QUANTUM HARDWARE OF LIVING MATTER

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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 37 years of my life to this enterprise and am still unable to write The Rules.

If I remember correctly, I got the basic idea of Topological Geometrodynamics (TGD) during autumn 1977, 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. This required also the understanding of the relationship to General Relativity.

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. During last year it became clear that 4-D Minkowski space and 4-D complex projective space CP_2 are completely unique in the sense that they allow twistor space with Kähler structure.

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 (CP_2) 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 (ZEO) 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 as it is expressed by Einstein's equations follows from Poincare invariance once it is realized that GRT space-time is obtained from the many-sheeted space-time of TGD by lumping together the space-time sheets to a regionof Minkowski space and endowing it with an effective metric given as a sum of Minkowski metric and deviations of the metrices of space-time sheets from Minkowski metric. Similar description relates classical gauge potentials identified as components of induced spinor connection to Yang-Mills gauge potentials in GRT space-time. Various topological inhomogenities below resolution scale identified as particles are described using energy momentum tensor and gauge currents.

- 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.

  The latest development was the realization that the well- definedness of electromagnetic charge as quantum number for the modes of the induced spinors field requires that the CP_2 projection of the region in which they are non-vanishing carries vanishing W boson field and is 2-D. This implies in the generic case their localization to 2-D surfaces: string world sheets and possibly also partonic 2-surfaces. This localization applies to all modes except covariantly constant right handed neutrino generating supersymmetry and mplies that string model in 4-D space-time is part of TGD. Localization is possible only for Kähler-Dirac assigned with Kähler action defining the dynamics of space-time surfaces. One must however leave open the question whether W field might vanish for the space-time of GRT if related to many-sheeted space-time in the proposed manner even when they do not vanish for space-time sheets.

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 in positive energyontology implies that space-time surfaces are analogous to Bohr orbits. This in positive energy ontology in which space-like 3-surface is basic object. It is not clear whether Bohr orbitology is necessary also in ZEO in which space-time surfaces connect space-like 3-surfaces at the light-like boundaries of causal diamond CD obtained as intersection of future and past directed light-cones (with CP_2 factor included). The reason is that the pair of 3-surfaces replaces the boundary conditions at single 3-surface involving also time derivatives. If one assumes Bohr orbitology then strong correlations between the 3-surfaces at the ends of CD follow. 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. The somewhat cryptic statement "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.

If one requires consistency of Negentropy Mazimization Principle with standard measurement theory, negentropic entanglement defined in terms of number theoretic negentropy is necessarily associated with a density matrix proportional to unit matrix and is maximal and is characterized by the dimension n of the unit matrix. Negentropy is positive and maximal for a p-adic unique prime dividing n.

- One of the latest threads in the evolution of ideas is not more than nine 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. Second motivation for the hierarchy of Planck constants comes from bio-electromagnetism suggesting that in living systems Planck constant could have large values making macroscopic quantum coherence possible. The interpretation of dark matter as a hierarchy of phases of ordinary matter characterized by the value of Planck constant is very natural.

  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 $h_{eff} = n \times h$ coming as a multiple of minimal value of Planck constant. Quite recently it became clear that the non-determinism of Kähler action is indeed the fundamental justification for the hierarchy: the integer n can be also interpreted as the integer characterizing the dimension of unit matrix characterizing negentropic entanglement made possible by the many-sheeted character of the space-time surface.

  Due to conformal invariance acting as gauge symmetry the n degenerate space-time sheets must be replaced with conformal equivalence classes of space-time sheets and conformal transformations correspond to quantum critical deformations leaving the ends of space-time surfaces invariant. Conformal invariance would be broken: only the sub-algebra for which conformal weights are divisible by n act as gauge symmetries. Thus deep connections between conformal invariance related to quantum criticality, hierarchy of Planck constants, negentropic entanglement, effective p-adic topology, and non-determinism of Kähler action perhaps reflecting p-adic non-determinism emerges.

  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 ZEO the notion of S-matrix was replaced with M-matrix defined between positive and negative energy parts of zero energy states. M-matrix 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 ZEO can be said to define a square root of thermodynamics at least formally. M-matrices in turn bombine to form the rows of unitary U-matrix defined between zero energy states.

- A decisive step was the strengthening of the General Coordinate Invariance to the requirement that the formulations of the theory in terms of light-like 3-surfaces identified as 3-surfaces at which the induced metric of space-time surfaces changes its signature and in terms of space-like 3-surfaces are equivalent. This means effective 2-dimensionality in the sense that partonic 2-surfaces defined as intersections of these two kinds of surfaces plus 4-D tangent space data at partonic 2-surfaces code for the physics. Quantum classical correspondence requires the coding of the quantum numbers characterizing quantum states assigned to the partonic 2-surfaces to the geometry of space-time surface. This is achieved by adding to the modified Dirac action a measurement interaction term assigned with light-like 3-surfaces.

- The replacement of strings with light-like 3-surfaces equivalent to space-like 3-surfaces means enormous generalization of the super conformal symmetries of string models. A further generalization of these symmetries to non-local Yangian symmetries generalizing the recently discovered Yangian symmetry of $\mathcal{N} = 4$ supersymmetric Yang-Mills theories is highly suggestive. Here the replacement of point like particles with partonic 2-surfaces means the replacement of conformal symmetry of Minkowski space with infinite-dimensional super-conformal algebras. Yangian symmetry provides also a further refinement to the notion of conserved quantum numbers allowing to define them for bound states using non-local energy conserved currents.

- A further attractive idea is that quantum TGD reduces to almost topological quantum field theory. This is possible if the Kähler action for the preferred extremals defining WCW Kähler function reduces to a 3-D boundary term. This takes place if the conserved currents are so called Beltrami fields with the defining property that the coordinates associated with flow lines extend to single global coordinate variable. This ansatz together with the weak form of electric-magnetic duality reduces the Kähler action to Chern-Simons term with the condition that the 3-surfaces are extremals of Chern-Simons action subject to the constraint force defined by the weak form of electric magnetic duality. It is the latter constraint which prevents the trivialization of the theory to a topological quantum field theory. Also the identification of the Kähler function of WCW as Dirac determinant finds support as well as the description of the scattering amplitudes in terms of braids with interpretation in terms of finite measurement resolution coded to the basic structure of the solutions of field equations.

- In standard QFT Feynman diagrams provide the description of scattering amplitudes. The beauty of Feynman diagrams is that they realize unitarity automatically via the so called Cutkosky rules. In contrast to Feynman's original beliefs, Feynman diagrams and virtual particles are taken only as a convenient mathematical tool in quantum field theories. QFT approach is however plagued by UV and IR divergences and one must keep mind open for the possibility that a genuine progress might mean opening of the black box of the virtual particle.

  In TGD framework this generalization of Feynman diagrams indeed emerges unavoidably. Light-like 3-surfaces replace the lines of Feynman diagrams and vertices are replaced by 2-D partonic 2-surfaces. Zero energy ontology and the interpretation of parton orbits as light-like "wormhole throats" suggests that virtual particle do not differ from on mass shell particles only in that the four- and three- momenta of wormhole throats fail to be parallel. The two throats of the wormhole contact 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.

The localization of the nodes of induced spinor fields to 2-D string world sheets (and possibly also to partonic 2-surfaces) implies a stringy formulation of the theory analogous to stringy variant of twistor formalism with string world sheets having interpretation as 2-braids. In TGD framework fermionic variant of twistor Grassmann formalism leads to a stringy variant of twistor diagrammatics in which basic fermions can be said to be on mass-shell but carry non-physical helicities in the internal lines. This suggests the generalization of the Yangian symmetry to infinite-dimensional super-conformal algebras.

TGD based view about quantum consciousness relies on following ideas and inputs.

- TGD inspired theory of consciousness can be seen as a generalization of quantum measurement theory by bringing in conscious observer. The basic new elements are the resolution of the basic problem of the measurement theory by the introduction of ZEO, which brings new elements also to the quantum measurement theory and leads to a view about how the arrow of time and its flow are generated. p-Adic physics brings in the notion of negentropic entanglement and Negentropy Maximization Principle provides the basic variational principle. The possibility of negentropic entanglement predicts evolution as gradual increase of negentropic resources of the Universe.

- The notion of self - at least as effective notion- emerges naturally from negentropic entanglement and from more precise view about sequence of state function reductions which now leaves invariant only the second part of zero energy state but changes the other one. The generation of "Akashic records" defined by negentropically entangled systems are in vital role in the understanding of evolution.

- CDs serve as correlates of selves and a hierarchy of selves is predicted and closely relates to the p-adic hierarchy and hierarchy of Planck constants. Subselves are interpreted as mental images of self and the sharing of mental images by fusion of subselves gives rise to a kind of stereo consciousness.

The following list gives the basic elements of TGD inspire quantum biology.

- 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 undersand 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.

- Magnetic body carrying dark matter and forming an onion-like structure with layers characterized by large values of Planck constant is the key concept of TGD inspired view about Quantum Mind to biology.. 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 then.

  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 zero energy ontology the braiding actually generalize to 2-braiding for string world sheets in 4-D space-time and brings in new elements.

- 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 amino-acids in a natural manner and vertebrate genetic code as correspondence between DNA and amino-acids 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.

- p-Adic physics can be identified as physics of cognition and intentionality. 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.

- 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.

Various anomalies of living matter have been in vital role in the development of not only TGD view about living matter but also TGD itself.

- 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. Also the findings about effects of ELF em fields on vertebrate brain were decisive and led to the proposal of the hierarchy of Planck constants found later to emerge naturally from the non-determinism of Kähler action. Rather satisfactorily, the other manner to introduce the hierarchy of Planck constants is in terms of gravitational Planck constant: at least in microscopic scales the equivalence of these approaches makes sense and leads to highly non-trivial predictions. The basic testable prediction is that dark photons have cyclotron frequencies inversely proportional to their massess but universal energy spectrum in visible and UV range which corresponds to the transition energies for biomolecules so that they are ideal for biocontrol at the level of both magnetic bodies and at the level of biochemistry.

- Water is in key role in living matter and also in TGD inspired view about living matter. The anomalies of water lead to a model for dark nuclei as dark proton strings with the surprising prediction that DNA, RNA, aninoacids and even tRNA are in one-one correspondence with the resulting 3-quark states and that vertebrate genetic code emerges naturally. This leads to a vision about water as primordial lifeform still playing a vital role in living organisms. The model of water memory and homeopathy in turn generalizes to a vision about how immune system might have evolved.

- Metabolic energy is necessary for conscious information processing in living matter. This suggests that metabolism should be basically tranfer of negentropic entanglement from nutrients to the organism. ATP could be seen as a molecule of consciousness in this picture and high energy phosphate bond would make possible the transfer of negentropy.

What I have said above is strongly biased view about the recent situation in quantum TGD and its applications to biology and consciousness. 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 37 years of TGD is a really vast bundle of thoughts and quite a challenge for anyone who is not able to cheat himself by taking the attitude of a blind believer or a light-hearted debunker trusting on the power of easy rhetoric tricks.

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

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

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

For a person approaching his sixty year birthday it is somewhat easier to overcome the hard

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

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Chapter 1

Introduction

1.1 Basic Ideas Of Topological Geometrodynamics (TGD)

Standard model describes rather successfully both electroweak and strong interactions but sees them as totally separate and contains a large number of parameters which it is not able to predict. For about four decades ago unified theories known as Grand Unified Theories (GUTs) trying to understand electroweak interactions and strong interactions as aspects of the same fundamental gauge interaction assignable to a larger symmetry group emerged. Later superstring models trying to unify even gravitation and strong and weak interactions emerged. The shortcomings of both GUTs and superstring models are now well-known. If TGD - whose basic idea emerged 37 years ago - would emerge now it would be seen as an attempt trying to solve the difficulties of these approaches to unification.

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

1.1.1 Basic Vision Very Briefly

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 basic vision and its relationship to existing theories is now rather well understood.

1. Space-times are representable as 4-surfaces in the 8-dimensional embedding space $H = M^4 \times CP_2$, where M^4 is 4-dimensional (4-D) Minkowski space and CP_2 is 4-D complex projective space (see Appendix).

2. Induction procedure (a standard procedure in fiber bundle theory, see Appendix) allows to geometrize various fields. Space-time metric characterizing gravitational fields corresponds to the induced metric obtained by projecting the metric tensor of H to the space-time surface. Electroweak gauge potentials are identified as projections of the components of CP_2 spinor connection to the space-time surface, and color gauge potentials as projections of CP_2 Killing vector fields representing color symmetries. Also spinor structure can be induced: induced spinor gamma matrices are projections of gamma matrices of H and induced spinor fields just H spinor fields restricted to space-time surface. Spinor connection is also projected. The interpretation is that distances are measured in embedding space metric and parallel translation using spinor connection of embedding space.

   The induction procedure applies to octonionic structure and the conjecture is that for preferred extremals the induced octonionic structure is quaternionic: again one just projects the octonion units. I have proposed that one can lift space-time surfaces in H to the Cartesian product of the twistor spaces of M^4 and CP_2, which are the only 4-manifolds allowing twistor space with Kähler structure [A13]. Now the twistor structure would be induced in some sense, and should co-incide with that associated with the induced metric. Clearly, the

2-spheres defining the fibers of twistor spaces of M^4 and CP_2 must allow identification: this 2-sphere defines the S^2 fiber of the twistor space of space-time surface. This poses constraint on the embedding of the twistor space of space-time surfaces as sub-manifold in the Cartesian product of twistor spaces.

3. Geometrization of quantum numbers is achieved. The isometry group of the geometry of CP_2 codes for the color gauge symmetries of strong interactions. Vierbein group codes for electroweak symmetries, and explains their breaking in terms of CP_2 geometry so that standard model gauge group results. There are also important deviations from standard model: color quantum numbers are not spin-like but analogous to orbital angular momentum: this difference is expected to be seen only in CP_2 scale. In contrast to GUTs, quark and lepton numbers are separately conserved and family replication has a topological explanation in terms of topology of the partonic 2-surface carrying fermionic quantum numbers.

   M^4 and CP_2 are unique choices for many other reasons. For instance, they are the unique 4-D space-times allowing twistor space with Kähler structure. M^4 light-cone boundary allows a huge extension of 2-D conformal symmetries. Embedding space H has a number theoretic interpretation as 8-D space allowing octonionic tangent space structure. M^4 and CP_2 allow quaternionic structures. Therefore standard model symmetries have number theoretic meaning.

4. Induced gauge potentials are expressible in terms of embedding space coordinates and their gradients and general coordinate invariance implies that there are only 4 field like variables locally. Situation is thus extremely simple mathematically. The objection is that one loses linear superposition of fields. The resolution of the problem comes from the generalization of the concepts of particle and space-time.

   Space-time surfaces can be also particle like having thus finite size. In particular, space-time regions with Euclidian signature of the induced metric (temporal and spatial dimensions in the same role) emerge and have interpretation as lines of generalized Feynman diagrams. Particle in space-time can be identified as a topological inhomogenuity in background space-time surface which looks like the space-time of general relativity in long length scales.

   One ends up with a generalization of space-time surface to many-sheeted space-time with space-time sheets having extremely small distance of about 10^4 Planck lengths (CP_2 size). As one adds a particle to this kind of structure, it touches various space-time sheets and thus interacts with the associated classical fields. Their effects superpose linearly in good approximation and linear superposition of fields is replaced with that for their effects.

   This resolves the basic objection. It also leads to the understanding of how the space-time of general relativity and quantum field theories emerges from TGD space-time as effective space-time when the sheets of many-sheeted space-time are lumped together to form a region of Minkowski space with metric replaced with a metric identified as the sum of empty Minkowski metric and deviations of the metrics of sheets from empty Minkowski metric. Gauge potentials are identified as sums of the induced gauge potentials. TGD is therefore a microscopic theory from which standard model and general relativity follow as a topological simplification however forcing to increase dramatically the number of fundamental field variables.

5. A further objection is that classical weak fields identified as induced gauge fields are long ranged and should cause large parity breaking effects due to weak interactions. These effects are indeed observed but only in living matter. A possible resolution of problem is implied by the condition that the modes of the induced spinor fields have well-defined electromagnetic charge. This forces their localization to 2-D string world sheets in the generic case having vanishing weak gauge fields so that parity breaking effects emerge just as they do in standard model. Also string model like picture emerges from TGD and one ends up with a rather concrete view about generalized Feynman diagrammatics. A possible objection is that the Kähler-Dirac gamma matrices do not define an integrable distribution of 2-planes defining string world sheet.

An even strong condition would be that the induced classical gauge fields at string world sheet vanish: this condition is allowed by the topological description of particles. The CP_2 projection of string world sheet would be 1-dimensional. Also the number theoretical condition that octonionic and ordinary spinor structures are equivalent guaranteeing that fermionic dynamics is associative leads to the vanishing of induced gauge fields.

The natural action would be given by string world sheet area, which is present only in the space-time regions with Minkowskian signature. Gravitational constant would be present as a fundamental constant in string action and the ratio $\hbar/G/R^2$ would be determined by quantum criticality condition. The hierarchy of Planck constants $h_{eff}/h = n$ assigned to dark matter in TGD framework would allow to circumvent the objection that only objects of length of order Planck length are possible since string tension given by $T = 1/\hbar_{eff}G$ apart from numerical factor could be arbitrary small. This would make possible gravitational bound states as partonic 2-surfaces as structures connected by strings and solve the basic problem of super string theories. This option allows the natural interpretation of M^4 type vacuum extremals with CP_2 projection, which is Lagrange manifold as good approximations for space-time sheets at macroscopic length scales. String area does not contribute to the Kähler function at all.

Whether also induced spinor fields associated with Kähler-Dirac action and de-localized inside entire space-time surface should be allowed remains an open question: super-conformal symmetry strongly suggests their presence. A possible interpretation for the corresponding spinor modes could be in terms of dark matter, sparticles, and hierarchy of Planck constants.

It is perhaps useful to make clear what TGD is not and also what new TGD can give to physics.

1. TGD is *not* just General Relativity made concrete by using embeddings: the 4-surface property is absolutely essential for unifying standard model physics with gravitation and to circumvent the incurable conceptual problems of General Relativity. The many-sheeted space-time of TGD gives rise only at macroscopic limit to GRT space-time as a slightly curved Minkowski space. TGD is *not* a Kaluza-Klein theory although color gauge potentials are analogous to gauge potentials in these theories.

   TGD space-time is 4-D and its dimension is due to completely unique conformal properties of light-cone boundary and 3-D light-like surfaces implying enormous extension of the ordinary conformal symmetries. Light-like 3-surfaces represent orbits of partonic 2-surfaces and carry fundamental fermions at 1-D boundaries of string world sheets. TGD is *not* obtained by performing Poincare gauging of space-time to introduce gravitation and plagued by profound conceptual problems.

2. TGD is *not* a particular string model although string world sheets emerge in TGD very naturally as loci for spinor modes: their 2-dimensionality makes among other things possible quantum deformation of quantization known to be physically realized in condensed matter, and conjectured in TGD framework to be crucial for understanding the notion of finite measurement resolution. Hierarchy of objects of dimension up to 4 emerge from TGD: this obviously means analogy with branes of super-string models.

   TGD is *not* one more item in the collection of string models of quantum gravitation relying on Planck length mystics. Dark matter becomes an essential element of quantum gravitation and quantum coherence in astrophysical scales is predicted just from the assumption that strings connecting partonic 2-surfaces serve are responsible for gravitational bound states.

   TGD is *not* a particular string model although AdS/CFT duality of super-string models generalizes due to the huge extension of conformal symmetries and by the identification of WCW gamma matrices as Noether super-charges of super-symplectic algebra having a natural conformal structure.

3. TGD is *not* a gauge theory. In TGD framework the counterparts of also ordinary gauge symmetries are assigned to super-symplectic algebra (and its Yangian [A4] [B8, B6, B7]), which is a generalization of Kac-Moody algebras rather than gauge algebra and suffers a

fractal hierarchy of symmetry breakings defining hierarchy of criticalities. TGD is *not* one more quantum field theory like structure based on path integral formalism: path integral is replaced with functional integral over 3-surfaces, and the notion of classical space-time becomes exact part of the theory. Quantum theory becomes formally a purely classical theory of WCW spinor fields: only state function reduction is something genuinely quantal.

