2-surfaces branching to n_1n_2 surfaces occurs. There is mathematical analogy between 3-surfaces and partonic 2-surfaces with 2-branes which are also obtained as piles of copies of surfaces which degenerate to single one. Now the degeneration of 3-branes would occur only at the 3-D boundary of the brane.

2. Living matter would be ordinary matter controlled by dark matter at magnetic flux quanta assignable to living system. Magnetic body would have onion-like layered structure. For instance photons with energies in EEG range would correspond to parts of magnetic body with the scale of wavelength which is now of the order of Earth radius.

Tests for the presence of dark matter.

1. The basic prediction is the existence of scaled versions of standard model physics. Particles with large Planck constant would have same masses as ordinary ones but scaled up Compton wave lengths would make gossible macroscopic quantum phases in much lower densities as usually. The proposal is that living matter involves scaled variants of electroweak physics and hadron physics. Also p-adically scaled variants with scale mass spectrum can be considred and resonant interactions between members of the two fractal hierarchies are natural when the scales co-incide.
 - (a) The scaled variant of QCD like physics is needed if color qualia are due to quark color. This is achieved by coding A,T,C,G to spin states of u quark pairs assignable to flux tube pairs in the model of DNA as tqc. Findings of mathematician Barbara Shipman [A26] suggests that the mathematics of colored quarks are involved with the honeybee dance via so called flag manifold $SU(3)/U(1) \times U(1)$ parametrizing different choices of color quantization axis. Could the presence of dark u quarks at the ends of flux tubes attach to DNA and lipid layers be tested? For instance, could it be detect the presence of quark charge equal to $2/3$?
 - (b) The prediction would be that at space-time sheets corresponding to given value of Planck constant long ranged color and/or electroweak interactions are present meaning the presence of new long range forces. Could these be partially responsible for the coherence of living matter: could color confinement play an essential role? Elementary particles are pairs of magnetic monopoles separated by Compton length: could also second monopole containing only neutrino pair be made visible by a suitable experimental arrangement? Maybe even ordinary condensed matter physics could involve Z^0 force below atomic length scale [K18].
2. One motivation for the hierarchy of Planck constants was the evidence that water behave as $H_{1.5}O$ in attosecond scale. The explanation was that 1/4 of hydrogen nuclei (protons) are dark. Could these experiments be carried out in other time scales and living matter? I have proposed

that the rich anomaly spectrum of water above freezing point could be understood if it is a multiphase system containing also dark components [K18]. Could one test this hypothesis by concrete model building and comparison with experimental facts?

3. Dark nucleons correspond to the states of DNA, RNA, tRNA, and aminoacids and vertebrate code has simple realization for dark nucleons. Could one prove experimentally the existence of dark nucleons? Perhaps as a dark plasma like phase?
4. Quantum coherence in unexpectedly long scales is predicted to be possible for dark matter. For instance, super-conductivity at temperatures at which it should not exist, becomes possible [K10, K11, K54]. I have proposed a model of high T_c superconductivity and also its biological variant based on electron pairs with large Planck constant and Compton length of order cell membrane thickness. Josephson current through cell membrane is one testable prediction. EEG would be partially determined by these Josephson currents. It is now known that photosynthesis involves macroscopic quantum coherence in unexpectedly long length scale. The model is in terms of large \hbar electron Cooper pairs. Also this model should be testable.
5. With inspiration coming from the model of quantal effects for ELF photons on vertebrate brain, EEG photons are identified as dark photons and biophotons as their decay products [K6]. This identification predicts that the energies of these photons are in visible and UV range. Could it be possible to see the emission of dark EEG photons with these energies in metabolic book keeping?

7.4.2 Tests for the notion of magnetic body

What kind of tests can one imagine for the notion of magnetic body?

1. The existence of magnetic bodies.
 - (a) Could one photograph dark matter at magnetic bodies? The mechanism would be transformation of ordinary photons to dark photons scattering from dark charged particles and transformation back to ordinary photons. Peter Gariaev might have already done this [K1]. This kinds of experiments might be continued and refined.
 - (b) How the existence of magnetic flux tubes connecting two objects - say living organisms - could be tested? What happens to flux tubes when the cells of living organism are taken far away from the organism. The experiments of Cleve Backster who introduced the notion of primary perception in the study of electrical reactions of plant which was harmed or threatened to be harmed suggest that this connection continues. Do the flux tubes remain intact and imply correlations between the distant cells and organism or - in the case that they are loops - are they split by reconnection mechanism? Could the flow of biologically important ions occur between the ends of flux tubes (it could also be that only electrons and protons and perhaps some dark nuclei - even quarks participate the flow). Could one use markers for the ions to test the existence of this kind of flows.
 - (c) How to measure the presence of the flux quanta of magnetic fields of magnetic bodies via the interaction of ordinary matter with classical electromagnetic fields created by dark particles? The description of this interaction is in terms of topological condensation to multiple space-time sheets [K92]. Now imbedding space effective covering and space-time has sheets analogous to those of Riemann surface of function $z^{1/n}$. This multi-sheetedness does not correspond to ordinary many-sheetedness. If all physics reduces to that associated with partonic 2-surfaces then classical fields carrying different values of Planck constant should interact since different sheets co-incide at partonic 2-surfaces. The (effective) value of Planck constant defined as the number of sheets of covering can depend on the region of 3-surface. Are there rules governing this change?
 - (d) Could one demonstrate the presence of magnetic monopoles at flux tube ends? Even elementary particles should possess magnetic body with largest flux tubes having length scale defined by the p-adic secondary p-adic length scale characterizing particle and characterizing the size scale of CD assignable to elementary particle. Also smaller layers of magnetic

body should be present: in particular that corresponding to the primary p-adic length scale of order Compton length. Secondary p-adic length scale corresponds to a time scale of .1 seconds for electron, the fundamental biorhythm. Could one identify bio-rhythms assignable to quarks which are more massive than electron. The QCD estimates for u and d quark masses are about 5 MeV and 20 MeV and this gives an idea about secondary p-adic time scale which should be a negative octave of .1 seconds. 12.5 ms (80 Hz) and 2.5 ms (400 Hz) are the estimates for the secondary p-adic time scales.

- (e) Magnetic body having fractal onionlike structure would play a key role neuroscience. The effects of ELF em fields on vertebrate brain at multiples of cyclotron frequencies were the original motivations for introducing the hierarchy of Planck constants. EEG would serve as communication and control tool in the system defined by magnetic body and biological body. EEG frequencies should correspond to linear combinations of harmonics of Josephson frequency for cell membrane as electronic (at least) super-conductor and harmonics of cyclotron frequencies for dark ions. This leads to a rich spectrum of quantitative predictions about EEG spectrum and attempts have been made to understand the dependence of EEG spectrum on state of consciousness. For Calcium ion the cyclotron frequency is 15 Hz.
- (f) Also magnetic body has dynamics - highest layers of body can disappear or reappear or completely new layer can emerge- and one can ask whether this dynamics could be experienced directly. The effects induced by Persinger's God helmet [?]ould have interpretation in terms of dynamics of magnetic Also OBEs could be understood as effects related directly to magnetic body [K74]. One can also ask whether astrophysical phenomena could effect directly the magnetic bodies and therefore conscious experiences. Effects of solar storms and auroras represent basic examples of this kind of effects. Maybe this could be tested?

2. The dynamics of flux tubes.

- (a) Phase transitions changing Planck constant would induce shrinking of magnetic flux tubes. These could correspond to volume changing transitions of gel phase in living matter. Bio-catalysis would rely on these phases transitions and they would allow bio-molecules in the dense soup of bio-molecules to find each other [K6].
- (b) Reconnection of magnetic bodies second fundamental dynamical process playing key role in living matter. $ATP \leftrightarrow ADP$ process would be involved with reconnection. ATP as a molecule of consciousness would accompany negentropic entanglement. Information molecules attaching to receptors would represent ends of flux tubes attaching to receptors and forming longer connected flux tubes. This would be basically generation of qualia in the length scale defined by the distance of the cell sending the information molecule and the cell receiving it. Remote sensory perception would rely on the same mechanism. One should be able to test the hypothesis that the stretching of flux tubes accompanying the diffusion of information molecule from sender to target represents deeper level of the dynamics of information molecules? The transfer of dark particles along the flux tube could be one possible signature.

If it is possible to demonstrate the existence of magnetic flux tubes by studying the flow of dark particles between two systems, one could try to test whether changes in the flow pattern by reconnection could become manifest via the flows.

- (c) Also remote mental interactions should involve generation of flux tubes between the biological and magnetic bodies of the target and operator and reconnection for loops could be the mechanism. Quantization of magnetic flux is necessary for this mechanism to work. Particle flows between target and operator would be one signature. For living target the coherence of counterparts of EEG would be second signature.