4. TGD view about spinor fields is *not* the standard one. Spinor fields appear at three levels. Spinor modes of the embedding space are analogs of spinor modes charactering incoming and outgoing states in quantum field theories. Induced second quantized spinor fields at space-time level are analogs of stringy spinor fields. Their modes are localized by the well-definedness of electro-magnetic charge and by number theoretic arguments at string world sheets. Kähler-Dirac action is fixed by supersymmetry implying that ordinary gamma matrices are replaced by what I call Kähler-Dirac gamma matrices - this something new. WCW spinor fields, which are classical in the sense that they are not second quantized, serve as analogs of fields of string field theory and imply a geometrization of quantum theory.

5. TGD is in some sense an extremely conservative geometrization of entire quantum physics: *no* additional structures such as gauge fields as independent dynamical degrees of freedom are introduced: Kähler geometry and associated spinor structure are enough. "Topological" in TGD should not be understood as an attempt to reduce physics to torsion (see for instance [B5]) or something similar. Rather, TGD space-time is topologically non-trivial in all scales and even the visible structures of everyday world represent non-trivial topology of space-time in TGD Universe.

6. Twistor space - or rather, a generalization of twistor approach replacing masslessness in 4-D sense with masslessness in 8-D sense and thus allowing description of also massive particles - emerged originally as a technical tool, and its Kähler structure is possible only for $H = M^4 \times CP_2$. It however turned out that much more than a technical tool is in question. What is genuinely new is the infinite-dimensional character of the Kähler geometry making it highly unique, and its generalization to p-adic number fields to describe correlates of cognition. Also the hierarchies of Planck constants $h_{eff} = n \times h$ reducing to the quantum criticality of TGD Universe and p-adic length scales and Zero Energy Ontology represent something genuinely new.

The great challenge is to construct a mathematical theory around these physically very attractive ideas and I have devoted the last41 years for the realization of this dream and this has resulted 24 online books about TGD and nine online books about TGD inspired theory of consciousness and of quantum biology.

1.1.2 Two Visions About TGD And Their Fusion

As already mentioned, TGD can be interpreted both as a modification of general relativity and generalization of string models.

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 [A9, A12, A7, A11].

The identification of the space-time as a sub-manifold [A10, A15] 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 sub-manifold 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.

The choice of H is unique from the condition that TGD has standard model symmetries. Also number theoretical vision selects $H = M^4 \times CP_2$ uniquely. M^4 and CP_2 are also unique spaces allowing twistor space with Kähler structure.

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.

Quite recently, it has turned out that fermionic strings inside space-time surfaces define an exact part of quantum TGD and that this is essential for understanding gravitation in long length scales. Also the analog of AdS/CFT duality emerges in that the Kähler metric can be defined either in terms of Kähler function identifiable as Kähler action assignable to Euclidian space-time regions or Kähler action + string action assignable to Minkowskian regions.

The recent view about construction of scattering amplitudes is very "stringy". By strong form of holography string world sheets and partonic 2-surfaces provide the data needed to construct scattering amplitudes. Space-time surfaces are however needed to realize quantum-classical correspondence necessary to understand the classical correlates of quantum measurement. There is a huge generalization of the duality symmetry of hadronic string models. Scattering amplitudes can be regarded as sequences of computational operations for the Yangian of super-symplectic algebra. Product and co-product define the basic vertices and realized geometrically as partonic 2-surfaces and algebraically as multiplication for the elements of Yangian identified as super-symplectic Noether charges assignable to strings. Any computational sequences connecting given collections of algebraic objects at the opposite boundaries of causal diamond (CD) produce identical scattering amplitudes.

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 and string like objects (counterpart of the "baby universes" of GRT) and the non-conservation of energy in GRT corresponds to the transfer of energy between different sheets of the space-time and possibly existence vapour phase.

What one obtains is what I have christened as many-sheeted space-time (see **Fig.** `http://tgdtheory.fi/appfigures/manysheeted.jpg` or **Fig. ??** in the appendix of this book). 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. CDs 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 the pair of initial and final states of a physical event, say particle reaction.

At space-time level ZEO means that 3-surfaces are pairs of space-like 3-surfaces at the opposite light-like boundaries of CD. Since the extremals of Kähler action connect these, one can say that by holography the basic dynamical objects are the space-time surface connecting these 3-surfaces. This changes totally the vision about notions like self-organization: self-organization by quantum jumps does not take for a 3-D system but for the entire 4-D field pattern associated with it.

General Coordinate Invariance (GCI) 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.

1.1.3 Basic Objections

Objections are the most powerful tool in theory building. The strongest objection against TGD is the observation that all classical gauge fields are expressible in terms of four embedding 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.

Second objection is that TGD space-time is quite too simple as compared to GRT space-time due to the imbeddability to 8-D embedding space. One can also argue that Poincare invariant theory of gravitation cannot be consistent with General Relativity. The above interpretation allows to understand the relationship to GRT space-time and how Equivalence Principle (EP) follows from Poincare invariance of TGD. The interpretation of GRT space-time is as effective space-time obtained by replacing many-sheeted space-time with Minkowski space with effective metric determined as a sum of Minkowski metric and sum over the deviations of the induced metrices of space-time sheets from Minkowski metric. Poincare invariance suggests strongly classical EP for the GRT limit in long length scales at least. One can consider also other kinds of limits such as the analog of GRT limit for Euclidian space-time regions assignable to elementary particles. In this case deformations of CP_2 metric define a natural starting point and CP_2 indeed defines a gravitational instanton with very large cosmological constant in Einstein-Maxwell theory. Also gauge potentials of standard model correspond classically to superpositions of induced gauge potentials over space-time sheets.

Topological field quantization

Topological field quantization distinguishes between TGD based and more standard - say Maxwellian - notion of field. In Maxwell's fields created by separate systems superpose and one cannot tell which part of field comes from which system except theoretically. In TGD these fields correspond to different space-time sheets and only their effects on test particle superpose. Hence physical systems have well-defined field identifies - field bodies - in particular magnetic bodies.

The notion of magnetic body carrying dark matter with non-standard large value of Planck constant has become central concept in TGD inspired theory of consciousness and living matter, and by starting from various anomalies of biology one ends up to a rather detailed view about the role of magnetic body as intentional agent receiving sensory input from the biological body and controlling it using EEG and its various scaled up variants as a communication tool. Among other thins this leads to models for cell membrane, nerve pulse, and EEG.

1.1.4 P-Adic Variants Of Space-Time Surfaces

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. One might say that TGD space-time is adelic. Also the hierarchy of Planck constants forces a generalization of the notion of space-time but this generalization can be understood in terms of the failure of strict determinism for Kähler action defining the fundamental variational principle behind the dynamics of space-time surfaces.

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.

1.1.5 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.

The theoretical framework involves several threads.

1. Quantum T(opological) G(eometro)D(ynamics) as a classical spinor geometry for infinite-dimensional WCW, 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.

2. 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" thread.

3. 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 strongly suggested by the failure of strict determinism for the fundamental variational principle. The identification

of hierarchy of Planck constants labelling phases of dark matter 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.

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.

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 eight online books [K54, K44, K33, K64, K49, K63, K62, K48] about TGD and nine online books about TGD inspired theory of consciousness and of quantum biology [K50, K8, K37, K6, K17, K24, K27, K47, K59] are warmly recommended to the interested reader.

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 ("world of classical worlds", WCW) 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 [A14, A16, A18]. 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 WCW 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 naïve 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 unexpected 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 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 [1]

4. WCW Dirac operator appearing in Super-Virasoro conditions, embedding space Dirac operator whose modes define the ground states of Super-Virasoro representations, Kähler-Dirac operator at space-time surfaces, and the algebraic variant of M^4 Dirac operator appearing in

[1] There are four kinds of Dirac operators in TGD. The geometrization of quantum theory requires Kähler metric definable either in terms of Kähler function identified as Kähler action for Euclidian space-time regions or as anticommutators for WCW gamma matrices identified as conformal Noether super-charges associated with the second quantized modified Dirac action consisting of string world sheet term and possibly also Kähler Dirac action in Minkowskian space-time regions. These two possible definitions reflect a duality analogous to AdS/CFT duality.

propagators. 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 defined between positive and negative energy parts of zero energy states which form orthonormal rows of what I call U-matrix as a matrix defined between zero energy states. Given M-matrix in turn would decompose to a product of a hermitian square root of 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 M-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.

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 and would correspond to a hierarchy of CDs with the temporal distances between tips coming as integer multiples of the CP_2 time.

The M-matrices associated with CDs are obtained by a discrete scaling from the minimal CD and characterized by integer n are naturally proportional to a representation matrix of scaling: $S(n) = S^n$, where S is unitary S-matrix associated with the minimal CD [K56]. This conforms with the idea about unitary time evolution as exponent of Hamiltonian discretized to integer power of S and represented as scaling with respect to the logarithm of the proper time distance between the tips of CD.

U-matrix elements between M-matrices for various CDs are proportional to the inner products $Tr[S^{-n_1} \circ H^i H^j \circ S^{n_2} \lambda]$, where λ represents unitarily the discrete Lorentz boost relating the moduli of the active boundary of CD and H^i form an orthonormal basis of Hermitian square roots of density matrices. $\circ$ tells that S acts at the active boundary of CD only. It turns out possible to construct a general representation for the U-matrix reducing its construction to that of S-matrix. S-matrix has interpretation as exponential of the Virasoro generator L_{-1} of the Virasoro algebra associated with super-symplectic algebra.

5. 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 (or Kähler-Dirac action) in which gamma matrices are replaced with the modified (Kähler-Dirac) gamma matrices defined as contractions of the canonical momentum currents with the embedding space gamma matrices. In this manner one achieves super-conformal symmetry and conservation of fermionic currents among other things and consistent Dirac equation. The Kähler-Dirac gamma matrices define as anti-commutators effective metric, which might provide geometrization for some basic observables of condensed matter physics. One might also 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 anti-fermion.

6. An important result relates to the notion of induced spinor connection. If one requires that spinor modes have well-defined em charge, one must assume that the modes in the generic situation are localized at 2-D surfaces - string world sheets or perhaps also partonic 2-surfaces - at which classical W boson fields vanish. Covariantly constant right handed neutrino generating super-symmetries forms an exception. The vanishing of also Z^0 field is possible for Kähler-Dirac action and should hold true at least above weak length scales. This implies that string model in 4-D space-time becomes part of TGD. Without these conditions classical weak fields can vanish above weak scale only for the GRT limit of TGD for which gauge potentials are sums over those for space-time sheets.

   The localization simplifies enormously the mathematics and one can solve exactly the Kähler-Dirac equation for the modes of the induced spinor field just like in super string models.

At the light-like 3-surfaces at which the signature of the induced metric changes from Euclidian to Minkowskian so that $\sqrt{g_4}$ vanishes one can pose the condition that the algebraic analog of massless Dirac equation is satisfied by the nodes so that Kähler-Dirac action gives massless Dirac propagator localizable at the boundaries of the string world sheets.

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.

It took long time to realize that there is no discretization in 4-D sense - this would lead to difficulties with basic symmetries. Rather, the discretization occurs for the parameters characterizing co-dimension 2 objects representing the information about space-time surface so that they belong to some algebraic extension of rationals. These 2-surfaces - string world sheets and partonic 2-surfaces - are genuine physical objects rather than a computational approximation. Physics itself approximates itself, one might say! This is of course nothing but strong form of holography.

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 $\sqrt{g_4}$ factorc coming from metric would be imaginary so that one would obtain sum of real term identifiable as Kähler function and imaginary term identifiable as the ordinary Minkowskian 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 Coulomb 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.

TGD as a generalized number theory

Quantum T(opological)D(ynamics) as a classical spinor geometry for infinite-dimensional configuration space ("world of classical worlds", WCW), 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.

1. 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.

In string model context one tries to reduces the physics to Planck scale. The price is the inability to say anything about physics in long length scales. In TGD p-adic physics takes care of this shortcoming by predicting the physics also in long length scales.

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 WCW? 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 various uncertainties, the number of the applications of the poorly defined p-adic physics has grown 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 embedding space and space-time concept and one can speak about real and p-adic space-time sheets. One can talk about adelic space-time, embedding space, and WCW.

The notion of p-adic manifold [K107] identified as p-adic space-time surface solving p-adic analogs of field equations and having real space-time sheet as chart map provided a possible solution of the basic challenge of relating real and p-adic classical physics. One can also speak of real space-time surfaces having p-adic space-time surfaces as chart maps (cognitive maps, "thought bubbles"). Discretization required having interpretation in terms of finite measurement resolution is unavoidable in this approach and this leads to problems with symmetries: canonical identification does not commute with symmetries.

It is now clear that much more elegant approach based on abstraction exists [K105]. The map of real preferred extremals to p-adic ones is not induced from a local correspondence between points but is global. Discretization occurs only for the parameters characterizing string world sheets and partonic 2-surfaces so that they belong to some algebraic extension of rationals. Restriction to these 2-surfaces is possible by strong form of holography. Adelization providing number theoretical universality reduces to algebraic continuation for the amplitudes from this intersection of reality and various p-adicities - analogous to a back of a book - to various number fields. There are no problems with symmetries but canonical identification is needed: various group invariant of the amplitude are mapped by canonical identification to various p-adic number fields. This is nothing but a generalization of the mapping of the p-adic mass squared to its real counterpart in p-adic mass calculations.

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 (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book). One can also understand how preferred p-adic primes could emerge as so called ramified primes of algebraic extension of rationals in question and characterizing string world sheets and partonic 2-surfaces. Preferred p-adic primes would be ramified primes for extensions for which the number of p-adic continuations of two-surfaces to space-time surfaces (imaginations) allowing also real continuation (realization of imagination) would be especially large. These ramifications would be winners in the fight for number theoretical survival. Also a generalization of p-adic length scale hypothesis emerges from NMP [K28].

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 a 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.

2. The role of classical number fields

The vision about the physical role of the classical number fields relies on certain speculative questions inspired by the idea that space-time dynamics could be reduced to associativity or co-associativity condition. Associativity means here associativity of tangent spaces of space-time region and co-associativity associativity of normal spaces of space-time region.

1. Could space-time surfaces X^4 be regarded as associative or co-associative ("quaternionic" is equivalent with "associative") surfaces of H endowed with octonionic structure in the sense that tangent space of space-time surface would be associative (co-associative with normal space associative) sub-space of octonions at each point of X^4 [K98]. This is certainly possible and an interesting conjecture is that the preferred extremals of Kähler action include associative and co-associative space-time regions.

2. Could the notion of compactification generalize to that of number theoretic compactification in the sense that one can map associative (co-associative) surfaces of M^8 regarded as octonionic linear space to surfaces in $M^4 \times CP_2$ [K98] ? This conjecture - $M^8 - H$ duality - would give for $M^4 \times CP_2$ deep number theoretic meaning. CP_2 would parametrize associative planes of octonion space containing fixed complex plane $M^2 \subset M^8$ and CP_2 point would thus characterize the tangent space of $X^4 \subset M^8$. The point of M^4 would be obtained by projecting the point of $X^4 \subset M^8$ to a point of M^4 identified as tangent space of X^4. This would guarantee that the dimension of space-time surface in H would be four. The conjecture is that the preferred extremals of Kähler action include these surfaces.

3. $M^8 - H$ duality can be generalized to a duality $H \rightarrow H$ if the images of the associative surface in M^8 is associative surface in H. One can start from associative surface of H and assume

that it contains the preferred M^2 tangent plane in 8-D tangent space of H or integrable distribution $M^2(x)$ of them, and its points to H by mapping M^4 projection of H point to itself and associative tangent space to CP_2 point. This point need not be the original one! If the resulting surface is also associative, one can iterate the process indefinitely. WCW would be a category with one object.

4. G_2 defines the automorphism group of octonions, and one might hope that the maps of octonions to octonions such that the action of Jacobian in the tangent space of associative or co-associative surface reduces to that of G_2 could produce new associative/co-associative surfaces. The action of G_2 would be analogous to that of gauge group.

5. One can also ask whether the notions of commutativity and co-commutativity could have physical meaning. The well-definedness of em charge as quantum number for the modes of the induced spinor field requires their localization to 2-D surfaces (right-handed neutrino is an exception) - string world sheets and partonic 2-surfaces. This can be possible only for Kähler action and could have commutativity and co-commutativity as a number theoretic counterpart. The basic vision would be that the dynamics of Kähler action realizes number theoretical geometrical notions like associativity and commutativity and their co-notions.

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 a sub-space of complexified octonions (addition of commuting imaginary unit i) their tangent space or normal space is quaternionic- and thus maximally associative or co-associative. These surfaces can be mapped in natural manner to surfaces in $M^4 \times CP_2$ [K98] provided one can assign to each point of tangent space a hyper-complex plane $M^2(x) \subset M^4 \subset M^8$. One can also speak about $M^8 - H$ duality.

This vision has very strong predictive power. It predicts that the preferred extremals of Kähler action correspond to either quaternionic or co-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.

Number theoretical compactification has inspired large number of conjectures. This includes 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 WCW metric and spinor structure in terms of second quantized induced spinor fields with modified Dirac action defined by Kähler action realizing the notion of finite measurement resolution and a connection with inclusions of hyper-finite factors of type II_1 about which Clifford algebra of WCW 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.

Associativity (co-associativity) would be that tangent (normal) spaces of space-time surfaces associative (co-associative) in some sense and thus quaternionic (co-quaternionic). This can be formulated in two ways.

1. One can introduce octonionic tangent space basis by assigning to the "free" gamma matrices octonion basis or in terms of octonionic representation of the embedding space gamma matrices possible in dimension $D = 8$.

2. Associativity (quaternionicity) would state that the projections of octonionic basic vectors or induced gamma matrices basis to the space-time surface generates associative (quaternionic)

sub-algebra at each space-time point. Co-associativity is defined in analogous manner and can be expressed in terms of the components of second fundamental form.

3. For gamma matrix option induced rather than Kähler-Dirac gamma matrices must be in question since Kähler-Dirac gamma matrices can span lower than 4-dimensional space and are not parallel to the space-time surfaces as embedding space vectors.

3. 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.

After the realization that infinite primes can be mapped to polynomials possibly 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.

The infinite primes at the first level of hierarchy, which represent analogs of bound states, can be mapped to irreducible polynomials, which in turn characterize the algebraic extensions of rationals defining a hierarchy of algebraic physics continuable to real and p-adic number fields. The products of infinite primes in turn define more general algebraic extensions of rationals. The interesting question concerns the physical interpretation of the higher levels in the hierarchy of infinite primes and integers mappable to polynomials of $n > 1$ variables.

1.1.6 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 $\hbar$ phases

D. Da Rocha and Laurent Nottale [E2] 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 that astrophysical systems are at some levels of the hierarchy of space-time sheets macroscopic quantum systems. The space-time sheets in question would carry dark matter.

Nottale's hypothesis would predict a gigantic value of h_{gr}. Equivalence Principle and the independence of gravitational Compton length on mass m implies however that one can restrict the values of mass m to masses of microscopic objects so that h_{gr} would be much smaller. Large h_{gr} could 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 [K91].

It is natural to assign the values of Planck constants postulated by Nottale to the space-time sheets mediating gravitational interaction and identifiable as magnetic flux tubes (quanta) possibly carrying monopole flux and identifiable as remnants of cosmic string phase of primordial cosmology. 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.

Certain experimental findings suggest the identification $h_{eff} = n\times = h_{gr}$. The large value of h_{gr} can be seen as a way to reduce the string tension of fermionic strings so that gravitational (in fact all!) bound states can be described in terms of strings connecting the partonic 2-surfaces defining particles (analogous to AdS/CFT description). The values $h_{eff}/h = n$ can be interpreted in terms of a hierarchy of breakings of super-conformal symmetry in which the super-conformal generators act as gauge symmetries only for a sub-algebras with conformal weights coming as multiples of n. Macroscopic quantum coherence in astrophysical scales is implied. If also Kähler-Dirac action is present, part of the interior degrees of freedom associated with the Kähler-Dirac part of conformal algebra become physical. A possible is that tfermionic oscillator operators generate super-symmetries and sparticles correspond almost by definition to dark matter with $h_{eff}/h = n > 1$. One implication would be that at least part if not all gravitons would be dark and be observed only through their decays to ordinary high frequency graviton ($E = hf_{high} = h_{eff}f_{low}$) of bunch of n low energy gravitons.