7.4.3 Bio-superconductivity

TGD inspired model of high T_c superconductivity

TGD inspired view about high T_c electronic superconductivity and its biological counterparts are discussed in [K10, K11, K54]. Also the TGD inspired model for ordinary high T_c electronic superconductivity relies on flux tubes assigned with stripes found to serve as kind of highways carrying

supra currents. High T_c super-conductivity involves two critical temperatures: T_c and T_{c_1} . Below the higher critical temperature T_{c_1} Cooper pairs with large Planck constant are assumed to be present but magnetic flux tubes are assumed to be rather short and closed (the phase is antiferromagnetic) so that macroscopic supra currents cannot flow. Around the lower critical temperature T_c flux tubes fluctuate and form by reconnection longer flux tubes and percolation type process giving rise to macroscopic supra currents becomes possible. By p-adic length scale hypothesis the basic dimensional parameters could correspond to cell membrane thickness (10 nm) and cell nucleus length scale ($2.5 \mu\text{m}$) even for ordinary high T_c super-conductivity.

An analogous mechanism is expected to be at work for cellular system and give rise to electronic supra current. Also biologically important bosonic ions should give rise to cyclotron Bose-Einstein condensates with large value of Planck constant. In the case of fermionic ions Cooper pairs would be required. Another possibility is formation of exotic ions when some neutral color bonds between nucleons in nuclear strings become charged. The energy change should be relatively small- of order keV- and there is evidence for this kind of states: nuclear reaction rates vary with a period of year explainable in terms of the variation of the distance from the Sun effecting also the intensity of X ray radiation from Sun.

Leakage of supra currents as basic mechanism

The basic element of the proposed vision is remotely induced leakage of supra currents from magnetic flux tubes to atomic space-time sheets. This same mechanism works for both endogenous biological self-organization and remote mental interactions which would form a standard element in the construction of our sensory representations. The most economic experimental strategy would be a direct verification of this basic mechanism.

An especially dramatic effect would be the appearance of ions from magnetic flux tubes to the target of remote mental interaction not present in the target initially. Sue Benford has found evidence for the appearance of S, Mg, and Al in X ray films which were exposed to the radiation coming from so called torsion generator [I20]. Intentional effort was involved with the experiment. What happened was that dots and tracks with typical size scale of one millimeter appeared in the X ray film. The dots and tracks did not allow identification as tracks of charged particles, and the exposed regions contained S, Mg and Al not present elsewhere. The leakage of energetic super-conducting ions to atomic space-time sheets dissipating their energy by emitting electromagnetic radiation and ionizing the atoms is the natural explanation for the effect [I20, I54]. Note that both X ray films and nuclear emulsions contain gelatin which is an organic compound and might increase the sensitivity of the system.

Time reversal for the leakage of supra currents

The time reversal of the mechanism generating the leakage of supra currents could be especially important for healing. This mechanism is consistent with the presence of remote bound state entanglement and anomalous production of metabolic energy when binding energy is liberated.

The mechanism would be accompanied by a mysterious disappearance of marker ions in the tissue, and manifest as time reversed function of various molecular machines certainly detectable. Phase conjugates of (that is time reversed) microwaves at critical frequencies could induce the healing process. For instance, de-differentiation of cells might be induced in this manner.

As explained earlier, geometric time reversal could typically involve generation of anomalous radiation by excitation of atoms or molecules by emission of negative energy photons. Rotating magnetic systems (Searl machine) would be especially interesting for proving that time reversal indeed occurs. One could try to demonstrate that biological rhythms correspond to dissipation-healing cycles (wake-up sleep period and metabolic cycles being basic examples).

7.4.4 Direct supra currents along magnetic flux tubes

Direct supra currents along magnetic flux tubes are also predicted besides Josephson currents. Direct supra currents would be excellent candidates for the direct currents of Becker [L26]. This model assumes that living matter is a semiconductor having underlying regular liquid crystal like structure.

The lipid layers of cell membranes are indeed liquid crystals and the braiding of magnetic flux tubes induced by the flows of the 2-D liquid formed by lipids is central in the model of DNA as topological quantum computer. According to Mae-Wan Ho liquid crystal patterns provide memory representations: in TGD one would achieve the same by the storage of liquid crystal flow patterns to the braidings of flux tubes. For the direct quantum currents the assumption of actual semiconductor structure might be un-necessarily strong.

Magnetic flux tubes can also carry longitudinal electric field and one can construct a simple model for the quantum states of charged particles in this kind of electric field. Large value of Planck constant is natural for long flux tubes. Flux tubes could have size scale of body or of even magnetic body. The model provides unexpected insights about character of quantal currents, allows to understand the amplitude windows for the effects of ELF em fields on vertebrate brain, the effective semiconductor property of living matter, and the effect of needles in acupuncture as metabolic effect. Disease as a loss of negentropic entanglement, healing as a regeneration of negentropic entanglement, the association of negentropic entanglement with ATP and high energy phosphate bond perhaps assignable to a Cooper pair like state, vacuum zero point kinetic energies as fundamental metabolic quanta, and loading of metabolic energy batteries by acceleration of charged particles in electric field so that they can be kicked to smaller space-time sheets are the basic of the model (it is essential that the currents are non-ohmic!). The challenge is to test the model for DC currents and the models of healing and acupuncture.

The model also proposes that the interaction of radiation fields is based on acceleration of charged particles on flux tubes having also topological sum contacts to "massless extremals" representing space-time correlate for radiation fields. The optimal situation is achieved when the electric field of ME is parallel or antiparallel to flux tube and ME therefore orthogonal to it. If the flux tube is near critical voltage for the generation of quantal DC current, the perturbation caused by the radiation field can induced by the quantal DC current accelerating charged particles and loading metabolic batteries by kicking them to smaller space-time sheets. This would directly correspond to the generation of ATP responsible for negentropic entanglement and generating eventually liberating metabolic energy. The killer prediction is that the biological effects are caused only at the second half of the cycle. In the case of EEG theta waves there is indeed evidence for this [J73].

7.5 TGD view about consciousness and biology

In the following TGD based view about consciousness and biology is summarized with emphasis on mechanisms. Proposals for tests are made when possible.

7.5.1 The notion of conscious hologram

Living system as conscious hologram is a metaphor emphasizing the fractal structure of sensor and cognitive representations. The model to be discussed relies heavily on the notion of magnetic flux tube and negentropic entanglement.

Attention

What is attention? What are its characteristic properties? What could be the quantum physical correlate for it. The naive view western view is that attention and perception is directed: there is observer and observed. The "Eastern" view says that observer and observed are one and same thing and this distinction applies only to memory about attention.

The proposed identification for the correlate of attention as negentropic entanglement having as space-time correlates magnetic flux tubes corresponds to the "Eastern" view: I have made also an attempt to explain how asymmetry between perceiver and perceived could emerge [K19]. Directing attention to an object of external world means formation of flux tubes connecting perceiver to the object. Qualia prevail as long as this attention continues. There is a resemblance with Orch Or of Hameroff and Penrose [J42] and with active information of Bohm [J3]: attention is the activity.

This view about attention means that ordinary sensory perception is a non-local process involving in an essential manner also the target.

The test would be finding whether (for instance) visual attention implies "intentional imprinting" in the object of attention. This relates directly also to the proposed mechanism of remote mental

interactions. In the case of hearing our ability to tell whether the sound comes from external world or not is a mystery if one believes that qualia are product of some neural activity. The flux tube model would assign also to hearing flux tubes which are attached to some object oscillating with the sound wave, even molecules of air. How it is possible to identify the sound source "correctly" if anything that oscillates with sound wave can serve as target of attention? The natural definition of source is in terms of intensity maximum. Both ears are needed to identify the direction of maximum intensity.

Model for qualia

Directed attention involves qualia. The qualia correspond to quantum number increments during the process leading from ZEO counterpart of initial prepared state to the final entangled states (identified as states at lower and upper boundaries of CD). State function reduction which eventually happens reduces the negentropic entanglement at the upper end of CD and after this there is possibly a memory of qualia, not genuine qualia anymore. Flux tubes connecting observer and observed are the correlates for the sensory perception and generation of qualia. This leads to sensory capacitor model in which the analog of dielectric breakdown amplifies the polarization between the ends of flux tubes. Besides this the process involves scaling up the lengths of the sensory capacitor flux tubes: perhaps by a phase transition increasing the value of Planck constant.

Various electrets and strong electric fields characterizing biomatter could relate to sensory perception at molecular and cellular level. Cell membrane could give rise to sensory perception of external world during nerve pulse which indeed involves dielectric breakdown. One might hope of finding at test for the generation of polarization in longer length scale during generation of qualia.

Fractality of sensory percepts and EEGs

The model of qualia suggests fractal sensory percepts. Sensory perception would be a process propagating from long to short length scales and generating qualia transforming to memories about qualia. Cell membranes and DNA could be end points of this process and lipids of the cell membrane liquid crystal would form pixels for a representation of external world analogous to that provided by computer monitor. In case of ordinary cells this representation would be about chemical environment, in the case of neurons about the external world. How this representations relates to our conscious experience?

It might be that negentropic entanglement in the scale of magnetic body is involved so that the process generating qualia begins from the level of magnetic body and proceeds downwards.

EEGs consisting of dark large \hbar photons with energies in visible and UV range are used to communicate sensory data to magnetic body as Josephson radiation from cell membranes with frequencies characterized by the value of Planck constant. The radiation would propagate along flux tubes and flux sheets. What is the precise meaning of this communication? Is it communication of symbolic representation constructed by brain and therefore communication of memories?

The fractal onionlike structure of magnetic body requires fractal hierarchy of analogs of EEG which could be called XYGs. Even weak bosons and gluons could give rise to the analog of EEG in appropriate length scales if dark matter hierarchy is realized. Biophotons are tentatively identified as decay products of large \hbar EEG photons and their scaled variants. Could this be tested somehow?

Fractality of memory representations would mean that scaled down "stories" lasting much shorter time than the real episode are formed and could be formed as several copies. This could be one of the key elements of intelligent behavior. There is evidence for this has been found by Yamaguchi et al [?, J72] in the case of theta waves. TGD based explanation in terms of phase transitions generating scaled versions of the real time representation of the event is discussed in [K19]. It might be possible to test this aspect of memory representations in terms of EEG waves as in the work of Yamaguchi.

Fractality of sensory representations

The notion of conscious hologram means that practically any part of body can represent any other part of body or even external world. Concerning the notion of conscious hologram at the length scale of body, Kirlian imaging with simultaneous electrical stimulation of other body parts, in particular ear, is very promising manner to test the hypothesis [I39]. It is also known that ear forms kind of fractal miniature of body with respect to acupuncture points so that stimulation of particular part of ear electrically creates sensation that particular part of body is stimulated [J51].

PLR spectroscopy [I34] provides a precise and accurate manner to prove the viability of the notion of conscious hologram empirically. What is needed is the analysis of the frequency spectrum: does it really contain the predicted differences of cyclotron harmonics. If this approach and its variants really work it becomes possible to determine experimentally the densities of super-conducting ions and Cooper pairs at parallel space-time sheets.

At the level of remote mental interactions the stimulation of brain electrically could induce in other brain nerve pulse pattern or even experience correlating with the nerve pulse pattern or even experience in the stimulated brain. Even water near criticality could provide this kind of representations. In Imaging laboratory at Hilversum, Holland the following experiment has been performed with success. The experiment involves water droplet near freezing point. A person with abilities of a healer asks for Universe to express something in the structure of the droplet. What results are beautiful fractal patterns representing say plant leaves, even a picture about the laboratory's architecture has been generated in this manner. Also the work of Emoto [I73] and work carried out in Aerospace Institute in Germany [I16]

7.5.2 TGD view about metabolism

TGD view about metabolism involves two new elements. First of all, TGD leads to the idea of universal metabolic quanta. These would make possible metabolism before the development of a complex chemical machinery which also would rely on universal metabolic energy quanta. Secondly, ATP seems to have two roles as a molecule of consciousness and as a metabolic quantum? These roles are very closely related and the connection with the modification of second law of thermodynamics is suggestive.

Many-sheeted space-time and universal metabolic energy currencies

The dropping of particle to a larger space-time sheet liberates energy which is the difference of the energies of the particle at two space-time sheets. If the interaction energy of the particle with the matter at space-time sheet can be neglected, the energy is just the difference of zero point kinetic energies. This energy depends on the details of the geometry of the space-time sheet. Assuming p-adic length scale hypothesis one obtains a general formula for the difference of zero point kinetic energies. These energy increments define ideal candidates for universal metabolic currencies and under certain additional conditions (say resonance with energies of some important molecular transitions) these currencies could be predecessors of the standard metabolic currency of order .5 eV. There is a more detailed treatment of universal metabolic currencies in [K6]. A model for how universal metabolic currency .5 eV assignal to the dropping of proton from atomic space-time sheet is discussed in [K33].

The hypothesis predicts the existence of anomalous lines in the spectrum of infrared photons. Also fractally scaled up and scaled down variants of these lines obtained by scaling by powers of 2 are predicted. The wavelength corresponding to .5 eV photon would be $\lambda = 2.48 \mu\text{m}$. These lines should be detectable both in laboratory and astrophysical systems and might even serve as a signature for a primitive metabolism. One can also consider dropping of Cooper pairs in which case zero point kinetic energy is scaled down by a factor of 1/2.

Interestingly, the spectrum of diffuse interstellar medium exhibits three poorly understood structures [I8] : Unidentified Infrared Bands (UIBs), Diffuse Interstellar Bands (DIBs) [I3] , and Extended Red Emission (ERE) [I71] allowing an interpretation in terms of dropping of protons or electrons (or their Cooper pairs) to larger space-time sheets. The model also suggests the interpretation of bio-photons in terms of generalizes EREs.

It must be emphasized that the identification of metabolic energy quanta as increments of zero point kinetic energies is untested and allows variants. Magnetic flux tubes are in longitudinal degrees of freedom effectively one-dimensional boxes, and the energy increment for the longitudinal excitations could replace the increment of zero point kinetic energy in the transfer of the particle between space-time sheets. Also excitations in transversal degrees of freedom (increment of cyclotron energy) are possible. These excitation energies could define universal metabolic energy quanta. This option emerges in the model for the generation of negentropic entanglement giving also the connection with the findings about effects of ELF em fields on vertebrate brain. The model predicts that metabolic energy transfer always involves generation of dark photon absorbed by magnetic flux tube so that negentropically entanglement non-local single particle excitation is created. One expects that IR

photons with energy around .5 eV (metabolic energy quantum) have biological effects. Also biophotons resulting from the transformation of dark photons to ordinary photons at this energy are possible.

Plasmoids as prebiotic life forms

A natural conjecture is that plasmoids involving charged plasma at magnetic flux quanta define prebiotic life forms [K23]. The minimum prerequisites for life would be present if the proposal for universal metabolic quanta is correct. Even dark nuclei could be regarded as plasma like structures so that even genetic code and nuclear counterparts of basic biomolecules could be involved.

The model of high T_c super-conductivity and the general vision about dark matter hierarchy have led to a rather precise model for magnetic body as an intentional agent utilizing biological body or its part as motor instrument and sensory receptor [K17]. Dark matter plasmoids and plasma oscillation patterns as representations of control commands are one important aspect of the model. The prediction is that plasmoids should have been predecessors of ordinary life forms. There is laboratory evidence that plasmoids behave like life forms [I52, I25]. Very high temperatures catastrophic for ordinary life forms could prevail at magnetic flux quanta associated with plasmoids. This forces a radical reconsideration of the question how pre-biotic life have evolved and forces to ask whether even the hot interior of Earth could have served or still serve as a seat of life.

The old Expanding Earth hypothesis explains the observation made already at the time of Wegener that all continents fit to a structure covering entire Earth if the radius of Earth were one half of the recent radius. A phase transition increasing the value of Planck constant for the space-time sheet of Earth by factor two could explain this finding and leads to a rather non-trivial vision about early life at Earth [K24].

ATP cannot serve as a correlate of negentropic entanglement during prebiotic period but this does not mean that negentropic entanglement would not be possible. One should understand why ATP makes possible negentropic entanglement. Negentropic entanglement allows states with negative binding energy which are not bound states in the usual sense. Why high energy phosphate bond would be example of this kind state? Understanding this might help to understand the conditions under which negentropic entanglement is possible. The laboratory evidence for plasmoids as prebiotic life forms [I25, I53] raises hopes that one could learn to create situations in which negentropic entanglement prevails.

In situations in which the target is in-animate matter, universal metabolic quanta might be relevant for the realizations of remote mental interactions.

Controlling metabolism by IR laser beams and DNA functioning by maser beams?

One could also test the 'dropping' of ions to larger space-time sheets. If the dropping ions have dissipated their energy this means that system acts like a maser at wavelength defined by the reduction of the zero point kinetic energy liberated in the dropping of the ion. The pumping process would correspond to the leakage of the supra currents to atomic or some other space-time sheet, and induced emission to the dropping induced by the photons already present.