Hierarchy of Planck constants from the anomalies of neuroscience and biology

The quantal ELF 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 a 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.

The hypothesis $h_{eff} = h_{gr}$ - at least for microscopic particles - implies that cyclotron energies of charged particles do not depend on the mass of the particle and their spectrum is thus universal although corresponding frequencies depend on mass. In bio-applications this spectrum would correspond to the energy spectrum of bio-photons assumed to result from dark photons by h_{eff} reducing phase transition and the energies of bio-photons would be in visible and UV range associated with the excitations of bio-molecules.

Also the anomalies of biology (see for instance [K38, K39, K57]) 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 embedding space [K81]. 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 embedding 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 embedding 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 embedding space is only effective. Many-sheeted coverings of the embedding space indeed emerge naturally in TGD framework. The huge vacuum degeneracy of Kähler action implies that the relationship between gradients of the embedding 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 embedding 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.

A more precise formulation is in terms of presence of large number of space-time sheets connecting given space-like 3-surfaces at the opposite boundaries of causal diamond. Quantum criticality presence of vanishing second variations of Kähler action and identified in terms of conformal invariance broken down to to sub-algebras of super-conformal algebras with conformal weights divisible by integer n is highly suggestive notion and would imply that n sheets of the effective covering are actually conformal equivalence classes of space-time sheets with same Kähler action and same values of conserved classical charges (see **Fig.** `http://tgdtheory.fi/appfigures/planckhierarchy.jpg` or **Fig. ??** the appendix of this book). n would naturally correspond the value of h_{eff} and its factors negentropic entanglement with unit density matrix would be between the n sheets of two coverings of this kind. p-Adic prime would be largest prime power factor of n.

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.

The recent view about the solutions of Kähler- Dirac action assumes that the modes have a well-defined em charge and this implies that localization of the modes to 2-D surfaces (right-handed neutrino is an exception). Classical W boson fields vanish at these surfaces and also classical Z^0 field can vanish. The latter would guarantee the absence of large parity breaking effects above intermediate boson scale scaling like h_{eff}.

1.1.7 Twistors in TGD and connection with Veneziano duality

The twistorialization of TGD has two aspects. The attempt to generalize twistor Grassmannian approach emerged first. It was however followed by the realization that also the twistor lift of TGD at classical space-time level is needed. It turned out that the progress in the understanding of the classical twistor lift has been much faster - probably this is due to my rather limited technical QFT skills.

Twistor lift at space-time level

8-dimensional generalization of ordinary twistors is highly attractive approach to TGD [K100]. The reason is that M^4 and CP_2 are completely exceptional in the sense that they are the only 4-D manifolds allowing twistor space with Kähler structure [A13]. The twistor space of $M^4 \times CP_2$ is Cartesian product of those of M^4 and CP_2. The obvious idea is that space-time surfaces allowing twistor structure if they are orientable are representable as surfaces in H such that the properly induced twistor structure co-incides with the twistor structure defined by the induced metric.

In fact, it is enough to generalize the induction of spinor structure to that of twistor structure so that the induced twistor structure need not be identical with the ordinary twistor structure possibly assignable to the space-time surface. The induction procedure reduces to a dimensional reduction of 6-D Kähler action giving rise to 6-D surfaces having bundle structure with twistor sphere as fiber and space-time as base. The twistor sphere of this bundle is imbedded as sphere in the product of twistor spheres of twistor spaces of M^4 and CP_2.

This condition would define the dynamics, and the original conjecture was that this dynamics is equivalent with the identification of space-time surfaces as preferred extremals of Kähler action. The dynamics of space-time surfaces would be lifted to the dynamics of twistor spaces, which are sphere bundles over space-time surfaces. What is remarkable that the powerful machinery of complex analysis becomes available.

It however turned out that twistor lift of TGD is much more than a mere technical tool. First of all, the dimensionally reduction of 6-D Kähler action contained besides 4-D Kähler action also a volume term having interpretation in terms of cosmological constant. This need not bring anything new, since all known extremals of Kähler action with non-vanishing induced Kähler form are minimal surfaces. There is however a large number of embeddings of twistor sphere of space-time surface to the product of twistor spheres. Cosmological constant has spectrum and depends on length scale, and the proposal is that coupling constant evolution reduces to that for cosmological constant playing the role of cutoff length. That cosmological constant could transform from a mere nuisance to a key element of fundamental physics was something totally new and unexpected.

1. The twistor lift of TGD at space-time level forces to replace 4-D Kähler action with 6-D dimensionally reduced Kähler action for 6-D surface in the 12-D Cartesian product of 6-D twistor spaces of M^4 and CP_2. The 6-D surface has bundle structure with twistor sphere as fiber and space-time surface as base.

   Twistor structure is obtained by inducing the twistor structure of 12-D twistor space using dimensional reduction. The dimensionally reduced 6-D Kähler action is sum of 4-D Kähler action and volume term having interpretation in terms of a dynamical cosmological constant depending on the size scale of space-time surface (or of causal diamond CD in zero energy ontology (ZEO)) and determined by the representation of twistor sphere of space-time surface in the Cartesian product of the twistor spheres of M^4 and CP_2.

2. The preferred extremal property as a representation of quantum criticality would naturally correspond to minimal surface property meaning that the space-time surface is separately an extremal of both Kähler action and volume term almost everywhere so that there is no coupling between them. This is the case for all known extremals of Kähler action with non-vanishing induced Kähler form.

   Minimal surface property could however fail at 2-D string world sheets, their boundaries and perhaps also at partonic 2-surfaces. The failure is realized in minimal sense if the 3-surface has 1-D edges/folds (strings) and 4-surface 2-D edges/folds (string world sheets) at which some partial derivatives of the embedding space coordinates are discontinuous but canonical momentum densities for the entire action are continuous.

   There would be no flow of canonical momentum between interior and string world sheet and minimal surface equations would be satisfied for the string world sheet, whose 4-D counterpart in twistor bundle is determined by the analog of 4-D Kähler action. These conditions allow the transfer of canonical momenta between Kähler- and volume degrees of freedom at string world sheets. These no-flow conditions could hold true at least asymptotically (near the boundaries of CD).

   $M^8 - H$ duality suggests that string world sheets (partonic 2-surfaces) correspond to images of complex 2-sub-manifolds of M^8 (having tangent (normal) space which is complex 2-plane of octonionic M^8).

3. Cosmological constant would depend on p-adic length scales and one ends up to a concrete model for the evolution of cosmological constant as a function of p-adic length scale and

other number theoretic parameters (such as Planck constant as the order of Galois group): this conforms with the earlier picture.

Inflation is replaced with its TGD counterpart in which the thickening of cosmic strings to flux tubes leads to a transformation of Kähler magnetic energy to ordinary and dark matter. Since the increase of volume increases volume energy, this leads rapidly to energy minimum at some flux tube thickness. The reduction of cosmological constant by a phase transition however leads to a new expansion phase. These jerks would replace smooth cosmic expansion of GRT. The discrete coupling constant evolution predicted by the number theoretical vision could be understood as being induced by that of cosmological constant taking the role of cutoff parameter in QFT picture [L28].

Twistor lift at the level of scattering amplitudes and connection with Veneziano duality

The classical part of twistor lift of TGD is rather well-understood. Concerning the twistorialization at the level of scattering amplitudes the situation is much more difficult conceptually - I already mentioned my limited QFT skills.

1. From the classical picture described above it is clear that one should construct the 8-D twistorial counterpart of theory involving space-time surfaces, string world sheets and their boundaries, plus partonic 2-surfaces and that this should lead to concrete expressions for the scattering amplitudes.

   The light-like boundaries of string world sheets as carriers of fermion numbers would correspond to twistors as they appear in twistor Grassmann approach and define the analog for the massless sector of string theories. The attempts to understand twistorialization have been restricted to this sector.

2. The beautiful basic prediction would be that particles massless in 8-D sense can be massive in 4-D sense. Also the infrared cutoff problematic in twistor approach emerges naturally and reduces basically to the dynamical cosmological constant provided by classical twistor lift.

   One can assign 4-momentum both to the spinor harmonics of the embedding space representing ground states of super-conformal representations and to light-like boundaries of string world sheets at the orbits of partonic 2-surfaces. The two four-momenta should be identical by quantum classical correspondence: this could be seen as a concretization of Equivalence Principle. Also a connection with string model emerges.

3. As far as symmetries are considered, the picture looks rather clear. Ordinary twistor Grassmannian approach boils down to the construction of scattering amplitudes in terms of Yangian invariants for conformal group of M^4. Therefore a generalization of super-symplectic symmetries to their Yangian counterpart seems necessary. These symmetries would be gigantic but how to deduce their implications?

4. The notion of positive Grassmannian is central in the twistor approach to the scattering amplitudes in $calN = 4$ SUSYs. TGD provides a possible generalization and number theoretic interpretation of this notion. TGD generalizes the observation that scattering amplitudes in twistor Grassmann approach correspond to representations for permutations. Since 2-vertex is the only fermionic vertex in TGD, OZI rules for fermions generalizes, and scattering amplitudes are representations for braidings.

   Braid interpretation encourages the conjecture that non-planar diagrams can be reduced to ordinary ones by a procedure analogous to the construction of braid (knot) invariants by gradual un-braiding (un-knotting).

This is however not the only vision about a solution of non-planarity. Quantum criticality provides different view leading to a totally unexpected connection with string models, actually with the Veneziano duality, which was the starting point of dual resonance model in turn leading via dual resonance models to super string models.

1. Quantum criticality in TGD framework means that coupling constant evolution is discrete in the sense that coupling constants are piecewise constant functions of length scale replaced by dynamical cosmological constant. Loop corrections would vanish identically and the recursion formulas for the scattering amplitudes (allowing only planar diagrams) deduced in twistor Grassmann would involve no loop corrections. In particular, cuts would be replaced by sequences of poles mimicking them like sequences of point charge mimic line charges. In momentum discretization this picture follows automatically.

2. This would make sense in finite measurement resolution realized in number theoretical vision by number-theoretic discretization of the space-time surface (cognitive representation) as points with coordinates in the extension of rationals defining the adele [L17]. Similar discretization would take place for momenta. Loops would vanish at the level of discretization but what would happen at the possibly existing continuum limit: does the sequence of poles integrate to cuts? Or is representation as sum of resonances something much deeper?

3. Maybe it is! The basic idea of behind the original Veneziano amplitudes (see `http://tinyurl.com/yyhwvbqb`) was Veneziano duality. This 4-particle amplitude was generalized by Yoshiro Nambu, Holber-Beck Nielsen, and Leonard Susskind to N-particle amplitude (see `http://tinyurl.com/yyvkx7as`) based on string picture, and the resulting model was called dual resonance model. The model was forgotten as QCD emerged. Later came superstring models and led to M-theory. Now it has become clear that something went wrong, and it seems that one must return to the roots. Could the return to the roots mean a careful reconsideration of the dual resonance model?

4. Recall that Veneziano duality (1968) was deduced by assuming that scattering amplitude can be described as sum over s-channel resonances or t-channel Regge exchanges and Veneziano duality stated that hadronic scattering amplitudes have representation as sums over s- or t-channel resonance poles identified as excitations of strings. The sum over exchanges defined by t-channel resonances indeed reduces at larger values of s to Regge form.

   The resonances had zero width, which was not consistent with unitarity. Further, there were no counterparts for the *sum* of s-, t-, and u-channel diagrams with continuous cuts in the kinematical regions encountered in QFT approach. What puts bells ringing is the u-channel diagrams would be non-planar and non-planarity is the problem of twistor Grassmann approach.

5. Veneziano duality is true only for s- and t- channels but not been s- and u-channel. Stringy description makes t-channel and s-channel pictures equivalent. Could it be that in fundamental description u-channels diagrams cannot be distinguished from s-channel diagrams or t-channel diagrams? Could the stringy representation of the scattering diagrams make u-channel twist somehow trivial if handles of string world sheet representing stringy loops in turn representing the analog of non-planarity of Feynman diagrams are absent? The permutation of external momenta for tree diagram in absence of loops in planar representation would be a twist of π in the representation of planar diagram as string world sheet and would not change the topology of the string world sheet and would not involve non-trivial world sheet topology.

   For string world sheets loops would correspond to handles. The presence of handle would give an edge with a loop at the level of 3-surface (self energy correction in QFT). Handles are not allowed if the induced metric for the string world sheet has Minkowskian signature. If the stringy counterparts of loops are absent, also the loops in scattering amplitudes should be absent.

   This argument applies only inside the Minkowskian space-time regions. If string world sheets are present also in Euclidian regions, they might have handles and loop corrections could emerge in this manner. In TGD framework strings (string world sheets) are identified to 1-D edges/folds of 3-surface at which minimal surface property and topological QFT property fails (minimal surfaces as calibrations). Could the interpretation of edge/fold as discontinuity of some partial derivatives exclude loopy edges: perhaps the branching points would be too singular?

A reduction to a sum over s-channel resonances is what the vanishing of loops would suggest. Could the presence of string world sheets make possible the vanishing of continuous cuts even at the continuum limit so that continuum cuts would emerge only in the approximation as the density of resonances is high enough?

The replacement of continuous cut with a sum of *infinitely* narrow resonances is certainly an approximation. Could it be that the stringy representation as a sum of resonances with *finite* width is an essential aspect of quantum physics allowing to get rid of infinities necessarily accompanying loops? Consider now the arguments against this idea.

1. How to get rid of the problems with unitarity caused by the zero width of resonances? Could *finite* resonance widths make unitarity possible? Ordinary twistor Grassmannian approach predicts that the virtual momenta are light-like but complex: obviously, the imaginary part of the energy in rest frame would have interpretation as resonance with.

   In TGD framework this generalizes for 8-D momenta. By quantum-classical correspondence (QCC) the classical Noether charges are equal to the eigenvalues of the fermionic charges in Cartan algebrable (maximal set of mutually commuting observables) and classical TGD indeed predicts complex momenta (Kähler coupling strength is naturally complex). QCC thus supports this proposal.

2. Sum over resonances/exchanges picture is in conflict with QFT picture about scattering of particles. Could *finite* resonance widths due to the complex momenta give rise to the QFT type scattering amplitudes as one develops the amplitudes in Taylor series with respect to the resonance width? Unitarity condition indeed gives the first estimate for the resonance width.

   QFT amplitudes should emerge in an approximation obtained by replacing the discrete set of finite width resonances with a cut as the distance between poles is shorter than the resolution for mass squared.

   In superstring models string tension has single very large value and one cannot obtain QFT type behavior at low energies (for instance, scattering amplitudes in hadronic string model are concentrated in forward direction). TGD however predicts an entire hierarchy of p-adic length scales with varying string tension. The hierarchy of mass scales corresponding roughly to the lengths and thickness of magnetic flux tubes as thickened cosmic strings and characterized by the value of cosmological constant predicted by twistor lift of TGD. Could this give rise to continuous QCT type cuts at the limit when measurement resolution cannot distinguish between resonances?

   The dominating term in the sum over sums of resonances in t-channel gives near forward direction approximately the lowest mass resonance for strings with the smallest string tension. This gives the behavior $1/(t-m_{min}^2)$, where m_{min} corresponds to the longest mass scale involved (the largest space-time sheet involved), approximating the $1/t$-behavior of massless theories. This also brings in IR cutoff, the lack of which is a problem of gauge theories. This should give rise to continuous QFT type cuts at the limit when measurement resolution cannot distinguish between resonances.

1.2 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. The basic idea is that quantum jump can be identified as momentum of consciousness. Thus a general theory of consciousness is unavoidable outcome. This theory is developed in detail in the books [K50, K8, K37, K6, K17, K24, K27, K47, K59].

It is good to list first the basic challenges of TGD inspired theory of consciousness. The challenges can be formulated as questions. Reader can decide how satisfactory the answered proposed by TGD are.

1. What does one mean with quantum jump? Can one overcome the basic problem of the standard quantum measurement theory, that which forcing Bohr to give up totally the idea about objective reality?
2. How do the experienced time and geometric time relate in this framework? How the arrow of subjective time translates to that of geometric time?
3. How to define conscious information? Is it conserved or even increased during time evolution as biological evolution suggests? How does this increase relate to second law implied basically by the randomness of state function reduction?
4. Conscious entities/selves/observers seem to exist. If they are real how do they emerge?

1.2.1 Quantum Jump As A Moment Of Consciousness

The identification of quantum jump between deterministic quantum histories (WCW 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 formally analogous to Schrödinger time evolution of infinite duration. The time evolution can however interpreted as a sequence of discrete scalings and Lorentz boosts of causal diamond (CD) and the time corresponds to the change of the proper time distance between between the tips of CD.

In TGD framework S-matrix is generalized to a triplet of U-, M-, and S-matrices. M-matrix is a hermitian square root of density matrix between positive and negative energy states multiplied by universal S-matrix depending on the scale of CD only. The square roots of projection operators form an orthonormal basis. U-matrix and S-matrix are completely universal objects characterizing the dynamics of evolution by self-organization.

The M-matrices associated with CDs are obtained by a discrete scaling from the minimal CD and characterized by integer n are naturally proportional to S^n, where S is the S-matrix associated with the minimal CD. This conforms with the idea about unitary time evolution as exponent of Hamiltonian discretized to integer power of S.

U-matrix elements between M-matrices for various CDs are proportional to the inner products $Tr[S^{-n_1} \circ H^i H^j \circ S^{n_2} \lambda]$, where λ represents unitarily the discrete Lorentz boost relating the moduli of the active boundary of CD and H^i form an orthonormal basis of Hermitian square roots of density matrices. $\circ$ tells that S acts at the active boundary of CD only. I turns out possible to construct a general representation for the U-matrix reducing its construction to that of S-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".

In ZEO U-matrix should correspond relates zero energy states to each other and M matrices defining the rows of U matrix should be assignable to a fixed CD. Zero energy states should have wave function in the moduli space of CDs such that the second boundary of every CD would belong to a boundary of fixed light-cone but second boundary would be free with possible constraint that the distance between the tips of CD is multiple of CP_2 time.

Zero energy states of ZEO 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 reduced/equivalently preparated 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.

The first state function reduction at given boundary of CD must change the roles of the ends of CDs. This reduction can be followed by a sequence of reductions to the same boundary of CD and not changing the boundary nor the parts of zero energy states associated with it but changing the states at the second end and also quantum distribution of the second boundary in the moduli space of CDs. In standard measurement theory the follow-up reductions would not affect the state at all.

The understanding of how the arrow of time and experience about its flow emerge have been the most difficult problem of TGD inspired theory of consciousness and I have considered several proposals during years having the geometry of future light-cone as the geometric core element.

1. The basic objection is that the arrow of geometric time alternates at embedding space level but we know that arrow of time looks the same in the part of the Universe we live. Possible exceptions however exist, for instance phase conjugate laser beams seem to obey opposite arrow of time. Also biological phenomena might involve non-standard arrow of time at some levels. This led Fantappie [J31] to introduce the notion of syntropy. This suggests that the arrow of time depends on the size scale of CD and of space-time sheet.

2. It took some time to realize that the solution of the problem is trivial in ZEO. In the ordinary quantum measurement theory one must assume that state function reduction can occur repeatedly: the assumption is that nothing happens to the state during repeated reductions. The outcome is Zeno effect: the watched pot does not boil.

   In TGD framework situation is different. Repeated state function reduction leaves the already reduce parts of zero energy state invariant but can change the part of states at the opposite boundary. One must allow a delocalization of the second boundary of CDs and one assumes that the second tip has quantized distance to the fixed one coming as multiple of CP_2 time. Also Lorentz boosts leaving the second CD boundary invariant must be allowed. One must therefore introduce a wave function in the moduli space of CDs with second boundary forming part of fixed light-cone boundary ($\delta M^4_\pm \times CP_2$).

3. The sequence of state function reductions on a fixed boundary of CD leads to the increase of the average temporal distance between the tips of CDs and this gives rise to the experience about flow of time as shifting of contents of perception towards future if the change is what contributes to conscious experience and gives rise to a fixed arrow of time.

4. Contrary to original working hypothesis, state function reduction in the usual sense does not solely determine the ordinary conscious experience. It can however contribute to conscious experience and the act of free will is a good candidate in this respect. TGD view about realization of intentional action assumes that intentional actions involve negative energy signals propagating backwards in geometric time. This would mean that at some level of CD hierarchy the arrow of geometric time indeed changes and the reduction start to occur at opposite boundary of CD at some level of length scale hierarchy.

1.2.2 Negentropy Maximization Principle (NMP)

Information is the basic aspect of consciousness and this motivates the introduction of Negentropy Maximization Principle (NMP) [K28] as the fundamental variational principle of consciousness theory. The amount of negentropy of zero energy state should increase in each quantum jump. The ordinary entanglement entropy is also non-negative so that negentropy could be at best zero. Since p-adic physics is assumed to be a correlate of cognition, it is natural to generalizes Shannon entropy to its number theoretic variant by replacing the probabilities appearing as arguments of logarithms of probabilities with their p-adic norms. This gives negentropy which can be positive so that NMP can generates entanglement.

Consistency with quantum measurement theory allows only negentropic density matrices proportional to unit matrix and negentropy has the largest positive value for the largest power of prime factor of the dimension of density matrix. Entanglement matrix proportional to unitary matrix familiar from quantum computation corresponds to unit density matrix and large $h_{eff} = n \times h$ states are excellent candidates for forming negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book).

The interpretation of negentropic entanglement is as a rule. The instances of the rule correspond to the pairs appearing in the superposition and the large the number of pairs is, the higher the abstraction level of the rule is. NMP is not in conflict with the second law since negentropy in the sense of NMP is not single particle property. Ordinary quantum jumps indeed generate entropy at the level of ensemble as also quantum jumps for states for which the density matrix is direct sum of unit matrices with various dimensions.

NMP forces the negentropic entanglement resources of the Universe to grow and thus implies evolution. I have coined the name "Akashic records" for these resources forming something analogous to library. It has turned out that the only viable option is that negentropic entanglement is experienced directly.

1.2.3 The Notion Of Self

The concept of self seems to be absolutely essential for the understanding of the macroscopic and macro-temporal aspects of consciousness and would be counterpart for observer in quantum measurement theory.

1. The original view was that self corresponds to a subsystem able to remain un-entangled under the sequential informational "time evolutions" U. It is however unclear how it could be possible to avoid generation of entanglement.

2. In ZEO the situation changes. Self corresponds to a sequence of quantum jumps for which the parts of zero energy states at either boundary of CD remaim unchanged. Therefore one can say that self defined in terms of parts of states assignable to this boundary remains unaffected as sub-system and does not generate entanglement. At the other boundary changes occur and give rise to the experience of time flow and arrow of time since the average temporal distance between the tips of CD tends to increase.

   When the reductions begin to occur at the opposite boundary of CD, self "falls asleep": symmetry suggests that new self living in opposite direction of geometric time is generated. Also in biological the change of time direction at some level of hierarchy might take place.

3. It looks natural to assume 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 sub-selves as kind of abstracted experience: the experiences of sub-selves S_i are not experienced as such but represent kind of averages $\langle S_{ij} \rangle$ of sub-sub-selves S_{ij}. Entanglement between selves, most naturally realized by the formation of flux tube 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.

4. Self corresponds in neuro science to self model defining a model for organism and for the external world. Information or negentropy seems to be necessary for understanding self. Negentropically entangled states - Akashic records - are excellent candidates for selves and would thus correspond to dark matter in TGD sense since the number of states in superposition corresponds to the integer n defining h_{eff}. It is enough that self is potentially conscious: this could mean that it conscious experience about self is generated only in interaction free measurement. Repeated state function reductions to given boundary of CD is second possibility. This would assign irreversibility and definite arrow of time and experience of time flow with self.

5. CDs would serve as embedding space correlates of selves and quantum jumps would be followed by cascades of state function reductions beginning from given CD and proceeding downwards to the smaller scales (smaller CDs). At space-time level space-time sheets in given p-adic length scale would be the natural correlates of selves. One ends also ends up

with concrete ideas about how the localization of the contents of sensory experience and cognition to the "upper" (changing) boundary of CD could take place. One cannot exclude the possibility that state function reduction cascades could also take place in parallel branches of the quantum state.

1.2.4 Relationship To Quantum Measurement Theory

TGD based quantum measurement has several new elements. Negentropic entanglement and hierarchy of Planck constants, NMP, the prediction that state function reduction can take place to both boundaries of CD implying that the arrow of geometric time can change (this is expected to occur in microscopic scales whether the arrow of time is not established), and the possibility to understand the flow and arrow of geometric time.

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 WCW 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. The assumption that localization occurs in zero modes in each quantum jump implies that the world of conscious experience looks classical. It is also consistent with 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!).

3. 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 WCW 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. In ZEO state preparation corresponds at some level of the self hierarchy to the a state function reduction to boundary opposite than before. In biology sensory perception and motor action would correspond to state function reduction sequences at opposite boundaries of CDs at some levels of the hierarchy.

Self measurement is governed by 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).

1.2.5 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 [K45]. 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.

ZEO brings in important additional element to the theory of self-organization. The maxima of Kähler function corresponds to the most probable 3-surfaces. Kähler function receives contributions only from the Euclidian regions ("lines" of generalized Feynman diagrams) whereas the contribution to vacuum functional from Minkowskian regions is exponent of imaginary action so that saddle points with stationary phase are in question in these regions. In ZEO 3-surfaces are replaced by pairs of 3-surfaces at opposite boundaries of CD. The maxima actually correspond to temporal patterns of classical fields connecting these 3-surfaces: this means that self-organization is four spatiotemporal rather than spatial patterns - a crucial distinction from the usual view allowing to understand the evolution of behavioral patterns quantally. In biology this allows to understand temporal evolutions of organisms as the most probable self-organization patterns having as correlates the evolutions of the magnetic body of the system.

1.2.6 Classical Non-Determinism Of Kähler Action

A further basic element is non-determinism of Kähler action. This led to the concepts of association sequence and cognitive space-time sheet, which are not wrong notions but replaced by new ones.

1. The huge vacuum degeneracy of the Kähler action suggests strongly that the preferred 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.

2. 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.

Later a more detailed view about non-determinism in the framework of ZEO has emerged and quantum criticality is here the basic notion. The space-time surface connecting two 3-surfaces at the ends of CD is not unique. Conformal transformations which act trivially at the ends of space-time surface generate a continuum of new extremals with the same value of Kähler action and classical conserved quantities. The number n of conformal equivalence classes is finite and defines the value of h_{eff} (see **Fig.** `http://tgdtheory.fi/appfigures/planckhierarchy.jpg` or **Fig. ??** in the appendix of this book). There exists a hierarchy of breakdowns of conformal symmetry labelled by n. The fractal hierarchy of CDs gives rise to fractal hierarchy of non-determinisms of this kind.

1.2.7 P-Adic Physics As Physics Of Cognition

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

A more 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 [K97] . The application this notion at the level of the embedding space implies that embedding space has a book like structure with various variants of the embedding space glued together along common rationals (algebraics, see **Fig.** `http://tgdtheory.fi/appfigures/book.jpg` or **Fig. ??** in the appendix of this book). 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 embedding space is discrete set of rationals (algebraics). Hence cognition and intentionality are almost completely outside the real cosmos and touch it at a discrete set of points only.

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

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

1.2.8 P-Adic And Dark Matter Hierarchies And Hierarchy Of Selves

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 [K15].

Dark matter hierarchy leads to detailed quantitative view about quantum biology with several testable predictions [K15]. 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 [K15]. Also a generalization of the notion of genetic code emerges resolving the paradoxes related to the standard dogma [K25, K15]. 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 [K15].

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 [K79, K15]. The larger the value of Planck constant, the longer the life-time of self measured as the increase of the average distance between tips of CDs appearing in the quantum superposition during the period of repeated reductions not affecting the part of the zero energy state at the other boundary of CD- Quantum jumps form also a hierarchy with respect to p-adic and dark hierarchies and the geometric durations of quantum jumps scale like $\hbar$.

The fact that we can remember phone numbers with 5 to 9 digits supports the view that self experiencse subselves as separate mental images. Averaging over experiences of sub-selves of sub-self would however occur.

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.

CD as an embedding 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 [K15]. 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 [K25, K15]. In fact, higher levels of dark matter hierarchy motivate the introduction of the notions of super-genome and hyper-genome. The genomes of entire organ can join to form super-genome expressing genes coherently. Hyper-genomes would result from the fusion of genomes of different organisms and collective levels of consciousness would express themselves via hyper-genome and make possible social rules and moral.

1.3 Quantum Biology And Quantum Neuroscience In TGD Universe

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.

1.3.1 Basic Physical Ideas

The following list gives the basic elements of TGD inspire quantum biology.

1. 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 undersand 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.

2. Magnetic body carrying dark matter and forming an onion-like structure with layers characterized by large values of Planck constant is the key concept of TGD inspired view about Quantum Mind to biology. 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 then.

   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 zero energy ontology the braiding actually generalize to 2-braiding for string world sheets in 4-D space-time and brings in new elements.

3. Zero energy ontology (ZEO) makes possible the proposed p-adic description of intentions and cognitions and their transformations to action. Time mirror mechanism (see **Fig.** `http:`

//tgdtheory.fi/appfigures/timemirror.jpg or **Fig. ??** in the appendix of the book) 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.

4. 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 amino-acids in a natural manner and vertebrate genetic code as correspondence between DNA and amino-acids 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 embedding 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 embedding 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.

5. 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 (see **Fig.** http://tgdtheory.fi/appfigures/cat.jpg or **Fig. ??** in the appendix of this book) 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.

6. 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 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.

1.3.2 Brain In TGD Universe

Brain cognizes and one should find physical correlates for cognition. Also the precise role of brain in information processing and its relationship to metabolism should be understood. Here magnetic body brings as a third player to the couple formed by environment and organism.

1. An attractive idea is that the negentropic entanglement can be assigned with magnetic flux tubes somehow 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 latest view encourages to consider the possibility that negentropic entanglement with what might be called Mother Gaia is what is transferred in metabolism.

2. The view about the function of brain differs from the standard view. The simplest option is that brain is a 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 these two options.

3. The role of EEG and its various counterparts at fractally scaled frequency ranges is to make possible communications to the various onion-like 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.

1.3.3 Anomalies

Various anomalies of living matter have been in vital role in the development of not only TGD view about living matter but also TGD itself.

1. 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. Also the findings about effects of ELF em fields on vertebrate brain were decisive and led to the proposal of the hierarchy of Planck constants found later to emerge naturally from the non-determinism of Kähler action. Rather satisfactorily, the other manner to introduce the hierarchy of Planck constants is in terms of gravitational Planck constant: at least in microscopic scales the equivalence of these approaches makes sense and leads to highly non-trivial predictions. The basic testable prediction is that dark photons have cyclotron frequencies inversely proportional to their massess but universal energy spectrum in visible and UV range which corresponds to the transition energies for biomolecules so that they are ideal for biocontrol at the level of both magnetic bodies and at the level of biochemistry.

2. Water is in key role in living matter and also in TGD inspired view about living matter. The anomalies of water lead to a model for dark nuclei as dark proton strings with the surprising prediction that DNA, RNA, anino-acids and even tRNA are in one-one correspondence with the resulting 3-quark states and that vertebrate genetic code emerges naturally. This leads to a vision about water as primordial life form still playing a vital role in living organisms. The model of water memory and homeopathy in turn generalizes to a vision about how immune system might have evolved.

3. Metabolic energy is necessary for conscious information processing in living matter. This suggests that metabolism should be basically transfer of negentropic entanglement from nutrients to the organism. ATP could be seen as a molecule of consciousness in this picture and high energy phosphate bond would make possible the transfer of negentropy.

1.4 Bird's Eye of View about the Topics of the Book

This book is almost as it was when I wrote the chapters for the first time - roughly around year 2000. A lot of progress has taken place after that and many new ideas have emerged. The hierarchy of Planck constants crucial quintessential for the understanding of biological self-organization has a number theoretic interpretation in the framework of adelic physics. The notion of hyper-finite factor gives mathematical realization for the hierarchy of measurement resolutions. The development about ideas related to quantum criticality is relevant also for quantum self-organization. Zero energy ontology (ZEO) generalizes quantum measurement theory to a theory of consciousness and abstracts the notions of behavioral pattern and function central in biology to key physical concepts. The twistor lift of TGD leads to the understanding of the role of length scale dependent cosmological constant having - somewhat surprisingly - implications also for biology. Therefore this book should be read with patience: the ideas were just born and were inept like few month old children but developing vigorously.

In this book I will discuss in detail the view about the quantum hardware of living systems taking seriously the new physics predicted by TGD. Since the vision is bound to be look highly speculative, it is good to emphasize that the most important predictions follow almost without any reference to the classical field equations using only quantum classical correspondence.

1.4.1 The implications deriving from the topology of space-time surface and from the properties of induced gauge fields

Quantum classical correspondence and the properties of the simplest extremals of Kähler action have served as the basic guideline in the attempts to understand the new physics predicted by TGD. The most dramatic predictions follow without even considering field equations in detail by using only quantum classical correspondence. These predictions form the backbone of TGD and TGD inspired theory of living mater.

The notions of many-sheeted space-time, topological field quantization and the notion of field/magnetic body, follow from simple topological considerations. The observation that space-time sheets can have arbitrarily large sizes and their interpretation as quantum coherence regions forces to conclude that in TGD Universe macroscopic and macro-temporal quantum coherence are possible in arbitrarily long scales. It took a relatively long time to realize that perhaps the only manner to understand this is a generalization of the quantum theory itself by allowing Planck constant to be dynamical and quantized. TGD leads indeed to a "prediction" for the spectrum of Planck constants and macroscopic quantum phases with large value of Planck constant allow an identification as a dark matter hierarchy.

Also long ranged classical color and electro-weak fields are an unavoidable prediction and it took a considerable time to make the obvious conclusion: TGD Universe is fractal containing fractal copies of standard model physics at various space-time sheets and labeled by the collection of p-adic primes assignable to elementary particles and by the level of dark matter hierarchy characterized partially by the value of Planck constant labeling the pages of the book like structure formed by singular covering spaces of the embedding space $M^4 \times CP_2$ glued together along a four-dimensional back. Particles at different pages are dark relative to each other since purely local interactions defined in terms of the vertices of Feynman diagram involve only particles at the same page.

The new view about energy and time finding a rigorous formulation in terms of zero energy ontology means that the sign of inertial energy depends on the time orientation of the space-time sheet and that negative energy space-time sheets serve as correlates for communications to the geometric past. This alone leads to profoundly new views about metabolism, long term memory, and realization of intentional action.

1.4.2 Vacuum degeneracy of Kähler action as a correlate for quantum criticality and 4-dimensional spin glass degeneracy

The general properties of Kähler action, in particular its vacuum degeneracy and the failure of the classical determinism in the conventional sense, have also very profound implications. Space-time surface as a generalization of Bohr orbit provides not only a representation for quantum state but also for sequences of quantum jumps and thus contents of consciousness. Vacuum degeneracy implies spin glass degeneracy in 4-D sense reflecting quantum criticality which is the fundamental characteristic of TGD Universe.

1.4.3 The simplest extremals of Kähler action as correlates for asymptotic self organization patterns

The detailed study of the simplest extremals of Kähler action interpreted as correlates for asymptotic self organization patterns provides additional insights [K70] . CP_2 type extremals representing elementary particles, cosmic strings, vacuum extremals, topological light rays ("massless extremal", ME), flux quanta of magnetic and electric fields represent the basic extremals. Pairs of wormhole throats identifiable as parton pairs define a completely new kind of particle carrying only color quantum numbers in ideal case and I have proposed their interpretation as quantum correlates for Boolean cognition. MEs and flux quanta of magnetic and electric fields are of special importance in living matter.

Topological light rays have interpretation as space-time correlates of "laser beams" of ordinary or dark photons or their electro-weak and gluonic counterparts. Neutral MEs carrying em and Z^0 fields are ideal for communication purposes and charged W MEs ideal for quantum control. Magnetic flux quanta containing dark matter are identified as intentional agents quantum controlling the behavior of the corresponding biological body parts utilizing negative energy W MEs. Bio-system in turn is populated by electrets identifiable as electric flux quanta.

1.4.4 Organization of "Quantum Hardware of Living Matter"

I have organized the book in 3 parts.

1. Two chapters in the 1st part of the book are devoted to the model of high T_c superconductivity relying strongly on the notions of quantum criticality and dark matter.

2. In 2nd part of the book quantum antenna hypothesis inspired by MEs and the notion of wormhole magnetic fields are discussed. Notice that the notion of wormhole magnetic field was introduced much before the hypothesis that elementary particles have a natural identification as pairs of wormhole contacts connected by flux tubes carrying monopole flux. In the recent interpretation wormhole contact pairs would be dark variants of p-adically scaled variants of ordinary particles.

3. In the 3rd part of the book two chapters are devoted to the possible biological implications of the hypothesis that dark matter corresponds to macroscopic quantum phases characterized by a large value of Planck constant and is the key actor in living matter.

I must apologize the fact the implications of the dark matter revolution have not been thoroughly considered in this book. Same applies to the implications of zero energy ontology (ZEO).

1.5 Sources

The eight online books about TGD [K54, K44, K64, K49, K33, K63, K62, K48] and nine online books about TGD inspired theory of consciousness and quantum biology [K50, K8, K37, K6, K17, K24, K27, K47, K59] are warmly recommended for the reader willing to get overall view about what is involved.

My homepage (`http://tinyurl.com/ybv8dt4n`) contains a lot of material about TGD. In particular, a TGD glossary at `http://tinyurl.com/yd6jf3o7`).

I have published articles about TGD and its applications to consciousness and living matter in *Journal of Non-Locality* (`http://tinyurl.com/ycyrxj4o` founded by Lian Sidorov and in *Prespacetime Journal* (`http://tinyurl.com/ycvktjhn`), *Journal of Consciousness Research and Exploration* (`http://tinyurl.com/yba4f672`), and *DNA Decipher Journal* (`http://tinyurl.com/y9z52khg`), all of them founded by Huping Hu. One can find the list about the articles published at `http://tinyurl.com/ybv8dt4n`. I am grateful for these far-sighted people for providing a communication channel, whose importance one cannot overestimate.

1.6 The contents of the book

1.6.1 PART I: BIO-SYSTEMS AS SUPER CONDUCTORS

Bio-Systems as Super-Conductors: Part I

In this chapter various TGD based ideas related to the role of super-conductivity in bio-systems are studied. TGD inspired theory of consciousness provides several motivations for this.

1. Empirical evidence for high T_c superconductivity in bio-systems

There is evidence for super-conductivity in bio-systems. DNA should be insulator but under some circumstances it becomes conductor and perhaps even high T_c quantum critical superconductor. Also evidence for Josephson effect has been reported. The so called ORMEs patented by Hudson are claimed to behave like superconductors: unfortunately the academic world has not taken these claims seriously enough to test them. The claimed properties of ORMEs conform with high quantum critical T_c super-conductivity and superfluidity. The strange findings about the strange quantal behavior of ionic currents through cell membranes suggest the presence of ionic supra currents.

2. Model for high T_c superconductivity

A 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.

With a sufficient amount of twisting and weaving these basic ideas one ends up to concrete model for high T_c superconductors as quantum critical superconductors consistent with the qualitative facts that I am personally aware. The following minimal model looks the most realistic option found hitherto.

1. The general idea is that magnetic flux tubes are carriers of supra currents. In anti-ferromagnetic phases these flux tube structures form small closed loops so that the system behaves as an insulator. Some mechanism leading to a formation of long flux tubes must exist. Doping creates holes located around stripes, which become positively charged and attract electrons to the flux tubes.

2. The basic mechanism for the formation of Cooper pairs is simple. Magnetic flux tubes would be carriers of dark particles and magnetic fields would be crucial for super-conductivity. Two parallel flux tubes carrying magnetic fluxes in opposite directions is the simplest candidate for super-conducting system. This conforms with the observation that antiferromagnetism is somehow crucial for high temperature super-conductivity. The spin interaction energy is proportional to Planck constant and can be above thermal energy: if the hypothesis that dark cyclotron energy spectrum is universal is accepted, then the energies would be in bio-photon range and high temperature super-conductivity is obtained. If fluxes are parallel spin $S = 1$ Cooper pairs are stable. $L = 2$ states are in question since the members of the pair are at different flux tubes.