1. The effectiveness of metabolic energy production in which proton drops and absorbs a negative energy photon of energy about .5 eV could be amplified by a beam of coherent IR light "kicking" protons back to the atomic space-time sheets. The irradiation by phase conjugate beam would "steal" energy from living system by inducing the dropping without locally usable energy. Whether living systems can "steal" energy from other life-forms in this manner could be tested. The "stealing" of the metabolic energy (there is probably a fractal hierarchy of "energy currencies") from cancer cells by phase conjugate laser light might be the first principle explanation for why Priore's machine works.
2. The dropping of ions from say $k = 151$ space-time sheet to larger space-time sheets creates microwaves with frequencies corresponding to zero point kinetic energies about $2^{-15}/A$ eV, A atomic number. For electron the energy is about 1/16 eV. These processes could define exotic forms of metabolism, perhaps at the level of DNA. This process could be amplified by an external microwave beam or its phase conjugate and phase conjugate beam could induce the correction of genetic errors.

The transformation of photon energy to metabolic energy could be following. Suppose that the electric field of IR photon is parallel to the flux tube which carries an electric field and is near criticality for the generation of quantal DC currents. If the direction of polarization is correct, the additional contribution to electric field induces direct current and acceleration of electrons and protons and their transfer to smaller space-time sheets and therefore loading of metabolic batteries. This could also make generation of ATP possible.

3. The scaling law of homeopathy [I68] states that high and low frequencies accompany each other and are in a constant ratio for which TGD predicts several values determined as ratios of zero point kinetic energies and cyclotron energies at magnetic flux tubes. The scaling law can be understood as follows: dropping of ions to cyclotron states generates with the zero point kinetic energy and cyclotron photons. Low frequency photons can interact resonantly with the system for which the internal excitations have same low frequency. This generates internal excitation with wavelength which is of the order of system size and this excitation couples resonantly to photons with wavelength equal to system size: thus high frequency photons result.

Thus one might achieve the above proposed effects using also low frequency irradiation. For instance, irradiation by kHz waves in order to achieve generation of bio-photons and irradiation by ELF waves in order to achieve generation of microwave photons. In fact, I started to develop the vision about living system as a macroscopic quantum system from the finding of Blackman [J19] and other pioneers of bio-electromagnetism that ELF radiation has delicate effects in the functioning of living matter. It seems that the basic mechanism might be the dropping of ions between space-time sheets or its time reversal. This mechanism could be tested also for remote objects.

7.5.3 The new view about DNA

The new view about DNA and cell involves several aspects.

1. The first vision about DNA was inspired on many-sheeted space-time alone and on the idea about the role of magnetic body of DNA. There was also a proposal about hierarchy of codes containing as a successors of genetic code memetic code assignable to Mersenne prime M_{127} characterizing electron [K30]. The codewords of this code could be represented as sequences of 21 DNA codons.
2. DNA as topological quantum computer model [K19] introduced a completely new level of information processing as counterpart of topological quantum computation made possible by magnetic flux tubes connecting DNA nucleotides and lipids of nuclear or cell membrane defining braiding. A realization of genetic code is involved. Perhaps the most convincing realization is in terms of 3+1 spin states of fermion pairs assignable to pairs of flux tubes. The realization using u quarks allows to stabilize DNA carrying 2 units of electric charge per nucleotide. The positive charge $4/3$ at the end of flux tube pair serves as possibly testable experimental signature for the proposal. Introns would be optimal for the topological quantum computation and the increase of the intronic fraction of DNA with the increase of evolutionary level conforms with the idea that the evolution of magnetic bodies distinguishes between us and our cousins.

The notion of magnetic body inspires also the proposal that magnetic flux sheets traversing through DNA make possible integration of genomes to higher level structures: this leads to the notions of super genome and hypergenome. Could these higher level genomes manifest themselves as coherent gene expression in the scale of organism and even of population? The development of collective levels of consciousness and cultural evolution would reflect directly the presence of this level of information processing. One implication is the failure of genetic determinism. For this there already exists empirical support. Already the fact that the genomes of humans and of rather primitive life forms do not differ much (apart from intronic portion) suggests that an unidentified level of information processing is involved.

3. Dark DNA as sequences of dark nucleon strings is a first completely unexpected twist in the development of ideas related to DNA and genetic code [L9, K31]. The theoretical challenge is to understand the relationship with ordinary DNA and its companion molecules. Is the transcription between dark nucleon counterpart of DNA, RNA, tRNA, aminoacids to their chemical

variants possible? How could one make dark protons and nuclear strings "visible". Scattering of photons from dark proton strings would involve transformation to dark photons and back. Also classical em fields created by the dark nuclei are in principle observable.

The presence of dark DNA could make possible active genetic engineering using the "virtual" world of dark DNA, and its companions and one can imagine that biology applies the analog of R&D in industry. This is obviously in conflict with the dogma that evolution is solely due to random change and selection.

4. What is amusing that the model for water memory and homeopathy led to this proposal [K31]. In the succession process water clusters would "steal" the magnetic bodies of dissolved polar ions and representations of the magnetic bodies as dark nucleon sequences would be generated. There could be also evolution driven by repeatedly occurring mechanical agitation implying increase of Planck constant associated with the magnetic bodies involved. All polar molecules have representation as a DNA sequence. The fundamental mechanism of immune system would be reconnection of magnetic flux tubes associated with the polar ions and the structures representing them so that the cyclotron radiation propagating along them could not interact with the biomolecules. Immunity would be the outcome from this "stealing of attention". If the transcription of dark nucleon sequences to the biochemical counterparts exist this could make possible to automatically generate genes coding for proteins which in turn "catch" the polar molecules that they represent.

A fascinating possibility is the transfer of genes homeopathically. Genes would be dissolved into water and succession process could be used to induce evolution of the magnetic bodies of the dark DNA associated with genes. These could be transferred to cells and germ cells and transcription to ordinary DNA would make possible genetic engineering.

7.5.4 Model of cell membrane as almost vacuum extremal

The model for cell membrane as almost vacuum extremals brings in additional new physics predicted by TGD. Vacuum extremals are basic solutions of field equations and their small non-vacuum deformations are expected to be important for quantum TGD. For instance, the long length scale limit of the theory in gravitational sector is expected to rely on almost vacuum extremals. 4-D spin glass degeneracy is also due to vacuum extremals and allows to have classical space-time correlates also for the non-deterministic aspects of quantum theory as a failure on standard form of classical determinism. Vacuum degeneracy also implies the realization for the hierarchy of Planck constants in terms of effective multiple coverings of the imbedding space.

Since quantum criticality is expected to be key attribute of sensory receptor, one expects that cell membrane is almost vacuum extremal. This would also imply that large values of Planck constant and dark matter are involved.

The model for cell membrane as almost vacuum extremal involves an assumption that Weinberg angle in this phase differs from its value for elementary particles, which are in many respects diametrical opposite of almost vacuum extremals. The model makes precise predictions about preferred photon energies in visible and UV range and these photon energies correspond to peak frequencies for the photoreceptors.

7.6 General model for remote mental interactions

The assumption that the notion of magnetic body and hierarchy of Planck constants defines key element in remote mental interactions reduces the tests at the level of physics to tests for these notions.

7.6.1 Direct metabolic correlates for remote mental interactions

The proposal is that ATP is the molecule of consciousness in the sense that its presence as relay in flux tube connection carrying negative entanglement entropy. ATP would be also the molecule of attention if negentropic flux tubes connecting perceiver and attended system serve as correlates of attention. There is complete symmetry between the two systems which conforms with the "Eastern" vision that

there is no distinction between observer and observed during observation. The distinction emerges only after the observation is over and sensory percept has become a memory.

Also remote mental interactions should have ATP as a correlate of intentional action at the end of the operator and the rate of metabolism might be used as a correlate for the remote mental interaction such as psychokinesis or intentional imprinting or human-machine interactions.

7.6.2 How to choose senders and receivers?

In the above discussion only the new physics phenomena suggested to be essential for both biology, neuroscience, and remote mental interactions are considered, and many experiments could be carried out without operator and target as they are used in remote mental interaction experiments. One might however hope that the model could give some idea about optimal planning of experiments related to remote mental interactions.

In these experiments an important aspect of testing is optimal choice of targets and the persons acting as sender.

1. Quite generally, the optimal target system for demonstrating these effects would be a critical system very sensitive to small perturbations. Any critical system would work, and one might even consider that the critical systems used to detect elementary particles might be used. Overcooled vapor or liquid or overheated liquid is one possibility. One could take register what happens in the system using same methods as in particle physics. Organic compounds might be by definition be this kind of systems.
2. One could also try to identify optimal 'senders'. Persons with strong will power or with firm belief on the effect, or persons with lower level of inhibition (children, actors, artists,...) could be considered as optimal 'senders'. One could find whether some drugs which remove inhibition, could enhance telepathic and psycho-kinetic abilities. The "blessed are the meek since they quantum entangle" prediction could be also tested. Indeed, one of the most dramatic experiments supporting psychokinesis was done using chicken which imprinted to a robot [J53]. The robot, whose behavior was programmed earlier by random number generator, tended to stay near the chicken, as if chicken had induced a quantum jumps changing the geometric past in macro-temporal time scales.