3. The higher critical temperature T_{c1} corresponds to a formation local configurations of parallel spins assigned to the holes of stripes giving rise to a local dipole fields with size scale of the order of the length of the stripe. Conducting electrons form Cooper pairs at the magnetic flux tube structures associated with these dipole fields. The elongated structure of the dipoles favors angular momentum $L = 2$ for the pairs. The presence of magnetic field favors Cooper pairs with spin $S = 1$.

4. Stripes can be seen as 1-D metals with delocalized electrons. The interaction responsible for the energy gap corresponds to the transversal oscillations of the magnetic flux tubes inducing oscillations of the nuclei of the stripe. These transverse phonons have spin and their exchange is a good candidate for the interaction giving rise to a mass gap. This could explain the BCS type aspects of high T_c super-conductivity.

5. Above T_c supra currents are possible only in the length scale of the flux tubes of the dipoles which is of the order of stripe length. The reconnections between neighboring flux tube structures induced by the transverse fluctuations give rise to longer flux tubes structures making possible finite conductivity. These occur with certain temperature dependent probability $p(T, L)$ depending on temperature and distance L between the stripes. By criticality $p(T, L)$ depends on the dimensionless variable $x = TL/\hbar$ only: $p = p(x)$. At critical temperature T_c transverse fluctuations have large amplitude and makes $p(x_c)$ so large that very long flux tubes are created and supra currents can run. The phenomenon is completely analogous to percolation.

6. The critical temperature $T_c = x_c\hbar/L$ is predicted to be proportional to $\hbar$ and inversely proportional to L (, which is indeed to be the case). If flux tubes correspond to a large value of $\hbar$, one can understand the high value of T_c. Both Cooper pairs and magnetic flux tube structures represent dark matter in TGD sense.

7. The model allows to interpret the characteristic spectral lines in terms of the excitation energy of the transversal fluctuations and gap energy of the Cooper pair. The observed 50 meV threshold for the onset of photon absorption suggests that below T_c also $S = 0$ Cooper pairs are possible and have gap energy about 9 meV whereas $S = 1$ Cooper pairs would have gap energy about 27 meV. The flux tube model indeed predicts that $S = 0$ Cooper pairs become stable below T_c since they cannot anymore transform to $S = 1$ pairs. Their presence could explain the BCS type aspects of high T_c super-conductivity. The estimate for $\hbar/\hbar_0 = r$ from critical temperature T_{c1} is about $r = 3$ contrary to the original expectations inspired by the model of of living system as a super-conductor suggesting much higher value. An unexpected prediction is that coherence length is actually r times longer than the coherence length predicted by conventional theory so that type I super-conductor could be in question with stripes serving as duals for the defects of type I super-conductor in nearly critical magnetic field replaced now by ferromagnetic phase.

   At qualitative level the model explains various strange features of high T_c superconductors. One can understand the high value of T_c and ambivalent character of high T_c super conductors, the existence of pseudogap and scalings laws for observables above T_c, the role of stripes and doping and the existence of a critical doping, etc...

3. The model for superconductivity in living matter

The model for high T_c superconductivity was inspired by the model of bio-superconductivity in which the flux tubes of magnetic fields are carriers of supra currents and the large value of Planck constant guarantees that gap energy and critical temperature are high enough. The transversal fluctuations of flux tubes provide the counterpart of phonons generating energy gap. Besides dark Cooper pairs also the Bose-Einstein condensates of dark bosonic ions define candidates for superconducting phases provided that the gap energies in longitudinal and transversal magnetic degrees of freedom are high enough. High enough values of Planck constant can guarantee this.

Bio-Systems as Super-Conductors: Part II

This chapter is devoted to further applications of the theory of high T_c superconductors as quantum critical superconductors involving dark matter hierarchy and large values of $h_{eff} = n \times h$. A new element is the model of cell membrane acting as Josephson junction: at microscopic transmembrane proteins would define Josephson junctions. The theory is applied to explain the strange findings about ionic currents through cell membrane, and the possibility that superconductivity and Bose-Einstein condensates are involved with atmospheric phenomena is considered.

1. Strange behavior of cellular water and quantal ionic currents through cell membrane

The fact that cellular water does not leak out of cell in a centrifugal force suggests that some fraction of water inside cell is in different phase. One explanation is that the nuclei of water inside cell are in doubly dark phase whereas electrons are in singly dark phase (having Compton length of 5 nm and perhaps directly “visible” using day technology!) as indeed predicted by the model of high Tc superconductivity. This conceptual framework could explain various findings challenging the notions of ionic pumps.

The empirical findings challenging the notions of ionic pumps and channels, nicely summarized by G. Pollack in his book, provide a strong support for the notions of many-sheeted space-time and ionic super-conductivity.

1. The selectivity of the cell membrane implies that channels cannot be simple sieves and there must be complex information processing involved.

2. The needed number of pumps specialized to particular ions is astronomical and the first question is where to put all these channels and pumps. On the other hand, if the cell constructs the pump or channel specialized to a given molecule only when needed, how does it know what the pump looks like if it has never seen the molecule? The needed metabolic energy to achieve all the pumping and channelling is huge. Strangely enough, pumping does not stop when cell metabolism stops.

3. One can also wonder why the ionic currents through cell membrane look quantal and are same through cell membrane and silicon rubber membrane.

These observations suggest strongly the presence non-dissipative ionic currents and quantum self-organization. The TGD based explanation would be in terms of high T_c electronic and possibly even ionic superconductivity associated with cell membrane made possible by the large h_{eff} phase for nuclei and electrons in the interior of cell. The model for electronic Cooper pairs as pairs of large h_{eff} electrons at parallel magnetic flux tubes with same (opposite) direction of magnetic field and in $S = 1$ ($S = 0$) state generalizes.

The empirical input also supports a view about homeostasis as a many-sheeted ionic flow equilibrium controlled by larger space-time sheets with the mediation of massless extremals (MEs) serving as space-time correlates for Bose-Einstein condensates of massless bosons (also of scaled down dark electro-weak bosons and gluons).

In the proposed picture one could understand how extremely low densities of ions and their supra currents can control much higher ion densities at the atomic space-time sheets. The liquid crystal nature of the bio-matter is crucial for the model. This vision allows also much better understanding of the effects of ELF em fields on bio-matter. Also the effects of homeopathic remedies and acupuncture known to crucially involve electromagnetic frequency signatures of chemicals can be understood if homeostasis is based on many-sheeted ionic flow equilibrium.

2. Two models of cell membrane

TGD inspires two views about cell membrane: the wiews need not be contradictory. For the first model cell is far from vacuum extremal, for the second model nearly vacuum extremal with classical Z^0 fields in key role.

1. There are several constraints on the first model coming from the TGD based identification of bio-photons as energy conserving decay products of dark photons and one ends up to a new view about metabolism and gneralization to of the notion of Josephson junction so that Josephson energy includes besides electrostatic energy also the difference of cyclotron energies at two sides of the membrane. It seem that that the first model might be enough when generalized along lines inspired by Pollack's findings about the fourth phase of water.

2. It has been clear from the beginning that the nearly vacuum extremals of Kähler action could play key role key role in living systems. The reason is their criticality making them ideal systems for sensory perception. These extremals carry classical em and Z^0 fields related to each other by a constant factor and this could explain the large parity breaking effects characterizing living matter. The assumption that at least some 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. Contrary to the original believe, this model

does not require non-standard value of Weinberg angle and this model and first model allow a hybrid.

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

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

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

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

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

4. These B-E condensates might be favored by the large negative spin interaction energies of spins with the magnetic field (proportional to h_{eff}) so that spontaneous magnetization of the magnetic body becomes possible. This kind or process would make possible for the system to gain energy and angular momentum by feeding charged particles to its magnetic body.

4. The model of ionic superconductivity

The model of ionic superconductivity is based on same mechanism as the electron one.

The general idea is that magnetic flux tubes are carriers of dark charged particles including ions and electrons. Usually magnetic field tends to destroy Cooper pairs since it tends to flip the spins of electrons of pair to same direction. In TGD flux quantization comes in rescue and magnetic fields favor the formation of Cooper pairs. If one has two parallel flux tubes with opposite directions of magnetic fluxes with large value of $h_{eff} = n \times h$, $S = 0$ Cooper pairs with even $L \geq 2$ are favored. This situation is encountered in systems near antiferromagnetic phase transition in small scales leading to formation of sequences of flux loops carrying Cooper pairs. Macroscopic super-conductivity results when the loops are reconnected to two long flux tubes with opposite fluxes. If the magnetic fluxes have same sign, $S = 1$ Cooper pairs with odd $L \geq 1$ are favored.

This model applies to both electrons and fermionic ions and if the proposal that h_{eff} is proportional to the mass of ion, it predicts same binding energies for all Cooper pairs as their spin-spin interaction energy. This hypothesis predicts universal spectrum of bio-photons energies if they result from dark photons and is motivated by the identification of gravitational Planck constant with h_{eff}. In this case binding energies would be in eV range and much above thermal energy at room temperature.

5. Atmospheric phenomena and superconductivity

There is a considerable evidence that various electromagnetic time scales associated with the atmospheric phenomena correspond to those associated with brain functioning. If magnetic sensory canvas hypothesis holds true, this is just what is expected. In this section these phenomena are considered in more detail with the aim being to build as concrete as possible vision about the dynamics involving the dark matter Bose-Einstein condensates at super-conducting magnetic magnetic flux quanta. A new element is the assumed presence of cell membrane like structures near vacuum extremals. If the potentials differences involved are same order of magnitude as in the case of cell membrane, the luminous phenomena can be understood in terms of effects caused by Josephson radiation at visible and UV frequencies.

Tornadoes and hurricanes provide the first example of self-organizing systems for which Bose-Einstein condensates of dark matter at magnetic and Z^0 magnetic flux quanta might be of relevance. Auroras represent a second phenomenon possibly involving supra currents of Cooper pairs and of exotic ions. Lightnings, sprites and elves might also involve higher levels of dark matter hierarchy. p-Adic length scale hypothesis and the hierarchy of Planck constants provide a strong grasp to these far from well-understood phenomena and allow to build rather detailed models for them as well as to gain concrete understanding about how dark matter hierarchy manifests itself in the electromagnetic phenomena at the level of atmosphere.

1.6.2 PART II: TOPOLOGICAL LIGHT RAYS AND WORMHOLE MAGNETIC FIELDS

Quantum Antenna Hypothesis

So called MEs (MEs or topological light rays) are non-vacuum extremals of both Kähler action and the EYM action serving as effective action of the theory. These extremals have cylindrical geometry and are carriers of purely classical vacuum currents and Einstein tensor, which are both light like. These vacuum currents generate coherent states of photons and gravitons with frequencies coming as multiples of the basic frequency determined by the length of the microtubule. They can also carry Bose-Einstein condensates of massless particles. It is proposed that microtubules and other linear structures could act as quantum antennae so that coherent light would be for brain same as radiowaves for us. MEs associated with axonal microtubules or axons themselves could serve as waveguides for the photons of coherent light and realize the notion of neural window abstracted from the paradigm of holographic brain. Vacuum currents could be also behind the ability of the biosystems to form representations of the external world.

There is indeed evidence for the quantum antenna hypothesis: some monocellulars are known to possess primitive microtubular vision, biophotons of Popp could could be generated by MEs and the observations of Callahan support the view that odour perception of insects relies on maser-like emissions by the odour molecules. The coherent light emitted in sonoluminescence could be generated by light-like vacuum currents associated with regions with size given roughly by the diameter of microtubule when vapour-to-liquid phase transition occurs at the final stage of the bubble collapse. Also the observed direct transformation of kinetic energy of fluid motion to chemical energy could involve generation of MEs.

The light-like boundaries of MEs might not be allowed by boundary conditions: MEs could appear as pairs glued together along boundaries or as a similar pair of ME and magnetic flux tube. If the boundaries are however possible, they have the same miraculous conformal properties as the boundary of future lightcone and MEs also allow holography in the sense of quantum gravity and string models and there are good hopes to generalize the construction of the WCW geometry and quantum TGD to take into account the classical non-determinism of Kähler action. MEs provide a justification for the intuition that the supersymplectic and superconformal symmetries of the lightcone boundary $\delta M^4_+ \times CP_2$, which are cosmological symmetries, generalize to approximate macroscopic symmetries acting on the light-like boundaries of the spacetime sheets inside future lightcone and broken only by quantum gravity. Supersymplectic symmetries almost-commute with Poincare symmetries and the gigantic almost-degenerate supersymplectic multiplets defined by genuinely quantum gravitational state functionals in the "world of worlds" correspond in a well-defined sense to higher abstraction level expected to be crucial for understanding consciousness. MEs are also tailor-made for quantum holography and teleportation. Quantum holography conceptualization inspires much more detailed views about how biosystems process information and how this information becomes conscious.

Wormhole Magnetic Fields

The first version of this chapter was written for almost two decades ago and some interpretations have changed since then. It was argued that two purely TGD based concepts: topological field quantization and wormhole BE condensate are fundamental for the understanding of biosystems. There is not reason to modify this claim. The ideas about the physical interpretation of wormhole contacts have however developed since then dramatically: in the recent formulation of the theory wormhole contacts define basic building bricks of elementary particles. Hierarchy of Planck constants assigned with dark matter is second new notion and this might allow to see wormhole BE-condensates as BE-condensates of dark variants of ordinary particles.

1. *Basic concepts*

Quantum classical correspondence suggests that gauge charges and p-adic coupling constant should have space-time counterparts. The first problem is to define precisely the concepts like classical gauge charge, gauge flux, topological condensation and evaporation. The crucial ingredients in the model are so called CP_2 type extremals. The realization that # contacts (topological sum contacts and $\#_B$ contacts (join along boundaries bonds) are accompanied by causal horizons which carry quantum numbers and allow identification as partons leads to a solution of this problem.

The partons associated with topologically condensed CP_2 type extremals carry elementary particle vacuum numbers whereas the parton pairs associated with # contacts connecting two space-time sheets with Minkowskian signature of induced metric define parton pairs. These parton pairs do not correspond to ordinary elementary particles. Gauge fluxes through # contacts can be identified as gauge charges of the partons. Gauge fluxes between space-time sheets can be transferred through # and $\#_B$ contacts concentrated near the boundaries of the smaller space-time sheet.

It has become clear that the notion of $\#_B$ contact might require a modification. There are reasons to argue that boundary conditions do not allow space-time surfaces to have boundaries but are replaced by 2-fold coverings obtained by gluing two space-time sheets along their boundaries together. The 3-D light-like orbits of wormhole contacts at which Minkowskian signature of the induced metric changes to Euclidian, have replaced boundaries and $\#_B$ contacts could be either magnetic flux tubes with Minkowskian metric or Euclidian flux tube like regions.

2. *Model for topologically quantized magnetic fields*

Topological field quantization replaces classical magnetic fields with bundles of flux tubes parallel to the field lines; flux tubes are cylindrical 3-surfaces with outer boundary. In particular, *"wormhole magnetic fields"* having charged wormholes situated at the boundaries of the flux tubes as their sources, are possible and are vacuum configurations in the sense that they do not contain ordinary matter at all. Since wormholes are very light particles, they can suffer BE condensation, and the resulting structure is macroscopic quantum system.

The recent view about particles suggests that wormhole BE-condensates are BE-condensates of particle with non-standard and large value of Planck constant. Magnetic fluxes and their braiding play key role in the TGD inspired model of topological quantum computation in living manner. This suggests that wormhole magnetic fields and more general structures of the same kind could realize quantum physicist's version about the computer scientist's dream about universe consisting of Turing machines emulating each other.

3. *Models for Comorosan effect, phantom DNA effect, and homeopathy*

It is shown that the concept of wormhole magnetic fields suggest a model of *Comorosan effect* and *phantom DNA effect*. Homeopathy could be explained in terms of the mind-like space-time sheets mimicking the properties of the drug and left to the solution in the repeated dilution of the drug. Wormhole magnetic fields provide a quantum mechanism of control from distance, say of the control of the behavior of cell organelles by cell nucleus as well as a model for the memory of bio-system in terms of integer valued winding numbers identifiable as quantized momenta of wormhole supra currents. Wormhole magnetic fields can also represent defects of electron and neutrino super conductors and serve as a templates for the topological condensation of ordinary matter. The fact that wormhole flux tubes are *hollow* cylinders, is in nice accordance with this idea (microtubules, axonal membranes, etc. are hollow cylinders).

4. TGD inspired model for psychokinesis

A model of psychokinesis (PK) based on the concept of wormhole magnetic field is proposed. The basic philosophy is that PK is not just some isolated exotic phenomenon but only a special case of the voluntary control of bodily motions, which we all routinely perform. The only difference is that the range of voluntary control extends over the boundaries of the body in case of PK. The conclusion is that PK phenomena must involve classical long range fields, which give for bio-systems spatial extension larger than what is visible (that is hands with which to grasp on external object!). According to TGD inspired theory of consciousness, cell, and even DNA can be conscious, and perform choices. Thus the model should also provide understanding about small scale bio-control such as the (possibly voluntary!) control of the motion of cell organelles performed by cell nucleus. There is also alternative approach to the understanding of psychokinesis based on the possibility of creation of space-time sheets having negative time orientation and negative classical energy density and one could consider the possibility that poltergeist effects could involve this mechanism. Many-sheeted space-time concept makes possible also psychokinesis based on levitation: what is needed that subsystem is able to topologically condense to a sufficiently large space-time sheet carrying very weak gravitational fields.

1.6.3 PART III: DARK MATTER AND LIVING MATTER

Dark Nuclear Physics and Condensed Matter

In this chapter the possible effects of dark matter in nuclear physics and condensed matter physics are considered. The spirit of the discussion is necessarily rather speculative. The most general form of the hierarchy would involve both singular coverings and factors spaces of CD (causal diamond of M^4) defined as intersection of future and past directed light-cones) and CP_2. There are grave objections against the allowance of factor spaces. In this case Planck constant could be smaller than its standard value and there are very few experimental indications for this. Quite recently came the realization that the hierarchy of Planck constants might emerge from the basic quantum TGD as a consequence of the extreme non-linearity of field equations implying that the correspondence between the derivatives of embedding space coordinates and canonical momentum is many-to-one. This makes natural to the introduction of covering spaces of CD and CP_2.

Planck constant would be effectively replaced with a multiple of ordinary Planck constant defined by the number of the sheets of the covering. The space-like 3-surfaces at the ends of the causal diamond and light-like 3-surfaces defined by wormhole throats carrying elementary particle quantum numbers would be quantum critical in the sense of being unstable against decay to many-sheeted structures. Charge fractionization could be understood in this scenario. Biological evolution would have the increase of the Planck constant as as one aspect. The crucial scaling of the size of CD by Planck constant can be justified by a simple argument. Note that primary p-adic length scales would scale as $\sqrt{\hbar}$ rather than $\hbar$ as assumed in the original model.

Recently the hierarchy of Planck constants have been traced to the non-determinism of Kähler action predicting in zero energy ontology (ZEO) that two space-like 3-surfaces at the ends of causal diamonds (CD) can be connected by several space-time surfaces. As a matter fact, by infinite number of them related by quantum critical deformations identifiable as conformal transformations respecting the light-likeness of partonic orbits at which the signature of the induced metric changes. The number of conformal equivalence classes of space-time sheets would be integer n defining the effective Planck constant $h_{eff} = n \times h$.

1. What darkness means?

Dark matter is identified as matter with non-standard value of Planck constant. The weak form of darkness states that only some field bodies of the particle consisting of flux quanta mediating bound state interactions between particles become dark. One can assign to each interaction a field body (em, Z^0, W, gluonic, gravitational) and p-adic prime and the value of Planck constant characterize the size of the particular field body. One might even think that particle mass can be assigned with its em field body and that Compton length of particle corresponds to the size scale of em field body.

Nuclear string model suggests that the sizes of color flux tubes and weak flux quanta associated with nuclei can become dark in this sense and have size of order atomic radius so that dark nuclear physics would have a direct relevance for condensed matter physics. If this happens, it becomes impossible to make a reductionistic separation between nuclear physics and condensed matter physics and chemistry anymore.

2. What dark nucleons are?

The basic hypothesis is that nuclei can make a phase transition to dark phase in which the size of both quarks and nuclei is measured in Angstroms. For the less radical option this transition could happen only for the color, weak, and em field bodies. Proton connected by dark color bonds super-nuclei with inter-nucleon distance of order atomic radius might be crucial for understanding the properties of water and perhaps even the properties of ordinary condensed matter. Large $\hbar$ phase for weak field body of D and Pd nuclei with size scale of atom would explain selection rules of cold fusion.

3. Anomalous properties of water and dark nuclear physics

A direct support for partial darkness of water comes from the $H_{1.5}O$ chemical formula supported by neutron and electron diffraction in attosecond time scale. The explanation could be that one fourth of protons combine to form super-nuclei with protons connected by color bonds and having distance sufficiently larger than atomic radius.

The crucial property of water is the presence of molecular clusters. Tedrahedral clusters allow an interpretation in terms of magic Z=8 protonic dark nuclei. The icosahedral clusters consisting of 20 tedrahedral clusters in turn have interpretation as magic dark dark nuclei: the presence of the dark dark matter explains large portion of the anomalies associated with water and explains the unique role of water in biology. In living matter also higher levels of dark matter hierarchy are predicted to be present. The observed nuclear transmutation suggest that also light weak bosons are present.

4. Implications of the partial darkness of condensed matter

The model for partially dark condensed matter inspired by nuclear string model and the model of cold fusion inspired by it allows to understand the low compressibility of the condensed matter as being due to the repulsive weak force between exotic quarks, explains large parity breaking effects in living matter, and suggests a profound modification of the notion of chemical bond having most important implications for bio-chemistry and understanding of bio-chemical evolution.

Dark Forces and Living Matter

The unavoidable presence of classical long ranged weak (and also color) gauge fields in TGD Universe has been a continual source of worries for more than two decades. The basic question has been whether electro-weak charges of elementary particles are screened in electro-weak length scale or not. The TGD based view about dark matter assumes that weak charges are indeed screened for ordinary matter in electro-weak length scale but that dark electro-weak bosons correspond to much longer symmetry breaking length scale. The localization of the modes of Kähler-Dirac action to 2-D surfaces at which W fields vanish realizes this idea concretely. Also Z^0 fields can vanish and are expected to do so above weak scale.

The large value of $\hbar$ in dark matter phase implies that Compton lengths and -times are scaled up. In particular, the sizes of nucleons and nuclei become of order atom size so that dark nuclear physics would have direct relevance for condensed matter physics. It becomes impossible to make a reductionistic separation between nuclear physics and condensed matter physics and chemistry anymore. This view forces a profound re-consideration of the earlier ideas in nuclear and condensed physics context. It however seems that most of the earlier ideas related to the classical Z^0 force and inspired by anomaly considerations survive in a modified form.

The weak form of electric-magnetic duality led to the identification of the long sought for mechanism causing the weak screening in electroweak scales. The basic implication of the duality is that Kähler electric charges of wormhole throats representing particles are proportional to Kähler magnetic charges so that the CP_2 projections of the wormhole throats are homologically non-trivial. The Kähler magnetic charges do not create long range monopole fields if they are neutralized by wormhole throats carrying opposite monopole charges and weak isospin neutralizing the axial isospin of the particle's wormhole throat. One could speak of confinement of weak isospin. The weak field bodies of elementary fermions would be replaced with string like objects with a length of order W boson Compton length. Electro-magnetic flux would be feeded to electromagnetic field body where it would be feeded to larger space-time sheets. Similar mechanism could apply in the case of color quantum numbers. Weak charges would be therefore screened for ordinary matter in electro-weak length scale but dark electro-weak bosons correspond to much longer symmetry breaking length scale for weak field body. Large values of Planck constant would make it possible to zoop up elementary particles and study their internal structure without any need for gigantic accelerators.

One can still worry about large parity breaking effects - say in nuclear physics- since the couplings of spinors to classical weak fields are there. Around 2012 it became clear that the condition that induced spinor fields have well defined em charge localizes their modes in the generic case to 2-surfaces carrying vanishing induced W gauge fields. It is quite possible that this localization is consistent with Kähler-Dirac equation only in ther Minkowskian regions were the effective metric defined by Kähler-Dirac gamma matrices can be effectively 2-dimensional.

On can pose the additional condition that also classical Z^0 field vanishes - at least above weak scale. Fundamental fermions would experience only em field so that the worries related to large parity breaking effects would disappear. The proportionality of weak scale to $h_{eff} = n \times h$ however predicts that weak fields are effectively massless belong scaled up weak scale. Therefore worries about large parity breaking effects in ordinary nuclear physics can be forgotten.

In this chapter possible implications of the dark weak force for the understanding of living matter are discussed. The basic question is how classical Z^0 fields could make itself visible. Large parity breaking effects in living matter suggests which direction one should look for the answer to the question. One possible answer is based on the observation that for vacuum extremals classical electromagnetic and Z^0 fields are proportional to each other and this means that the electromagnetic charges of dark fermions standard are replaced with effective couplings in which the contribution of classical Z^0 force dominates. This modifies dramatically the model for the cell membrane as a Josephson junction and raises the scale of Josephson energies from IR range just above thermal threshold to visible and ultraviolet. The amazing finding is that the Josephson energies for biologically important ions correspond to the energies assigned to the peak frequencies in the biological activity spectrum of photoreceptors in retina suggesting. This suggests that almost vacuum extremals and thus also classical Z^0 fields could be in a central role in the understanding of the functioning of the cell membrane and of sensory qualia. This would also explain the large parity breaking effects in living matter.

A further conjecture is that EEG and its predicted fractally scaled variants which same energies in visible and UV range but different scales of Josephson frequencies correspond to Josephson photons with various values of Planck constant. The decay of dark ELF photons with energies of visible photons would give rise to bunches of ordinary ELF photons. Biophotons in turn could correspond to ordinary visible photons resulting in the phase transition of these photons to photons with ordinary value of Planck constant. This leads to a very detailed view about the role of dark electromagnetic radiation in biomatter and also to a model for how sensory qualia are realized. The general conclusion might be that most effects due to the dark weak force are associated with almost vacuum extremals.

About the New Physics Behind Qualia

This chapter was originally about the new physics behind qualia. The model of qualia indeed involves a lot of new physics: many-sheeted space-time; massless extremals; magnetic and cyclotron phase transitions associated with quantum critical quantum spin glass phases of exotic super conductors at cellular space-time sheets; classical color and electro-weak gauge fields in macroscopic length scales, to name the most important ingredients. Gradually the chapter however expanded so that it touches practically all new physics possibly relevant to TGD inspired quantum biology. Various physical mechanisms are discussed in exploratory spirit rather than restricting the consideration to those ideas which seem to be the final word about quantum biology or qualia just at this moment.

Part I

BIO-SYSTEMS AS SUPER CONDUCTORS

Chapter 2

Bio-Systems as Super-Conductors: Part I

2.1 Introduction

In this chapter various TGD based ideas related to high T_c superconductivity and to the role of super-conductivity in bio-systems are studied. TGD inspired theory of consciousness provides several motivations for this.

1. Supra currents and Josephson currents provide excellent tools of bio-control allowing large space-time sheets to control the smaller space-time sheets. The predicted hierarchy of dark matter phases characterized by a large value of $\hbar$ and thus possessing scaled up Compton and de Broglie wavelengths allows to have quantum control of short scales by long scales utilizing de-coherence phase transition. Quantum criticality is the basic property of TGD Universe and quantum critical super-conductivity is therefore especially natural in TGD framework. The competing phases could be ordinary and large $\hbar$ phases and supra currents would flow along the boundary between the two phases.

2. It is possible to make a tentative identification of the quantum correlates of the sensory qualia quantum number increments associated with the quantum phase transitions of various macroscopic quantum systems [K16] and various kind of Bose-Einstein condensates and super-conductors are the most relevant ones in this respect.

3. The state basis for the fermionic Fock space spanned by N creation operators can be regarded as a Boolean algebra consisting of statements about N basic statements. Hence fermionic degreees of freedom could correspond to the Boolean mind whereas bosonic degrees of freedom would correspond to sensory experiencing and emotions. The integer valued magnetic quantum numbers (a purely TGD based effect) associated with the defect regions of super conductors of type I provide a very robust information storage mechanism and in defect regions fermionic Fock basis is natural. Hence not only fermionic super-conductors but also their defects are biologically interesting [K18, K40, K15].

2.1.1 General Ideas About Super-Conductivity In Many-Sheeted Space-Time

The notion of many-sheeted space-time alone provides a strong motivation for developing TGD based view about superconductivity and I have developed various ideas about high T_c superconductivity [D52] in parallel with ideas about living matter as a macroscopic quantum system. A further motivation and a hope for more quantitative modelling comes from the discovery of various non-orthodox super-conductors including high T_c superconductors [D52, D57, D6]. heavy fermion super-conductors and ferromagnetic superconductors [D51, D39, D26]. The standard BCS theory does not work for these super-conductors and the mechanism for the formation of Cooper pairs is not understood. There is experimental evidence that quantum criticality [D73] is a key feature of many non-orthodox super-conductors. TGD provides a conceptual framework and bundle of ideas making it possible to develop models for non-orthodox superconductors.

Quantum criticality, hierarchy of dark matters, and dynamical $\hbar$

Quantum criticality is the basic characteristic of TGD Universe and quantum critical superconductors provide an excellent test bed to develop the ideas related to quantum criticality into a more concrete form. The hypothesis that Planck constants in CD (causal diamond defined as the intersection of the future and past directed light-cones of M^4) and CP_2 degrees of freedom are dynamical possessing quantized spectrum given as integer multiples of minimum value of Planck constant [K81, K80] adds further content to the notion of quantum criticality.

After several alternatives I ended with the conjecture that the value of $\hbar$ is in the general case given by $\hbar = n \times \hbar_0$. Integer n characterizes a sub-algebra of super-symplectic algebra or related algebra with conformal structure characterized by the property that conformal weights are n-multiples of those of the full algebra. The sub-algebra is isomorphic with the full algebra so that a fractal hierarchy of sub-algebras is obtained. One obtains an infinite hierarchy of conformal gauge symmetry breaking hierarchies defined by the sequences of integers n_i dividing n_{i+1}.

The identification in terms of hierarchies of inclusions of hyper-finite factors of type II_1 is natural. Also the interpretation in terms of finite measurement resolution makes sense. As n increases the sub-algebra acting as conformal gauge symmetries is reduced so that some gauge degrees of freedom are transformed to physical ones. The transitions increasing n occur spontaneously since criticality is reduced. A good metaphor for TGD Universe is as a hill at the top of a hill at the top.... In biology this interpretation is especially interesting since living systems can be seen as systems doing their best to stay at criticality using metabolic energy feed as a tool to achieve this. Ironically, the increase of $\hbar$ would mean increase of measurement resolution and evolution!

The only coupling constant of the theory is Kähler coupling constant $\alpha_K = g_K^2/4\pi\hbar$, which appears in the definition of the Kähler function K characterizing the geometry of the configuration space of 3-surfaces (the "world of classical worlds"). The exponent of K defines vacuum functional analogous to the exponent of Hamiltonian in thermodynamics. The allowed value of $\alpha_K = g_K^2/4\pi\hbar$ should be analogous to critical temperature and determined by quantum criticality requirement. There are two possible interpretations for the hierarchy of Planck constants.

1. The actual value of $\hbar$ is always its standard value and value of $\alpha_K = g_K 2/4\pi\hbar$ is always its maximal value $\alpha_K(n = 1$ but there are n space-time sheets contributing the same value of Kähler action effectively scaling up the value of $\hbar_0$ to $n\hbar_0$ scaling down the value of $\alpha_K(1)$ to $\alpha_K(1)/n$. The n sheets would belong to n different conformal gauge equivalence classes of space-time surfaces connecting fixed 3-surfaces at opposite boundaries of CD. This interpretation is analogous to the introduction of the singular covering space of embedding space.

   One can of course ask whether all values $0 < m \leq n$ for the number of "actualized" sheets are possible. A possible interpretation would be in terms of charge fractionization.

2. One could also speak of genuine hierarchy of Planck constants $\hbar = n\hbar_0$ predicting a genuine hierarchy of Kähler coupling strengths $\alpha_K(n) = \alpha_K(n = 1)/n$. In thermodynamical analogy zero temperature is an accumulation of critical temperatures behaving like $1/n$. Intriguingly, in p-adic thermodynamics p-adic temperature is quantized for purely number theoretical reasons as $1/n$ multiples of the maximal p-adic temperature. Note that Kähler function is the analog of free energy. In this interpretation the n sheets are identified.

Phases with different values n behave like dark matter with respect to each other in the sense that they do not have direct interactions except at criticality for the phase transition changing the value of n to its multiple or divisor. In large $\hbar(CD)$ phases various quantum time and length scales are scaled up which means macroscopic and macro-temporal quantum coherence.

Number theoretic complexity argument favors the hypothesis that the integers n 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, might be 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.

Contrary to the original hypothesis inspired by the requirement that gravitational coupling is renormalization group invariant, α_K does not seem to depend on p-adic prime whereas gravitational constant is proportional to L_p^2. The situation is saved by the assumption that gravitons correspond to the largest non-super-astrophysical Mersenne prime M_{127} so that gravitational coupling is effectively RG invariant in p-adic coupling constant evolution [L28].

$\hbar(CD)$ appears in the commutation and anti-commutation relations of various superconformal algebras. 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 Planck constants 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.

A further great idea is that the transition to large $\hbar$ phase occurs when perturbation theory based on the expansion in terms of gauge coupling constant ceases to converge: Mother Nature would take care of the problems of theoretician. The transition to large $\hbar$ phase obviously reduces gauge coupling strength α so that higher orders in perturbation theory are reduced whereas the lowest order "classical" predictions remain unchanged. A possible quantitative formulation of the criterion is that maximal 2-particle gauge interaction strength parameterized as $Q_1Q_2\alpha$ satisfies the condition $Q_1Q_2\alpha \simeq 1$.

TGD thus predicts an infinite hierarchy of phases behaving like dark or partially dark matter with respect to the ordinary matter and each other [K84] and the value of $\hbar$ is only one characterizer of these phases. These phases, especially so large $\hbar$ phase, seem to be essential for the understanding of even ordinary hadronic, nuclear and condensed matter physics [K84, K94, K80]. This strengthens the motivations for finding whether dark matter might be involved with quantum critical super-conductivity.

Cusp catastrophe serves as a metaphor for criticality. In the case of high T_c superconductivity temperature and doping are control variables and the tip of cusp is at maximum value of T_c. Critical region correspond to the cusp catastrophe. Quantum criticality suggests the generalization of the cusp to a fractal cusp. Inside the critical lines of cusp there are further cusps which corresponds to higher levels in the hierarchy of dark matters labeled by increasing values of $\hbar$ and they correspond to a hierarchy of subtle quantum coherent dark matter phases in increasing length scales. The proposed model for high T_c super-conductivity involves only single value of Planck constant but it might be that the full description involves very many values of them.

Many-sheeted space-time concept and ideas about macroscopic quantum phases

Many-sheeted space-time leads to obvious ideas concerning the realization of macroscopic quantum phases.

1. The dropping of particles to larger space-time sheets is a highly attractive mechanism of super-conductivity. If space-time sheets are thermally isolated, the larger space-time sheets could be at extremely low temperature and super-conducting.

2. The possibility of large $\hbar$ phases allows to give up the assumption that space-time sheets characterized by different p-adic length scales are thermally isolated. The scaled up versions of a given space-time sheet corresponding to a hierarchy of values of $\hbar$ are possible such that the scale of kinetic energy and magnetic interaction energy remain same for all these space-time sheets. For the scaled up variants of space-time sheet the critical temperature for superconductivity could be higher than room temperature.

3. The idea that wormhole contacts can form macroscopic quantum phases and that the interaction of ordinary charge carriers with the wormhole contacts feeding their gauge fluxes to larger space-time sheets could be responsible for the formation of Cooper pairs, have been

around for a decade [K55]. The rather recent realization that wormhole contacts can be actually regarded as space-time correlates for Higgs particles suggests also a new view about the photon massivation in super-conductivity.

4. Quantum classical correspondence has turned out be a very powerful idea generator. For instance, one can ask what are the space-time correlates for various notions of condensed matter such as phonons, BCS Cooper pairs, holes, etc...

2.1.2 TGD Inspired Model For High T_c Superconductivity

The TGD inspired model for high T_c super-conductivity relies on the notions of quantum criticality, dynamical quantized Planck constant requiring a generalization of the 8-D embedding 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.

With a sufficient amount of twisting and weaving these basic ideas one ends up to concrete models for high T_c superconductors as quantum critical superconductors consistent with the qualitative facts that I am personally aware. The following minimal model looks the most realistic option found hitherto.

1. The general idea is that magnetic flux tubes are carriers of supra currents. In anti-ferromagnetic phases these flux tube structures form small closed loops so that the system behaves as an insulator. Some mechanism leading to a formation of long flux tubes must exist. Doping creates holes located around stripes, which become positively charged and attract electrons to the flux tubes.

2. Usually magnetic field tends to destroy Cooper pairs since it tends to flip the spins of electrons of pair to same direction. In TGD flux quantization comes in rescue and magnetic fields favor the formation of Cooper pairs. If one has two parallel flux tubes with opposite directions of magnetic fluxes with large value of $h_{eff} = nh$, $S = 0$ Cooper pairs with even $L \geq 2$ are favored. This situation is encountered in systems near antiferromagnetic phase transition in small scales leading to formation of sequences of flux loops carrying Cooper pairs. Macroscopic super-conductivity results when the loops are reconnected to two long flux tubes with opposite fluxes. If the magnetic fluxes have same sign, $S = 1$ Cooper pairs with odd $L \geq 1$ are favored.

3. The higher critical temperature T_{c1} corresponds to a formation local configurations of parallel spins assigned to the holes of stripes giving rise to a local dipole fields with size scale of the order of the length of the stripe. Conducting electrons form Cooper pairs at the magnetic flux tube structures associated with these dipole fields. The presence of magnetic field favors Cooper pairs with spin $S = 1$. It took long time to realize that pairs of large h_{eff} magnetic flux tubes with fluxes in opposite directions are ideal for carrying Cooper pairs with members of the pair at the different flux tubes. Large spin interaction energy with magnetic field proportional to $h_{eff} = nh$ stablizes the pair.

4. Stripes can be seen as 1-D metals with de-localized electrons. The interaction responsible for the energy gap corresponds to the transversal oscillations of the magnetic flux tubes inducing oscillations of the nuclei of the stripe. These transverse phonons have spin and their exchange is a good candidate for the interaction giving rise to a mass gap. This could explain the claimed BCS type aspects of high T_c super-conductivity. Another interpretation is as spin density waves now known to be important for high temperature superconductivity.

5. Above T_c supra currents are possible only in the length scale of the flux tubes of the dipoles which is of the order of stripe length. The reconnections between neighboring flux tube structures induced by the transverse fluctuations give rise to longer flux tubes structures making possible finite conductivity. These occur with certain temperature dependent probability $p(T, L)$ depending on temperature and distance L between the stripes. By criticality $p(T, L)$ depends on the dimensionless variable $x = TL/\hbar$ only: $p = p(x)$. At critical temperature T_c transverse fluctuations have large amplitude and makes $p(x_c)$ so large that very long flux tubes are created and supra currents can run. The phenomenon is completely analogous to percolation [D11].

6. The critical temperature $T_c = x_c\hbar/L$ is predicted to be proportional to $\hbar$ and inversely proportional to L (, which is indeed to be the case). If flux tubes correspond to a large value of $\hbar$, one can understand the high value of T_c. Both Cooper pairs and magnetic flux tube structures represent dark matter in TGD sense.