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Chapter 1

Appendix

A-1 Basic properties of CP_2

A-1.1 CP_2 as a manifold

CP_2 , the complex projective space of two complex dimensions, is obtained by identifying the points of complex 3-space C^3 under the projective equivalence

$$(z^1, z^2, z^3) \equiv \lambda(z^1, z^2, z^3) . \quad (\text{A-1.1})$$

Here λ is any non-zero complex number. Note that CP_2 can be also regarded as the coset space $SU(3)/U(2)$. The pair z^i/z^j for fixed j and $z^i \neq 0$ defines a complex coordinate chart for CP_2 . As j runs from 1 to 3 one obtains an atlas of three coordinate charts covering CP_2 , the charts being holomorphically related to each other (e.g. CP_2 is a complex manifold). The points $z^3 \neq 0$ form a subset of CP_2 homeomorphic to R^4 and the points with $z^3 = 0$ a set homeomorphic to S^2 . Therefore CP_2 is obtained by "adding the 2-sphere at infinity to R^4 ".

Besides the standard complex coordinates $\xi^i = z^i/z^3$, $i = 1, 2$ the coordinates of Eguchi and Freund [A28] will be used and their relation to the complex coordinates is given by

$$\begin{aligned} \xi^1 &= z + it , \\ \xi^2 &= x + iy . \end{aligned} \quad (\text{A-1.2})$$

These are related to the "spherical coordinates" via the equations

$$\begin{aligned} \xi^1 &= r \exp(i \frac{(\Psi + \Phi)}{2}) \cos(\frac{\Theta}{2}) , \\ \xi^2 &= r \exp(i \frac{(\Psi - \Phi)}{2}) \sin(\frac{\Theta}{2}) . \end{aligned} \quad (\text{A-1.3})$$

The ranges of the variables r, Θ, Φ, Ψ are $[0, \infty], [0, \pi], [0, 4\pi], [0, 2\pi]$ respectively.

Considered as a real four-manifold CP_2 is compact and simply connected, with Euler number Euler number 3, Pontryagin number 3 and second $b = 1$.

A-1.2 Metric and Kähler structure of CP_2

In order to obtain a natural metric for CP_2 , observe that CP_2 can be thought of as a set of the orbits of the isometries $z^i \rightarrow \exp(i\alpha)z^i$ on the sphere S^5 : $\sum z^i \bar{z}^i = R^2$. The metric of CP_2 is obtained by projecting the metric of S^5 orthogonally to the orbits of the isometries. Therefore the distance between the points of CP_2 is that between the representative orbits on S^5 .

The line element has the following form in the complex coordinates

$$ds^2 = g_{a\bar{b}} d\xi^a d\bar{\xi}^b , \quad (\text{A-1.4})$$

where the Hermitian, in fact Kähler metric $g_{a\bar{b}}$ is defined by

$$g_{a\bar{b}} = R^2 \partial_a \partial_{\bar{b}} K , \quad (\text{A-1.5})$$

where the function K , Kähler function, is defined as

$$\begin{aligned} K &= \log(F) , \\ F &= 1 + r^2 . \end{aligned} \quad (\text{A-1.6})$$

The Kähler function for S^2 has the same form. It gives the S^2 metric $dzd\bar{z}/(1+r^2)^2$ related to its standard form in spherical coordinates by the coordinate transformation $(r, \phi) = (\tan(\theta/2), \phi)$.

The representation of the CP_2 metric is deducible from S^5 metric is obtained by putting the angle coordinate of a geodesic sphere constant in it and is given

$$\frac{ds^2}{R^2} = \frac{(dr^2 + r^2 \sigma_3^2)}{F^2} + \frac{r^2(\sigma_1^2 + \sigma_2^2)}{F} , \quad (\text{A-1.7})$$

where the quantities σ_i are defined as

$$\begin{aligned} r^2 \sigma_1 &= \text{Im}(\xi^1 d\xi^2 - \xi^2 d\xi^1) , \\ r^2 \sigma_2 &= -\text{Re}(\xi^1 d\xi^2 - \xi^2 d\xi^1) , \\ r^2 \sigma_3 &= -\text{Im}(\xi^1 d\bar{\xi}^1 + \xi^2 d\bar{\xi}^2) . \end{aligned} \quad (\text{A-1.8})$$

R denotes the radius of the geodesic circle of CP_2 . The vierbein forms, which satisfy the defining relation

$$s_{kl} = R^2 \sum_A e_k^A e_l^A , \quad (\text{A-1.9})$$

are given by

$$\begin{aligned} e^0 &= \frac{dr}{F} , & e^1 &= \frac{r\sigma_1}{\sqrt{F}} , \\ e^2 &= \frac{r\sigma_2}{\sqrt{F}} , & e^3 &= \frac{r\sigma_3}{F} . \end{aligned} \quad (\text{A-1.10})$$

The explicit representations of vierbein vectors are given by

$$\begin{aligned} e^0 &= \frac{dr}{F} , & e^1 &= \frac{r(\sin\Theta \cos\Psi d\Phi + \sin\Psi d\Theta)}{2\sqrt{F}} , \\ e^2 &= \frac{r(\sin\Theta \sin\Psi d\Phi - \cos\Psi d\Theta)}{2\sqrt{F}} , & e^3 &= \frac{r(d\Psi + \cos\Theta d\Phi)}{2F} . \end{aligned} \quad (\text{A-1.11})$$

The explicit representation of the line element is given by the expression

$$ds^2/R^2 = \frac{dr^2}{F^2} + \frac{r^2}{4F^2} (d\Psi + \cos\Theta d\Phi)^2 + \frac{r^2}{4F} (d\Theta^2 + \sin^2\Theta d\Phi^2) . \quad (\text{A-1.12})$$

The vierbein connection satisfying the defining relation

$$de^A = -V_B^A \wedge e^B, \tag{A-1.13}$$

is given by

$$\begin{aligned} V_{01} &= -\frac{e^1}{r}, & V_{23} &= \frac{e^1}{r}, \\ V_{02} &= -\frac{e^2}{r}, & V_{31} &= \frac{e^2}{r}, \\ V_{03} &= (r - \frac{1}{r})e^3, & V_{12} &= (2r + \frac{1}{r})e^3. \end{aligned} \tag{A-1.14}$$

The representation of the covariantly constant curvature tensor is given by

$$\begin{aligned} R_{01} &= e^0 \wedge e^1 - e^2 \wedge e^3, & R_{23} &= e^0 \wedge e^1 - e^2 \wedge e^3, \\ R_{02} &= e^0 \wedge e^2 - e^3 \wedge e^1, & R_{31} &= -e^0 \wedge e^2 + e^3 \wedge e^1, \\ R_{03} &= 4e^0 \wedge e^3 + 2e^1 \wedge e^2, & R_{12} &= 2e^0 \wedge e^3 + 4e^1 \wedge e^2. \end{aligned} \tag{A-1.15}$$

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

$$\begin{aligned} B &= 2re^3, \\ J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) = \frac{r}{F^2} dr \wedge (d\Psi + \cos\Theta d\Phi) + \frac{r^2}{2F} \sin\Theta d\Theta d\Phi. \end{aligned} \tag{A-1.19}$$

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

$$\begin{aligned} B &= \sum_{k=1,2} P_k dQ_k, \\ J &= \sum_{k=1,2} dP_k \wedge dQ_k. \end{aligned} \tag{A-1.20}$$

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 [A21]. However, the coupling of the spinors to a half odd multiple of the Kähler potential leads to a respectable spinor structure. Because the delicacies associated with the spinor structure of CP_2 play a fundamental role in TGD, the arguments of Hawking are repeated here.

To see how the space can fail to have an ordinary spinor structure consider the parallel transport of the vierbein in a simply connected space M . The parallel propagation around a closed curve with a base point x leads to a rotated vierbein at x : $e^A = R_B^A e^B$ and one can associate to each closed path an element of $SO(4)$.

Consider now a one-parameter family of closed curves $\gamma(v) : v \in (0, 1)$ with the same base point x and $\gamma(0)$ and $\gamma(1)$ trivial paths. Clearly these paths define a sphere S^2 in M and the element $R_B^A(v)$ defines a closed path in $SO(4)$. When the sphere S^2 is contractible to a point e.g., homologically trivial, the path in $SO(4)$ is also contractible to a point and therefore represents a trivial element of the homotopy group $\Pi_1(SO(4)) = Z_2$.

For a homologically nontrivial 2-surface S^2 the associated path in $SO(4)$ can be homotopically nontrivial and therefore corresponds to a nonclosed path in the covering group $Spin(4)$ (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_α^k (understood as vectors of H) are covariantly constant quantities with respect to the covariant derivative taking into account that the tangent vectors are vectors both with respect to H and X^4 .

In [A15] a general characterization of the geodesic sub-manifolds for an arbitrary symmetric space G/H is given. Geodesic sub-manifolds are in 1-1-correspondence with the so called Lie triple systems of the Lie-algebra g of the group G . The Lie triple system t is defined as a subspace of g characterized by the closedness property with respect to double commutation

$$[X, [Y, Z]] \in t \text{ for } X, Y, Z \in t . \tag{A-1.22}$$

$SU(3)$ allows, besides geodesic lines, two nonequivalent (not isometry related) geodesic spheres. This is understood by observing that $SU(3)$ allows two nonequivalent $SU(2)$ algebras corresponding to

subgroups $SO(3)$ (orthogonal 3×3 matrices) and the usual isospin group $SU(2)$. By taking any subset of two generators from these algebras, one obtains a Lie triple system and by exponentiating this system, one obtains a 2-dimensional geodesic sub-manifold of CP_2 .

Standard representatives for the geodesic spheres of CP_2 are given by the equations

$$S_I^2 : \xi^1 = \bar{\xi}^2 \text{ or equivalently } (\Theta = \pi/2, \Psi = 0) ,$$

$$S_{II}^2 : \xi^1 = \xi^2 \text{ or equivalently } (\Theta = \pi/2, \Phi = 0) .$$

The non-equivalence of these sub-manifolds is clear from the fact that isometries act as holomorphic transformations in CP_2 . The vanishing of the second fundamental form is also easy to verify. The first geodesic manifold is homologically trivial: in fact, the induced Kähler form vanishes identically for S_I^2 . S_{II}^2 is homologically nontrivial and the flux of the Kähler form gives its homology equivalence class.

A-2 CP_2 geometry and standard model symmetries

A-2.1 Identification of the electro-weak couplings

The delicacies of the spinor structure of CP_2 make it a unique candidate for space S . First, the coupling of the spinors to the $U(1)$ gauge potential defined by the Kähler structure provides the missing $U(1)$ factor in the gauge group. Secondly, it is possible to couple different H -chiralities independently to a half odd multiple of the Kähler potential. Thus the hopes of obtaining a correct spectrum for the electromagnetic charge are considerable. In the following it will be demonstrated that the couplings of the induced spinor connection are indeed those of the GWS model [B8] and in particular that the right handed neutrinos decouple completely from the electro-weak interactions.

To begin with, recall that the space H allows to define three different chiralities for spinors. Spinors with fixed H -chirality $e = \pm 1$, CP_2 -chirality l, r and M^4 -chirality L, R are defined by the condition

$$\begin{aligned} \Gamma\Psi &= e\Psi , \\ e &= \pm 1 , \end{aligned} \tag{A-2.1}$$

where Γ denotes the matrix $\Gamma_9 = \gamma_5 \times \gamma_5$, $1 \times \gamma_5$ and $\gamma_5 \times 1$ respectively. Clearly, for a fixed H -chirality CP_2 - and M^4 -chiralities are correlated.

The spinors with H -chirality $e = \pm 1$ can be identified as quark and lepton like spinors respectively. The separate conservation of baryon and lepton numbers can be understood as a consequence of generalized chiral invariance if this identification is accepted. For the spinors with a definite H -chirality one can identify the vielbein group of CP_2 as the electro-weak group: $SO(4) = SU(2)_L \times SU(2)_R$.

The covariant derivatives are defined by the spinorial connection

$$A = V + \frac{B}{2}(n_+ 1_+ + n_- 1_-) . \tag{A-2.2}$$

Here V and B denote the projections of the vielbein and Kähler gauge potentials respectively and $1_{+(-)}$ projects to the spinor H -chirality $+(-)$. The integers n_{\pm} are odd from the requirement of a respectable spinor structure.

The explicit representation of the vielbein connection V and of B are given by the equations

$$\begin{aligned} V_{01} &= -\frac{e^1}{r} , & V_{23} &= \frac{e^1}{r} , \\ V_{02} &= -\frac{e^2}{r} , & V_{31} &= \frac{e^2}{r} , \\ V_{03} &= (r - \frac{1}{r})e^3 , & V_{12} &= (2r + \frac{1}{r})e^3 , \end{aligned} \tag{A-2.3}$$

and

$$B = 2re^3 , \tag{A-2.4}$$

respectively. The explicit representation of the vielbein is not needed here.

Let us first show that the charged part of the spinor connection couples purely left handedly. Identifying Σ_3^0 and Σ_2^1 as the diagonal (neutral) Lie-algebra generators of $SO(4)$, one finds that the charged part of the spinor connection is given by

$$A_{ch} = 2V_{23}I_L^1 + 2V_{13}I_L^2, \quad (\text{A-2.5})$$

where one have defined

$$\begin{aligned} I_L^1 &= \frac{(\Sigma_{01} - \Sigma_{23})}{2}, \\ I_L^2 &= \frac{(\Sigma_{02} - \Sigma_{13})}{2}. \end{aligned} \quad (\text{A-2.6})$$

A_{ch} is clearly left handed so that one can perform the identification

$$W^\pm = \frac{2(e^1 \pm ie^2)}{r}, \quad (\text{A-2.7})$$

where W^\pm denotes the charged intermediate vector boson.

Consider next the identification of the neutral gauge bosons γ and Z^0 as appropriate linear combinations of the two functionally independent quantities

$$\begin{aligned} X &= re^3, \\ Y &= \frac{e^3}{r}, \end{aligned} \quad (\text{A-2.8})$$

appearing in the neutral part of the spinor connection. We show first that the mere requirement that photon couples vectorially implies the basic coupling structure of the GWS model leaving only the value of Weinberg angle undetermined.

To begin with let us define

$$\begin{aligned} \bar{\gamma} &= aX + bY, \\ \bar{Z}^0 &= cX + dY, \end{aligned} \quad (\text{A-2.9})$$

where the normalization condition

$$ad - bc = 1,$$

is satisfied. The physical fields γ and Z^0 are related to $\bar{\gamma}$ and \bar{Z}^0 by simple normalization factors.

Expressing the neutral part of the spinor connection in term of these fields one obtains

$$\begin{aligned} A_{nc} &= [(c+d)2\Sigma_{03} + (2d-c)2\Sigma_{12} + d(n_+1_+ + n_-1_-)]\bar{\gamma} \\ &+ [(a-b)2\Sigma_{03} + (a-2b)2\Sigma_{12} - b(n_+1_+ + n_-1_-)]\bar{Z}^0. \end{aligned} \quad (\text{A-2.10})$$

Identifying Σ_{12} and $\Sigma_{03} = 1 \times \gamma_5 \Sigma_{12}$ as vectorial and axial Lie-algebra generators, respectively, the requirement that γ couples vectorially leads to the condition

$$c = -d. \quad (\text{A-2.11})$$

Using this result plus previous equations, one obtains for the neutral part of the connection the expression

$$A_{nc} = \gamma Q_{em} + Z^0(I_L^3 - \sin^2\theta_W Q_{em}) . \quad (\text{A-2.12})$$

Here the electromagnetic charge Q_{em} and the weak isospin are defined by

$$\begin{aligned} Q_{em} &= \Sigma^{12} + \frac{(n_+1_+ + n_-1_-)}{6} , \\ I_L^3 &= \frac{(\Sigma^{12} - \Sigma^{03})}{2} . \end{aligned} \quad (\text{A-2.13})$$

The fields γ and Z^0 are defined via the relations

$$\begin{aligned} \gamma &= 6d\bar{\gamma} = \frac{6}{(a+b)}(aX + bY) , \\ Z^0 &= 4(a+b)\bar{Z}^0 = 4(X - Y) . \end{aligned} \quad (\text{A-2.14})$$

The value of the Weinberg angle is given by

$$\sin^2\theta_W = \frac{3b}{2(a+b)} , \quad (\text{A-2.15})$$

and is not fixed completely. Observe that right handed neutrinos decouple completely from the electro-weak interactions.

The determination of the value of Weinberg angle is a dynamical problem. The angle is completely fixed once the YM action is fixed by requiring that action contains no cross term of type γZ^0 . Pure symmetry non-broken electro-weak YM action leads to a definite value for the Weinberg angle. One can however add a symmetry breaking term proportional to Kähler action and this changes the value of the Weinberg angle.