7. The model allows to interpret the characteristic spectral lines in terms of the excitation energy of the transversal fluctuations and gap energy of the Cooper pair. The observed 50 meV threshold for the onset of photon absorption suggests that below T_c also $S = 0$ Cooper pairs are possible and have gap energy about 9 meV whereas $S = 1$ Cooper pairs would have gap energy about 27 meV. The flux tube model indeed predicts that $S = 0$ Cooper pairs become stable below T_c since they cannot anymore transform to $S = 1$ pairs. Their presence could explain the BCS type aspects of high T_c super-conductivity. The estimate for $\hbar/\hbar_0 = r$ from critical temperature T_{c1} is about $r = 3$ contrary to the original expectations inspired by the model of of living system as a super-conductor suggesting much higher value. An unexpected prediction is that coherence length is actually r times longer than the coherence length predicted by conventional theory so that type I super-conductor could be in question with stripes serving as duals for the defects of type I super-conductor in nearly critical magnetic field replaced now by ferromagnetic phase.

8. TGD suggests preferred values for $r = \hbar/\hbar_0$ and the applications to bio-systems favor powers of $r = 2^{11}$. $r = 2^{11}$ predicts that electron Compton length is of order atomic size scale. Bio-superconductivity could involve electrons with $r = 2^{22}$ having size characterized by the thickness of the lipid layer of cell membrane.

At qualitative level the model explains various strange features of high T_c superconductors. One can understand the high value of T_c and ambivalent character of high T_c super conductors, the existence of pseudogap and scalings laws for observables above T_c, the role of stripes and doping and the existence of a critical doping, etc...

The model explains the observed ferromagnetic super-conductivity at quantum criticality [D51]. Since long flux tubes already exist, the overcritical transverse of fluctuations of the magnetic flux tubes inducing reconnections are now not responsible for the propagation of the super currents now. The should however provide the binding mechanism of $S = 1, L = 2$ Cooper pairs via the coupling of the fluctuations to excitation in the direction of flux tubes. I have considered effectively one-dimensional phonons in the direction of flux tubes as a candidates for this excitation. Spin density waves looks however a more realistic possibility. Also a modulated ferromagnetic phase consisting of stripes of opposite magnetization direction allows superconductivity [D51] and could be understood in terms of $S = 0$ Cooper pairs with electrons of the pair located at the neighboring stripes (flux tubes in TGD model.

2.1.3 Empirical Evidence For High T_c Superconductivity In Bio-Systems

There is evidence for super-conductivity in bio-systems. DNA should be insulator but under some circumstances it becomes conductor [I14] and perhaps even high T_c quantum critical super-conductor. Also evidence for Josephson effect has been reported [D34]. The so called ORMEs patented by Hudson [H7] are claimed to behave like superconductors: unfortunately the academic world has not taken these claims seriously enough to test them. The claimed properties of ORMEs conform with high quantum critical T_c super-conductivity and superfluidity. The strange findings about the strange quantal behavior of ionic currents through cell membranes [I29] suggest the presence of ionic supra currents. This evidence is discussed in the next chapter [K10].

2.2 General TGD Based View About Super-Conductivity

Today super-conductivity includes besides the traditional low temperature super-conductors many other non-orthodox ones [D65]. These unorthodox super-conductors carry various attributes such as cuprate, organic, dichalcogenide, heavy fermion, bismute oxide, ruthenate, antiferromagnetic and ferromagnetic. Mario Rabinowitz has proposed a simple phenomenological theory of super-fluidity and super-conductivity which helps non-specialist to get a rough quantitative overall view about super-conductivity [D65].

2.2.1 Basic Phenomenology Of Super-Conductivity

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

Basic phenomenology of super-conductivity

The transition to super-conductivity occurs at critical temperature T_c and involves a complete loss of electrical resistance. Super-conductors expel magnetic fields (Meissner effect) and when the external magnetic field exceeds a critical value H_c super-conductivity is lost either completely or partially. In the transition to super-conductivity specific heat has singularity. For long time magnetism and super-conductivity were regarded as mutually exclusive phenomena but the discovery of ferromagnetic super-conductors [D51, D26] has demonstrated that reality is much more subtle.

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

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

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

The observation that spin triplet Cooper pairs might be possible in ferro-magnets stimulates the question whether ferromagnetism and super-conductivity might tolerate each other after all, and the answer is affirmative [D26]. The article [D51] provides an enjoyable summary of experimental discoveries.

Basic parameters of super-conductors from universality?

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

It has been suggested [D65] that these parameters might be more or less universal so that they would not depend on the specific properties of the interaction responsible for the formation of Cooper pairs. The motivation comes from the fact that the properties of ordinary Bose-Einstein condensates do not depend on the details of interactions. This raises the hope that these parameters might be expressible in terms of some basic parameters such as T_c and the density of conduction electrons allowing to deduce Fermi energy E_F and Fermi momentum k_F if Fermi surface is sphere. In [D65] formulas for the basic parameters are indeed suggested based on this of argumentation assuming that Cooper pairs form a Bose-Einstein condensate.

1. The most important parameters are critical temperature T_c and critical magnetic field H_c in principle expressible in terms of gap energy. In [D65] the expression for T_c is deduced from the condition that the de Broglie wavelength λ must satisfy in supra phase the condition

$$\lambda \geq 2d = 2(\frac{n_c}{g})^{-1/D} \tag{2.2.1}$$

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

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

$$T_c \leq \frac{h^2}{4Dm}(\frac{n_c}{g})^{2/D} \ . \tag{2.2.2}$$

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

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

$$\begin{aligned} n_c &= \frac{1}{2}\frac{4\pi k_F^2 \Delta k}{\frac{4}{3}\pi k_F^3} n \ , \\ kT_c &= E_F - E(k_F - \Delta k) \simeq \frac{h^2 k_F \Delta k}{m} \ . \end{aligned} \tag{2.2.3}$$

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

$$n_c(D) = \frac{D}{2}\frac{T_c}{E_F} n(D) \ . \tag{2.2.4}$$

The dimensionless coefficient is expressible solely in terms of n and effective mass m. In [D65] it is demonstrated that the inequality 2.3.2 replaced with equality when combined with 2.3.4 gives a satisfactory fit for 16 super-conductors used as a sample.

Note that the Planck constant appearing in E_F and T_c in Eq. 2.3.4 must correspond to ordinary Planck constant $\hbar_0$. This implies that equations 2.3.2 and 2.3.4 are consistent within orders of magnitudes. For $D = 2$, which corresponds to high T_c superconductivity, the substitution of n_c from Eq. 2.3.4 to Eq. 2.3.2 gives a consistency condition from which n_c disappears completely. The condition reads as

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

Obviously the equation is not completely consistent.

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

$$\lambda^{-2} = \frac{4\pi e^2 n_c}{m_e} \ . \tag{2.2.5}$$

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

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

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

$$\xi = \frac{4\hbar v_F}{E_g} \ . \tag{2.2.6}$$

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

For instance, BCS theory predicts $n = 3.52$ for metallic super-conductors and $n = 8$ holds true for cuprates [D65]. For cuprates one obtains $\xi = 2n^{-1/3}$ [D65]. This expression can be criticized since cuprates are Mott insulators and it is not at all clear whether a description as Fermi gas makes sense. The fact that high T_c super-conductivity involves breakdown of anti-ferromagnetic order might justify the use of Fermi gas description for conducting holes resulting in the doping.

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

2.2.2 Universality Of The Parameters In TGD Framework

Universality idea conforms with quantum criticality of TGD Universe. The possibility to express everything in terms of density of critical temperature coding for the dynamics of Cooper pair formation and the density charge carriers would make it also easy to understand how p-adic scalings and transitions to large $\hbar$ phase affect the basic parameters. The possible problem is that the replacement of inequality of Eq. 2.3.2 with equality need not be sensible for large $\hbar$ phases. It will be found that in many-sheeted space-time T_c does not directly correspond to the gap energy and the universality of the critical temperature follows from the p-adic length scale hypothesis.

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

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

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

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

1. Scaling of T_c and E_g

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

$$\begin{aligned} E_g &= \hbar\omega_c exp(-1/X) \ , \\ X &= n(E_F)U_0 = \frac{3}{2}N(E_F)\frac{U_0}{E_F} \ , \\ n(E_F) &= \frac{3}{2}\frac{N(E_F)}{E_F} \ . \\ \omega_c &= \omega_D = (6\pi^2)^{1/3}c_s n_n^{1/3} \ . \end{aligned} \tag{2.2.7}$$

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

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

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

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

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

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

2. Scaling of ξ and λ

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

3. Scaling of H_c and B

The critical magnetization is given by

$$H_c(T) = \frac{\Phi_0}{\sqrt{8}\pi\xi(T)\lambda(T)} \ , \tag{2.2.8}$$

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

Magnetic flux quantization condition is replaced by

$$\int 2eBdS = n\hbar 2\pi \ . \tag{2.2.9}$$

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

2.2.3 Quantum Criticality And Super-Conductivity

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

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

How the quantum criticality of superconductors relates to TGD quantum criticality

There is empirical support that super-conductivity in high T_c super-conductors and ferromagnetic systems [D51, D39] is made possible by quantum criticality [D73]. In the experimental situation quantum criticality means that at sufficiently low temperatures quantum rather than thermal fluctuations are able to induce phase transitions. Quantum criticality manifests itself as fractality and simple scaling laws for various physical observables like resistance in a finite temperature range and also above the critical temperature. This distinguishes sharply between quantum critical super conductivity from BCS type super-conductivity. Quantum critical super-conductivity also exists in a finite temperature range and involves the competition between two phases.

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

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

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

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

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

Quantum critical super-conductors in TGD framework

For quantum critical super-conductivity in heavy fermions systems, a small variation of pressure near quantum criticality can destroy ferromagnetic (anti-ferromagnetic) order so that Curie (Neel) temperature goes to zero. The prevailing spin fluctuation theory [D23] assumes that these transitions are induced by long ranged and slow spin fluctuations at critical pressure P_c. These fluctuations make and break Cooper pairs so that the idea of super-conductivity restricted around critical point is indeed conceivable.

Heavy fermion systems, such as cerium-indium alloy $CeIn_3$ are very sensitive to pressures and a tiny variation of density can drastically modify the low temperature properties of the systems. Also other systems of this kind, such as $CeCu_2Ge_2$, $CeIn_3$, $CePd_2Si_2$ are known [D51, D26]. In these cases super-conductivity appears around anti-ferromagnetic quantum critical point.

The last experimental breakthrough in quantum critical super-conductivity was made in Grenoble [D39]. URhGe alloy becomes super-conducting at $T_c = .280$ K, loses its super-conductivity at $H_c = 2$ Tesla, and becomes again super-conducting at $H_c = 12$ Tesla and loses its super-conductivity again at $H = 13$ Tesla. The interpretation is in terms of a phase transition changing the magnetic order inducing the long range spin fluctuations.

TGD based models of atomic nucleus [K94] and condensed matter [K80] assume that weak gauge bosons with Compton length of order atomic radius play an essential role in the nuclear and condensed matter physics. The assumption that condensed matter nuclei possess anomalous weak charges explains the repulsive core of potential in van der Waals equation and the very low compressibility of condensed matter phase as well as various anomalous properties of water phase, provide a mechanism of cold fusion and sono-fusion, etc. [K80, K79]. The pressure sensitivity of these systems would directly reflect the physics of exotic quarks and electro-weak gauge bosons.

A possible mechanism behind the phase transition to super-conductivity could be the scaling up of the sizes of the space-time sheets of nuclei.

Also the electrons of Cooper pair (and only these) could make a transition to large $\hbar$ phase. This transition would induce quantum overlap having geometric overlap as a space-time correlate. The formation of flux tubes between neighboring atoms would be part of the mechanism. For instance, the criticality condition $4n^2\alpha = 1$ for BE condensate of n Cooper pairs would give $n = 6$ for the size of a higher level quantum unit possibly formed formed from Cooper pairs. If one does not assume invariance of energies obtained by fractionization of principal quantum number, this transition has dramatic effects on the spectrum of atomic binding energies scaling as $1/\hbar^2$ and practically universal spectrum of atomic energies would result [K79] not depending much on nuclear charge. It seems that this prediction is non-physical.

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

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

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

Large $\hbar$ phase for some nuclei might be involved and make possible large space-time sheets of size at least of order of ξ at which conduction electrons forming Cooper pairs would topologically condense like quarks around hadronic space-time sheets (in [K80] a model of water as a partially dark matter with one fourth of hydrogen ions in large $\hbar$ phase is developed).

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

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

2.2.4 Space-Time Description Of The Mechanisms OfSuper-Conductivity

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

Leading questions

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

1. The work of Rabinowitch [D65] suggests that that the basic parameters of super-conductors might be rather universal and depend on T_c and conduction electron density only and be to a high degree independent of the mechanism of super-conductivity. This is in a sharp contrast to the complexity of even BCS model with its somewhat misty description of the phonon exchange mechanism.
   Questions: Could there exist a simple universal description of various kinds of super-conductivities?

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

3. The effective masses of electrons in ferromagnetic super-conductors are in the range of 10-100 electron masses [D51] and this forces to question the idea that ordinary Cooper pairs are current carriers.
   Questions: Can one consider the possibility that the p-adic length scale of say electron can vary so that the actual mass of electron could be large in condensed matter systems? For quarks and neutrinos this seems to be the case [K26, K31]. Could it be that the Gaussian Mersennes $(1+i)^k-1$, $k = 151, 157, 163, 167$ spanning the p-adic lengthscale range 10 nm-2.5 μm very relevant from the point of view of biology correspond to p-adic length especially relevant for super-conductivity?

Second group of questions is inspired by quantum classical correspondence.

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

2. Quantum classical correspondence forces to ask for the space-time correlates for the existing quantum description of phonons.
   Questions: Can one assign space-time sheets with phonons or should one identify them as oscillations of say space-time sheets at which atoms are condensed? Or should the microscopic description of phonons in atomic length scales rely on the oscillations of wormhole contacts connecting atomic space-time sheets to these larger space-time sheets? The identification of phonons as wormhole contacts would be completely analogous to the similar identification of gauge bosons except that phonons would appear at higher levels of the hierarchy of space-time sheets and would be emergent in this sense. As a matter fact, even gauge bosons as

pairs of fermion and anti-fermion are emergent structures in TGD framework and this plays fundamental role in the construction of QFT limit of TGD in which bosonic part of action is generated radiatively so that all coupling constants follow as predictions [K82]. Could Bose-Einstein condensates of wormhole contacts be relevant for the description of super-conductors or more general macroscopic quantum phases?

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

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

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

3. Suppose that one takes seriously the ideas about the possibility of dark weak interactions with the Compton scale of weak bosons scaled up to say atomic length scale so that weak bosons are effectively massless below this length scale [K80]. Questions: Could the dark weak length scale which is of order atomic size replace lattice constant in the expression of sound velocity? What is the space-time correlate for sound velocity?

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

The existence of wormhole contacts is one of the most stunning predictions of TGD. First I realized that wormhole contacts can be regarded as parton-antiparton pairs with parton and antiparton assignable to the light-like causal horizons accompanying wormhole contacts. Then came the idea that Higgs particle could be identified as a wormhole contact. It was soon followed by the identification all bosonic states as wormhole contacts [K26]. Finally I understood that this applies also to their super-symmetric partners, which can be also fermion [K82]. Fermions and their super-partners would in turn correspond to wormhole throats resulting in the topological condensation of small deformations of CP_2 type vacuum extremals with Euclidian signature of metric to the background space-time sheet. This framework opens the doors for more concrete models of also super-conductivity involving the effective massivation of photons as one important aspect in the case of ordinary super-conductors.

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

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

The ideas that a genuine Higgs type photon massivation is involved with super-conductivity and that coherent states of Cooper pairs really make sense are somewhat questionable since the conservation of charge and fermion number is lost for coherent states. A further questionable feature is that a quantum superposition of many-particle states with widely different masses would be in question. These interpretational problems can be resolved elegantly in zero energy ontology [K72] in which the total conserved quantum numbers of quantum state are vanishing. In this picture the energy, fermion number, and total charge of any positive energy state are compensated by opposite quantum numbers of the negative energy state in geometric future. This makes possible to speak about superpositions of Cooper pairs and charged Higgs bosons separately in positive energy sector.

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

Space-time correlate for quantum critical superconductivity

The explicit model for high T_c super-conductivity relies on quantum criticality involving long ranged quantum fluctuations inducing reconnection of flux tubes of local (color) magnetic fields associated with parallel spins associated with stripes to form long flux tubes serving as wires along which Cooper pairs flow. Essentially [D11] [D11] type phenomenon would be in question. The role of the doping by holes is to make room for Cooper pairs to propagate by the reconnection mechanism: otherwise Fermi statistics would prevent the propagation. Too much doping reduces the number of current carriers, too little doping leaves too little room so that there exists some optimal doping. In the case of high T_c super-conductors quantum criticality corresponds to a quite wide temperature range, which provides support for the quantum criticality of TGD Universe. The probability $p(T)$ for the formation of reconnections is what matters and exceeds the critical value at T_c.

2.2.5 Super-Conductivity At Magnetic Flux Tubes

Super-conductivity at the magnetic flux tubes of magnetic flux quanta is one the basic hypothesis of the TGD based model of living matter. There is also evidence for magnetically mediated super-conductivity in extremely pure samples [D40]. The magnetic coupling was only observed at lattice densities close to the critical density at which long-range magnetic order is suppressed. Quantum criticality that long flux tubes serve as pathways along which Cooper pairs can propagate. In anti-ferromagnetic phase these pathways are short-circuited to closed flux tubes of local magnetic fields.

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

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

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

Besides Cooper pairs also Bose-Einstein condensates of bosonic ions are possible in large $\hbar$ phase and would give rise to super-conductivity. TGD inspired nuclear physics predicts the existence of exotic bosonic counterparts of fermionic nuclei with given (A, Z) [L2], [L2].

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

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

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

An essential element of the picture is that topological quantization of the magnetic flux tubes occurs. In fact, the flux tubes of Earth's magnetic field have thickness of order cell size from the quantization of magnetic flux. The observations about the effects of ELF em fields on bio-matter [J17] suggest that similar mechanism is at work also for ions and in fact give very strong support for bio-super conductivity based on the proposed mechanism.

Energy gaps for superconducting magnetic flux tubes and walls

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

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

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

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

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

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

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

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

A new phase of matter in the temperature range between pseudo gap temperature and T_c?

Kram sent a link to a Science Daily popular article titled "High-Temperature Superconductor Spills Secret: A New Phase of Matter?" (see `http://tinyurl.com/49vnvsu`: see also `http://tinyurl.com/yb7rs3fs`). For more details see the article in Science [D36].

Zhi-Xun Shen of the Stanford Institute for Materials and Energy Science (SIMES), a joint institute of the Department of Energy's SLAC National Accelerator Laboratory and Stanford University, led the team of researchers, which discovered that in the temperature region between the pseudo gap temperature and genuine temperature for the transition to super-conducting phase there exists a new phase of matter. The new phase would not be super-conducting but would be characterized by an order of its own which remains to be understood. This phase would be present also in the super-conducting phase.

The announcement does not come as a complete surprise for me. A new phase of matter is what TGD inspired model of high T_c superconductivity indeed predicts. This phase would consist of Cooper pairs of electrons with a large value of Planck constant but associated with magnetic flux tubes with short length so that no macroscopic supra currents would be possible.

The transition to super-conducting phase involves long range fluctuations at quantum criticality and the analog of a phenomenon known as percolation (see `http://tinyurl.com/oytvosv`) [D11]. For instance, the phenomenon occurs for the filtering of fluids through porous materials. At critical threshold the entire filter suddenly wets as fluid gets through the filter. Now this phenomenon would occur for magnetic flux tubes carrying the Cooper pairs. At criticality the short magnetic flux tubes fuse by reconnection to form long ones so that supra currents in macroscopic scales become possible.

It is not clear whether this prediction is consistent with the finding of Shen and others. The simultaneous presence of short and long flux tubes in macroscopically super-conducting phase is certainly consistent with TGD prediction. The situation depends on what one means with super-conductivity. Is super-conductivity super-conductivity in macroscopic scales only or should one call also short scale super-conductivity not giving rise to macroscopic super currents as super-conductivity. In other words: do the findings of Shen's team prove that the electrons above gap temperature do not form Cooper pairs or only that there are no macroscopic supra currents?