To evaluate the value of the Weinberg angle one can express the neutral part F_{nc} of the induced gauge field as

$$F_{nc} = 2R_{03}\Sigma^{03} + 2R_{12}\Sigma^{12} + J(n_+1_+ + n_-1_-) , \quad (\text{A-2.16})$$

where one has

$$\begin{aligned} R_{03} &= 2(2e^0 \wedge e^3 + e^1 \wedge e^2) , \\ R_{12} &= 2(e^0 \wedge e^3 + 2e^1 \wedge e^2) , \\ J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) , \end{aligned} \quad (\text{A-2.17})$$

in terms of the fields γ and Z^0 (photon and Z - boson)

$$F_{nc} = \gamma Q_{em} + Z^0(I_L^3 - \sin^2\theta_W Q_{em}) . \quad (\text{A-2.18})$$

Evaluating the expressions above one obtains for γ and Z^0 the expressions

$$\begin{aligned} \gamma &= 3J - \sin^2\theta_W R_{03} , \\ Z^0 &= 2R_{03} . \end{aligned} \quad (\text{A-2.19})$$

For the Kähler field one obtains

$$J = \frac{1}{3}(\gamma + \sin^2\theta_W Z^0) . \quad (\text{A-2.20})$$

Expressing the neutral part of the symmetry broken YM action

$$\begin{aligned} L_{ew} &= L_{sym} + f J^{\alpha\beta} J_{\alpha\beta} , \\ L_{sym} &= \frac{1}{4g^2} Tr(F^{\alpha\beta} F_{\alpha\beta}) , \end{aligned} \quad (A-2.21)$$

where the trace is taken in spinor representation, in terms of γ and Z^0 one obtains for the coefficient X of the γZ^0 cross term (this coefficient must vanish) the expression

$$\begin{aligned} X &= -\frac{K}{2g^2} + \frac{fp}{18} , \\ K &= Tr [Q_{em}(I_L^3 - \sin^2\theta_W Q_{em})] , \end{aligned} \quad (A-2.22)$$

In the general case the value of the coefficient K is given by

$$K = \sum_i \left[-\frac{(18 + 2n_i^2)\sin^2\theta_W}{9} \right] , \quad (A-2.23)$$

where the sum is over the spinor chiralities, which appear as elementary fermions and n_i is the integer describing the coupling of the spinor field to the Kähler potential. The cross term vanishes provided the value of the Weinberg angle is given by

$$\sin^2\theta_W = \frac{9 \sum_i 1}{(fg^2 + 2 \sum_i (18 + n_i^2))} . \quad (A-2.24)$$

In the scenario where both leptons and quarks are elementary fermions the value of the Weinberg angle is given by

$$\sin^2\theta_W = \frac{9}{(\frac{fg^2}{2} + 28)} . \quad (A-2.25)$$

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 [B13] .

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 [B4] .

The action of the reflection P on spinors is given by

$$\Psi \rightarrow P\Psi = \gamma^0 \otimes \gamma^0 \Psi . \quad (A-2.26)$$

in the representation of the gamma matrices for which γ^0 is diagonal. It should be noticed that W and Z^0 bosons break parity symmetry as they should since their charge matrices do not commute with the matrix of P .

The guess that a complex conjugation in CP_2 is associated with T transformation of the physicist turns out to be correct. One can verify by a direct calculation that pure Dirac action is invariant under T realized according to

$$\begin{aligned} m^k &\rightarrow T(M^k) , \\ \xi^k &\rightarrow \bar{\xi}^k , \\ \Psi &\rightarrow \gamma^1 \gamma^3 \otimes 1 \Psi . \end{aligned} \quad (A-2.27)$$

The operation bearing closest resemblance to the ordinary charge conjugation corresponds geometrically to complex conjugation in CP_2 :

$$\begin{aligned}\xi^k &\rightarrow \bar{\xi}^k, \\ \Psi &\rightarrow \Psi^\dagger \gamma^2 \gamma^0 \otimes 1.\end{aligned}\tag{A-2.28}$$

As one might have expected symmetries CP and T are exact symmetries of the pure Dirac action.

A-3 Basic facts about induced gauge fields

Since the classical gauge fields are closely related in TGD framework, it is not possible to have space-time sheets carrying only single kind of gauge field. For instance, em fields are accompanied by Z^0 fields for extremals of Kähler action. Weak forces is however absent unless the space-time sheets contains topologically condensed exotic weakly charged particles responding to this force. Same applies to classical color forces. The fact that these long range fields are present forces to assume that there exists a hierarchy of scaled up variants of standard model physics identifiable in terms of dark matter.

Classical em fields are always accompanied by Z^0 field and some components of color gauge field. For extremals having homologically non-trivial sphere as a CP_2 projection em and Z^0 fields are the only non-vanishing electroweak gauge fields. For homologically trivial sphere only W fields are non-vanishing. Color rotations does not affect the situation.

For vacuum extremals all electro-weak gauge fields are in general non-vanishing although the net gauge field has $U(1)$ holonomy by 2-dimensionality of the CP_2 projection. Color gauge field has $U(1)$ holonomy for all space-time surfaces and quantum classical correspondence suggest a weak form of color confinement meaning that physical states correspond to color neutral members of color multiplets.

A-3.1 Induced gauge fields for space-times for which CP_2 projection is a geodesic sphere

If one requires that space-time surface is an extremal of Kähler action and has a 2-dimensional CP_2 projection, only vacuum extremals and space-time surfaces for which CP_2 projection is a geodesic sphere, are allowed. Homologically non-trivial geodesic sphere correspond to vanishing W fields and homologically non-trivial sphere to non-vanishing W fields but vanishing γ and Z^0 . This can be verified by explicit examples.

$r = \infty$ surface gives rise to a homologically non-trivial geodesic sphere for which e_0 and e_3 vanish imply the vanishing of W field. For space-time sheets for which CP_2 projection is $r = \infty$ homologically non-trivial geodesic sphere of CP_2 one has

$$\gamma = \left(\frac{3}{4} - \frac{\sin^2(\theta_W)}{2}\right)Z^0 \simeq \frac{5Z^0}{8}.$$

The induced W fields vanish in this case and they vanish also for all geodesic sphere obtained by $SU(3)$ rotation.

$Im(\xi^1) = Im(\xi^2) = 0$ corresponds to homologically trivial geodesic sphere. A more general representative is obtained by using for the phase angles of standard complex CP_2 coordinates constant values. In this case e^1 and e^3 vanish so that the induced em, Z^0 , and Kähler fields vanish but induced W fields are non-vanishing. This holds also for surfaces obtained by color rotation. Hence one can say that for non-vacuum extremals with 2-D CP_2 projection color rotations and weak symmetries commute.

A-3.2 Space-time surfaces with vanishing em, Z^0 , or Kähler fields

In the following the induced gauge fields are studied for general space-time surface without assuming the extremal property. In fact, extremal property reduces the study to the study of vacuum extremals and surfaces having geodesic sphere as a CP_2 projection and in this sense the following arguments are somewhat obsolete in their generality.

Space-times with vanishing em, Z^0 , or Kähler fields

The following considerations apply to a more general situation in which the homologically trivial geodesic sphere and extremal property are not assumed. It must be emphasized that this case is possible in TGD framework only for a vanishing Kähler field.

Using spherical coordinates (r, Θ, Ψ, Φ) for CP_2 , the expression of Kähler form reads as

$$\begin{aligned} J &= \frac{r}{F^2} dr \wedge (d\Psi + \cos(\Theta)d\Phi) + \frac{r^2}{2F} \sin(\Theta) d\Theta \wedge d\Phi , \\ F &= 1 + r^2 . \end{aligned} \quad (\text{A-3.1})$$

The general expression of electromagnetic field reads as

$$\begin{aligned} F_{em} &= (3 + 2p) \frac{r}{F^2} dr \wedge (d\Psi + \cos(\Theta)d\Phi) + (3 + p) \frac{r^2}{2F} \sin(\Theta) d\Theta \wedge d\Phi , \\ p &= \sin^2(\Theta_W) , \end{aligned} \quad (\text{A-3.2})$$

where Θ_W denotes Weinberg angle.

a) The vanishing of the electromagnetic fields is guaranteed, when the conditions

$$\begin{aligned} \Psi &= k\Phi , \\ (3 + 2p) \frac{1}{r^2 F} (d(r^2)/d\Theta)(k + \cos(\Theta)) + (3 + p) \sin(\Theta) &= 0 , \end{aligned} \quad (\text{A-3.3})$$

hold true. The conditions imply that CP_2 projection of the electromagnetically neutral space-time is 2-dimensional. Solving the differential equation one obtains

$$\begin{aligned} r &= \sqrt{\frac{X}{1-X}} , \\ X &= D \left[\left| \frac{k+u}{C} \right| \right]^\epsilon , \\ u &\equiv \cos(\Theta) , \quad C = k + \cos(\Theta_0) , \quad D = \frac{r_0^2}{1+r_0^2} , \quad \epsilon = \frac{3+p}{3+2p} , \end{aligned} \quad (\text{A-3.4})$$

where C and D are integration constants. $0 \leq X \leq 1$ is required by the reality of r . $r = 0$ would correspond to $X = 0$ giving $u = -k$ achieved only for $|k| \leq 1$ and $r = \infty$ to $X = 1$ giving $|u+k| = [(1+r_0^2)/r_0^2]^{(3+2p)/(3+p)}$ achieved only for

$$\text{sign}(u+k) \times \left[\frac{1+r_0^2}{r_0^2} \right]^{\frac{3+2p}{3+p}} \leq k+1 ,$$

where $\text{sign}(x)$ denotes the sign of x .

The expressions for Kähler form and Z^0 field are given by

$$\begin{aligned} J &= -\frac{p}{3+2p} X du \wedge d\Phi , \\ Z^0 &= -\frac{6}{p} J . \end{aligned} \quad (\text{A-3.5})$$

The components of the electromagnetic field generated by varying vacuum parameters are proportional to the components of the Kähler field: in particular, the magnetic field is parallel to the Kähler magnetic field. The generation of a long range Z^0 vacuum field is a purely TGD based feature not encountered in the standard gauge theories.

b) The vanishing of Z^0 fields is achieved by the replacement of the parameter ϵ with $\epsilon = 1/2$ as becomes clear by considering the condition stating that Z^0 field vanishes identically. Also the relationship $F_{em} = 3J = -\frac{3}{4} \frac{r^2}{F} du \wedge d\Phi$ is useful.

c) The vanishing Kähler field corresponds to $\epsilon = 1, p = 0$ in the formula for em neutral space-times. In this case classical em and Z^0 fields are proportional to each other:

$$\begin{aligned} Z^0 &= 2e^0 \wedge e^3 = \frac{r}{F^2}(k+u) \frac{\partial r}{\partial u} du \wedge d\Phi = (k+u) du \wedge d\Phi \ , \\ r &= \sqrt{\frac{X}{1-X}} \ , \ X = D|k+u| \ , \\ \gamma &= -\frac{p}{2} Z^0 \ . \end{aligned} \tag{A-3.6}$$

For a vanishing value of Weinberg angle ($p = 0$) em field vanishes and only Z^0 field remains as a long range gauge field. Vacuum extremals for which long range Z^0 field vanishes but em field is non-vanishing are not possible.

The effective form of CP_2 metric for surfaces with 2-dimensional CP_2 projection

The effective form of the CP_2 metric for a space-time having vanishing em, Z^0 , or Kähler field is of practical value in the case of vacuum extremals and is given by

$$\begin{aligned} ds_{eff}^2 &= (s_{rr}(\frac{dr}{d\Theta})^2 + s_{\Theta\Theta})d\Theta^2 + (s_{\Phi\Phi} + 2ks_{\Phi\Psi})d\Phi^2 = \frac{R^2}{4}[s_{\Theta\Theta}^{eff}d\Theta^2 + s_{\Phi\Phi}^{eff}d\Phi^2] \ , \\ s_{\Theta\Theta}^{eff} &= X \times \left[\frac{\epsilon^2(1-u^2)}{(k+u)^2} \times \frac{1}{1-X} + 1 - X \right] \ , \\ s_{\Phi\Phi}^{eff} &= X \times [(1-X)(k+u)^2 + 1 - u^2] \ , \end{aligned} \tag{A-3.7}$$

and is useful in the construction of vacuum imbedding of, say Schwartzchild metric.

Topological quantum numbers

Space-times for which either em, Z^0 , or Kähler field vanishes decompose into regions characterized by six vacuum parameters: two of these quantum numbers (ω_1 and ω_2) are frequency type parameters, two (k_1 and k_2) are wave vector like quantum numbers, two of the quantum numbers (n_1 and n_2) are integers. The parameters ω_i and n_i will be referred as electric and magnetic quantum numbers. The existence of these quantum numbers is not a feature of these solutions alone but represents a much more general phenomenon differentiating in a clear cut manner between TGD and Maxwell's electrodynamics.

The simplest manner to avoid surface Kähler charges and discontinuities or infinities in the derivatives of CP_2 coordinates on the common boundary of two neighboring regions with different vacuum quantum numbers is topological field quantization, 3-space decomposes into disjoint topological field quanta, 3-surfaces having outer boundaries with possibly macroscopic size.

Under rather general conditions the coordinates Ψ and Φ can be written in the form

$$\begin{aligned} \Psi &= \omega_2 m^0 + k_2 m^3 + n_2 \phi + \text{Fourier expansion} \ , \\ \Phi &= \omega_1 m^0 + k_1 m^3 + n_1 \phi + \text{Fourier expansion} \ . \end{aligned} \tag{A-3.8}$$

m^0, m^3 and ϕ denote the coordinate variables of the cylindrical M^4 coordinates) so that one has $k = \omega_2/\omega_1 = n_2/n_1 = k_2/k_1$. The regions of the space-time surface with given values of the vacuum parameters ω_i, k_i and n_i and m and C are bounded by the surfaces at which space-time surface becomes ill-defined, say by $r > 0$ or $r < \infty$ surfaces.

The space-time surface decomposes into regions characterized by different values of the vacuum parameters r_0 and Θ_0 . At $r = \infty$ surfaces n_2, ω_2 and m can change since all values of Ψ correspond to the same point of CP_2 : at $r = 0$ surfaces also n_1 and ω_1 can change since all values of Φ correspond to same point of CP_2 , too. If $r = 0$ or $r = \infty$ is not in the allowed range space-time surface develops a boundary.

This implies what might be called topological quantization since in general it is not possible to find a smooth global imbedding for, say a constant magnetic field. Although global imbedding exists

it decomposes into regions with different values of the vacuum parameters and the coordinate u in general possesses discontinuous derivative at $r = 0$ and $r = \infty$ surfaces. A possible manner to avoid edges of space-time is to allow field quantization so that 3-space (and field) decomposes into disjoint quanta, which can be regarded as structurally stable units a 3-space (and of the gauge field). This doesn't exclude partial join along boundaries for neighboring field quanta provided some additional conditions guaranteeing the absence of edges are satisfied.

For instance, the vanishing of the electromagnetic fields implies that the condition

$$\Omega \equiv \frac{\omega_2}{n_2} - \frac{\omega_1}{n_1} = 0 \quad , \quad (\text{A-3.9})$$

is satisfied. In particular, the ratio ω_2/ω_1 is rational number for the electromagnetically neutral regions of space-time surface. The change of the parameter n_1 and n_2 (ω_1 and ω_2) in general generates magnetic field and therefore these integers will be referred to as magnetic (electric) quantum numbers.

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Index

- H*-chirality, 393
- , 389
- modified massless Dirac operator, 34
- algebraic quantum field theory, 43
- anomalous cognition, 305, 306
- anti-commutativity, 33
- anticipation, 305
- autoscopy, 311
- Betti number, 389
- bi-algebra, 43
- bicameral mind, 304
- braid group, 43
- c*, 389
- co-module, 158
- complexified gamma matrices of the configuration space, 33
- computer metaphor, 154
- coordinates of Eguchi and Freund, 389
- covariantly constant, 391
- delayed luminescence, 254
- delta function, 42
- electro-weak couplings, 393
- electro-weak interactions, 393
- emergence of symbols, 154
- exclusion zones, 190
- gamma ray bursters, 307
- Geodesic sub-manifolds, 392
- glial cell, 160
- Hermitian conjugation, 42
- holonomy, 397
- homotopy group, 392
- Hopf algebra, 43
- hyper-finite factors of type II_1 , 42
- induced spinor connection, 393
- intentional agent, 322
- Kähler form, 391
- Kähler function, 390
- Kähler metric, 390
- Kähler potential, 391
- Lie triple system, 392
- line element, 389
- magnetic monopole, 391
- magnetospheric consciousness, 308
- model for the generation of nerve pulse, 303
- OBEs induced by electric stimulation, 311
- observable, 42
- parallel transport, 392
- path integral, 42
- Pontryagin number, 389
- Popp, 253, 254
- primary sensory qualia, 305
- Priore's machine, 362
- pump-channel paradigm, 154
- ribbon algebra, 43
- spinor connection, 394
- spinor structure, 392
- super nova explosion, 308
- symplectic structure, 391
- telekinesis and electrostatics, 293
- tunnel experience, 299
- vielbein group, 393
- vierbein, 390
- vierbein connection, 390
- Weinberg angle, 395