Whether the model works as such or not is not a life and death question for the TGD based model. One can quite well imagine that the first phase transition increasing $\hbar$ does not yet produce electron Compton lengths long enough to guarantee that the overlap criterion for the formation of Cooper pairs is satisfied. The second phase transition increasing $\hbar$ would do this and also scale up the lengths of magnetic flux tubes making possible the flow of supra currents as such even without reconnections. Also reconnections making possible the formation of very long flux tubes could be involved and would be made possible by the increase in the length of flux tubes.

21-Micrometer mystery

21 micrometer radiation from certain red giant stars have perplexed astronomers for more than a decade [D18]. Emission forms a wide band (with width about 4 micrometers) in the infrared

spectrum, which suggests that it comes form a large complex molecule or a solid or simple molecules found around starts. Small molecules are ruled out since they produce narrow emission lines. The feature can be only observed in very precise evolutionary state, in the transition between red giant phase and planetary nebular state, in which star blows off dust that is rich in carbon compounds. There is no generally accepted explanation for 21-micrometer radiation.

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

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

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

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

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

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

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L5].

2.3 General TGD Based View About Super-Conductivity

Today super-conductivity includes besides the traditional low temperature super-conductors many other non-orthodox ones [D65]. These unorthodox super-conductors carry various attributes such as cuprate, organic, dichalcogenide, heavy fermion, bismute oxide, ruthenate, antiferromagnetic and ferromagnetic. Mario Rabinowitz has proposed a simple phenomenological theory of super-fluidity and super-conductivity which helps non-specialist to get a rough quantitative overall view about super-conductivity [D65].

2.3.1 Basic Phenomenology Of Super-Conductivity

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

Basic phenomenology of super-conductivity

The transition to super-conductivity occurs at critical temperature T_c and involves a complete loss of electrical resistance. Super-conductors expel magnetic fields (Meissner effect) and when the external magnetic field exceeds a critical value H_c super-conductivity is lost either completely or partially. In the transition to super-conductivity specific heat has singularity. For long time magnetism and super-conductivity were regarded as mutually exclusive phenomena but the discovery of ferromagnetic super-conductors [D51, D26] has demonstrated that reality is much more subtle.

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

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

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

The observation that spin triplet Cooper pairs might be possible in ferro-magnets stimulates the question whether ferromagnetism and super-conductivity might tolerate each other after all, and the answer is affirmative [D26]. The article [D51] provides an enjoyable summary of experimental discoveries.

Basic parameters of super-conductors from universality?

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

It has been suggested [D65] that these parameters might be more or less universal so that they would not depend on the specific properties of the interaction responsible for the formation of Cooper pairs. The motivation comes from the fact that the properties of ordinary Bose-Einstein condensates do not depend on the details of interactions. This raises the hope that these parameters might be expressible in terms of some basic parameters such as T_c and the density of conduction electrons allowing to deduce Fermi energy E_F and Fermi momentum k_F if Fermi surface is sphere. In [D65] formulas for the basic parameters are indeed suggested based on this of argumentation assuming that Cooper pairs form a Bose-Einstein condensate.

1. The most important parameters are critical temperature T_c and critical magnetic field H_c in principle expressible in terms of gap energy. In [D65] the expression for T_c is deduced from the condition that the de Broglie wavelength λ must satisfy in supra phase the condition

$$\lambda \geq 2d = 2(\frac{n_c}{g})^{-1/D} \tag{2.3.1}$$

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

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

$$T_c \leq \frac{h^2}{4Dm}(\frac{n_c}{g})^{2/D} . \tag{2.3.2}$$

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

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

$$\begin{aligned} n_c &= \frac{1}{2}\frac{4\pi k_F^2 \Delta k}{\frac{4}{3}\pi k_F^3} n , \\ kT_c &= E_F - E(k_F - \Delta k) \simeq \frac{h^2 k_F \Delta k}{m} . \end{aligned} \tag{2.3.3}$$

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

$$n_c(D) = \frac{D}{2}\frac{T_c}{E_F} n(D) . \tag{2.3.4}$$

The dimensionless coefficient is expressible solely in terms of n and effective mass m. In [D65] it is demonstrated that the inequality 2.3.2 replaced with equality when combined with 2.3.4 gives a satisfactory fit for 16 super-conductors used as a sample.

Note that the Planck constant appearing in E_F and T_c in Eq. 2.3.4 must correspond to ordinary Planck constant $\hbar_0$. This implies that equations 2.3.2 and 2.3.4 are consistent within orders of magnitudes. For $D = 2$, which corresponds to high T_c superconductivity, the substitution of n_c from Eq. 2.3.4 to Eq. 2.3.2 gives a consistency condition from which n_c disappears completely. The condition reads as

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

Obviously the equation is not completely consistent.

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

$$\lambda^{-2} = \frac{4\pi e^2 n_c}{m_e} . \tag{2.3.5}$$

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

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

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

$$\xi = \frac{4\hbar v_F}{E_g} . \tag{2.3.6}$$

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

For instance, BCS theory predicts $n = 3.52$ for metallic super-conductors and $n = 8$ holds true for cuprates [D65]. For cuprates one obtains $\xi = 2n^{-1/3}$ [D65]. This expression can be criticized since cuprates are Mott insulators and it is not at all clear whether a description as Fermi gas makes sense. The fact that high T_c super-conductivity involves breakdown of anti-ferromagnetic order might justify the use of Fermi gas description for conducting holes resulting in the doping.

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

2.3.2 Universality Of The Parameters In TGD Framework

Universality idea conforms with quantum criticality of TGD Universe. The possibility to express everything in terms of density of critical temperature coding for the dynamics of Cooper pair formation and the density charge carriers would make it also easy to understand how p-adic scalings and transitions to large $\hbar$ phase affect the basic parameters. The possible problem is that the replacement of inequality of Eq. 2.3.2 with equality need not be sensible for large $\hbar$ phases. It will be found that in many-sheeted space-time T_c does not directly correspond to the gap energy and the universality of the critical temperature follows from the p-adic length scale hypothesis.

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

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

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

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

1. Scaling of T_c and E_g

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

$$\begin{aligned} E_g &= \hbar\omega_c exp(-1/X) \ , \\ X &= n(E_F)U_0 = \frac{3}{2}N(E_F)\frac{U_0}{E_F} \ , \\ n(E_F) &= \frac{3}{2}\frac{N(E_F)}{E_F} \ . \\ \omega_c &= \omega_D = (6\pi^2)^{1/3}c_s n_n^{1/3} \ . \end{aligned} \tag{2.3.7}$$

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

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

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

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

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

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

2. Scaling of ξ and λ

If n_c for high T_c super-conductor scales as $1/\hbar^D$ one would have $\lambda \propto \hbar^{D/2}$. High T_c property however suggests that the scaling is weaker. ξ would scale as $\hbar$ for given v_F and T_c. For $D = 2$

case the this would suggest that high T_c super-conductors are of type I rather than type II as they would be for ordinary $\hbar$. This conforms with the quantum criticality which would be counterpart of critical behavior of super-conductors of type I in nearly critical magnetic field.

3. Scaling of H_c and B

The critical magnetization is given by

$$H_c(T) = \frac{\Phi_0}{\sqrt{8}\pi\xi(T)\lambda(T)} , \tag{2.3.8}$$

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

Magnetic flux quantization condition is replaced by

$$\int 2eBdS = n\hbar 2\pi \ . \tag{2.3.9}$$

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

2.3.3 Quantum Criticality And Super-Conductivity

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

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

How the quantum criticality of superconductors relates to TGD quantum criticality

There is empirical support that super-conductivity in high T_c super-conductors and ferromagnetic systems [D51, D39] is made possible by quantum criticality [D73]. In the experimental situation quantum criticality means that at sufficiently low temperatures quantum rather than thermal fluctuations are able to induce phase transitions. Quantum criticality manifests itself as fractality and simple scaling laws for various physical observables like resistance in a finite temperature range and also above the critical temperature. This distinguishes sharply between quantum critical super conductivity from BCS type super-conductivity. Quantum critical super-conductivity also exists in a finite temperature range and involves the competition between two phases.

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

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

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

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

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

Quantum critical super-conductors in TGD framework

For quantum critical super-conductivity in heavy fermions systems, a small variation of pressure near quantum criticality can destroy ferromagnetic (anti-ferromagnetic) order so that Curie (Neel) temperature goes to zero. The prevailing spin fluctuation theory [D23] assumes that these transitions are induced by long ranged and slow spin fluctuations at critical pressure P_c. These fluctuations make and break Cooper pairs so that the idea of super-conductivity restricted around critical point is indeed conceivable.

Heavy fermion systems, such as cerium-indium alloy $CeIn_3$ are very sensitive to pressures and a tiny variation of density can drastically modify the low temperature properties of the systems. Also other systems of this kind, such as $CeCu_2Ge_2$, $CeIn_3$, $CePd_2Si_2$ are known [D51, D26]. In these cases super-conductivity appears around anti-ferromagnetic quantum critical point.

The last experimental breakthrough in quantum critical super-conductivity was made in Grenoble [D39]. URhGe alloy becomes super-conducting at $T_c = .280$ K, loses its super-conductivity at $H_c = 2$ Tesla, and becomes again super-conducting at $H_c = 12$ Tesla and loses its super-conductivity again at $H = 13$ Tesla. The interpretation is in terms of a phase transition changing the magnetic order inducing the long range spin fluctuations.

TGD based models of atomic nucleus [K94] and condensed matter [K80] assume that weak gauge bosons with Compton length of order atomic radius play an essential role in the nuclear and condensed matter physics. The assumption that condensed matter nuclei possess anomalous weak charges explains the repulsive core of potential in van der Waals equation and the very low compressibility of condensed matter phase as well as various anomalous properties of water phase, provide a mechanism of cold fusion and sono-fusion, etc. [K80, K79]. The pressure sensitivity of these systems would directly reflect the physics of exotic quarks and electro-weak gauge bosons. A possible mechanism behind the phase transition to super-conductivity could be the scaling up of the sizes of the space-time sheets of nuclei.

Also the electrons of Cooper pair (and only these) could make a transition to large $\hbar$ phase. This transition would induce quantum overlap having geometric overlap as a space-time correlate. The formation of flux tubes between neighboring atoms would be part of the mechanism. For instance, the criticality condition $4n^2\alpha = 1$ for BE condensate of n Cooper pairs would give $n = 6$ for the size of a higher level quantum unit possibly formed formed from Cooper pairs. If one does not assume invariance of energies obtained by fractionization of principal quantum number, this transition has dramatic effects on the spectrum of atomic binding energies scaling as $1/\hbar^2$

and practically universal spectrum of atomic energies would result [K79] not depending much on nuclear charge. It seems that this prediction is non-physical.

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

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

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

Large $\hbar$ phase for some nuclei might be involved and make possible large space-time sheets of size at least of order of ξ at which conduction electrons forming Cooper pairs would topologically condense like quarks around hadronic space-time sheets (in [K80] a model of water as a partially dark matter with one fourth of hydrogen ions in large $\hbar$ phase is developed).

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

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

2.3.4 Space-Time Description Of The Mechanisms OfSuper-Conductivity

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

Leading questions

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

1. The work of Rabinowitch [D65] suggests that that the basic parameters of super-conductors might be rather universal and depend on T_c and conduction electron density only and be to a high degree independent of the mechanism of super-conductivity. This is in a sharp contrast to the complexity of even BCS model with its somewhat misty description of the phonon exchange mechanism.
Questions: Could there exist a simple universal description of various kinds of super-conductivities?

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

3. The effective masses of electrons in ferromagnetic super-conductors are in the range of 10-100 electron masses [D51] and this forces to question the idea that ordinary Cooper pairs are current carriers.
Questions: Can one consider the possibility that the p-adic length scale of say electron can vary so that the actual mass of electron could be large in condensed matter systems? For quarks and neutrinos this seems to be the case [K26, K31]. Could it be that the Gaussian Mersennes $(1+i)^k-1$, $k = 151, 157, 163, 167$ spanning the p-adic lengthscale range 10 nm-2.5 μm very relevant from the point of view of biology correspond to p-adic length especially relevant for super-conductivity?

Second group of questions is inspired by quantum classical correspondence.

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

2. Quantum classical correspondence forces to ask for the space-time correlates for the existing quantum description of phonons.
Questions: Can one assign space-time sheets with phonons or should one identify them as oscillations of say space-time sheets at which atoms are condensed? Or should the microscopic description of phonons in atomic length scales rely on the oscillations of wormhole contacts connecting atomic space-time sheets to these larger space-time sheets? The identification of phonons as wormhole contacts would be completely analogous to the similar identification of gauge bosons except that phonons would appear at higher levels of the hierarchy of space-time sheets and would be emergent in this sense. As a matter fact, even gauge bosons as pairs of fermion and anti-fermion are emergent structures in TGD framework and this plays fundamental role in the construction of QFT limit of TGD in which bosonic part of action is generated radiatively so that all coupling constants follow as predictions [K82]. Could Bose-Einstein condensates of wormhole contacts be relevant for the description of super-conductors or more general macroscopic quantum phases?

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

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

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

3. Suppose that one takes seriously the ideas about the possibility of dark weak interactions with the Compton scale of weak bosons scaled up to say atomic length scale so that weak bosons are effectively massless below this length scale [K80].
   Questions: Could the dark weak length scale which is of order atomic size replace lattice constant in the expression of sound velocity? What is the space-time correlate for sound velocity?

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

The existence of wormhole contacts is one of the most stunning predictions of TGD. First I realized that wormhole contacts can be regarded as parton-antiparton pairs with parton and antiparton assignable to the light-like causal horizons accompanying wormhole contacts. Then came the idea that Higgs particle could be identified as a wormhole contact. It was soon followed by the identification all bosonic states as wormhole contacts [K26]. Finally I understood that this applies also to their super-symmetric partners, which can be also fermion [K82]. Fermions and their super-partners would in turn correspond to wormhole throats resulting in the topological condensation of small deformations of CP_2 type vacuum extremals with Euclidian signature of metric to the background space-time sheet. This framework opens the doors for more concrete models of also super-conductivity involving the effective massivation of photons as one important aspect in the case of ordinary super-conductors.

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

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

The ideas that a genuine Higgs type photon massivation is involved with super-conductivity and that coherent states of Cooper pairs really make sense are somewhat questionable since the conservation of charge and fermion number is lost for coherent states. A further questionable feature is that a quantum superposition of many-particle states with widely different masses would be in question. These interpretational problems can be resolved elegantly in zero energy ontology [K72] in which the total conserved quantum numbers of quantum state are vanishing. In this picture the energy, fermion number, and total charge of any positive energy state are compensated by opposite quantum numbers of the negative energy state in geometric future. This makes possible to speak about superpositions of Cooper pairs and charged Higgs bosons separately in positive energy sector.

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

Space-time correlate for quantum critical superconductivity

The explicit model for high T_c super-conductivity relies on quantum criticality involving long ranged quantum fluctuations inducing reconnection of flux tubes of local (color) magnetic fields associated with parallel spins associated with stripes to form long flux tubes serving as wires along which Cooper pairs flow. Essentially [D11] [D11] type phenomenon would be in question. The role of the doping by holes is to make room for Cooper pairs to propagate by the reconnection mechanism: otherwise Fermi statistics would prevent the propagation. Too much doping reduces the number of current carriers, too little doping leaves too little room so that there exists some optimal doping. In the case of high T_c super-conductors quantum criticality corresponds to a quite wide temperature range, which provides support for the quantum criticality of TGD Universe. The probability $p(T)$ for the formation of reconnections is what matters and exceeds the critical value at T_c.

2.3.5 Super-Conductivity At Magnetic Flux Tubes

Super-conductivity at the magnetic flux tubes of magnetic flux quanta is one the basic hypothesis of the TGD based model of living matter. There is also evidence for magnetically mediated super-conductivity in extremely pure samples [D40]. The magnetic coupling was only observed at lattice densities close to the critical density at which long-range magnetic order is suppressed. Quantum criticality that long flux tubes serve as pathways along which Cooper pairs can propagate. In anti-ferromagnetic phase these pathways are short-circuited to closed flux tubes of local magnetic fields.

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

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

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

Besides Cooper pairs also Bose-Einstein condensates of bosonic ions are possible in large $\hbar$ phase and would give rise to super-conductivity. TGD inspired nuclear physics predicts the existence of exotic bosonic counterparts of fermionic nuclei with given (A, Z) [L2], [L2].

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

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

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

An essential element of the picture is that topological quantization of the magnetic flux tubes occurs. In fact, the flux tubes of Earth's magnetic field have thickness of order cell size from the quantization of magnetic flux. The observations about the effects of ELF em fields on bio-matter [J17] suggest that similar mechanism is at work also for ions and in fact give very strong support for bio-super conductivity based on the proposed mechanism.

Energy gaps for superconducting magnetic flux tubes and walls

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

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

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

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

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

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

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

2. The transition to large $\hbar$ phase could provide a more elegant way out of the difficulty. The criterion for a sequence of transitions to a large $\hbar$ phase could be easily satisfied if there is a large number of charge Cooper pairs at the magnetic flux tube. Kinetic energy gap

remains invariant if the length of the flux tube scales as $\hbar$. If the magnetic flux is quantized as a multiple of $\hbar$ and flux tube thickness scales as $\hbar^2$, B must scale as $1/\hbar$ so that also magnetic energy remains invariant under the scaling. This would allow to have stability without assuming low temperature at magnetic flux tubes.

2.4 TGD Based Model For High T_c Super Conductors

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

2.4.1 Some Properties Of High T_c Super Conductors

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

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

The mechanism of high T_c super conductivity is still poorly understood [D56, D58].

1. It is agreed that electronic Cooper pairs are charge carriers. It is widely accepted that electrons are in relative d-wave state rather than in s-wave (see [D50] and the references mentioned in [D56]). Cooper pairs are believed to be in spin triplet state and electrons combine to form $L = 2$ angular momentum state. The usual phonon exchange mechanism does not generate the attractive interaction between the members of the Cooper pair having spin. There is also a considerable evidence for BCS type Cooper pairs and two kinds of Cooper pairs could be present.

2. High T_c super conductors have spin glass like character [D54]. High T_c superconductors have anomalous properties also above T_c suggesting quantum criticality implying fractal scaling of various observable quantities such as resistivity. At high temperatures cuprates are anti-ferromagnets and Mott insulators meaning freezing of the electrons. Superconductivity and conductivity are believed to occur along dynamical stripes which are antiferromagnetic defects.

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

4. The doping of the super-conductor with electron holes is essential for high T_c superconductivity, and there is a critical doping fraction $p = .14$ at which T_c is highest. The interpretation is that holes make possible for the Cooper pairs to propagate. There is considerable evidence that holes gather on one-dimensional stripes with thickness of order few atom sizes and lengths in the range 1-10 nm [D58], which are fluctuating in time scale of 10^{-12} seconds. These stripes are also present in non-superconducting state but in this case they do not fluctuate appreciably. The most plausible TGD based interpretation is in terms of fluctuations of magnetic flux tubes allowing for the formation of long connected flux tubes making super-conductivity possible. The fact that the fluctuations would be oscillations analogous to acoustic wave and might explain the BCS type aspects of high T_c super-conductivity.

5. T_c is inversely proportional to the distance L between the stripes. A possible interpretation would be that full super-conductivity requires de-localization of electrons also with respect to stripes so that T_c would be proportional to the hopping probability of electron between neighboring stripes expected to be proportional to $1/L$ [D58].

From free fermion gas to Fermi liquids to quantum critical systems

The article of Jan Zaanen [D57] gives an excellent non-technical discussion of various features of high T_c super-conductors distinguishing them from BCS super-conductors. After having constructed a color flux tube model of Cooper pairs I found it especially amusing to learn that the analogy of high T_c super-conductivity as a quantum critical phenomenon involving formation of dynamical stripes to QCD in the vicinity of the transition to the confined phase leading to the generation of string like hadronic objects was emphasized also by Zaanen.

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

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

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

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

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

Dynamical stripes appear in mesoscopic time and length scales corresponding to 1-10 nm length scale and picosecond time scale. The stripes are in a well-defined sense dual to the magnetized stripe like structures in type I super-conductor near criticality, which suggests analog of type I super-conductivity. The stripes are anti-ferromagnetic defects at which neighboring spins fail to be antiparallel. It has been found that stripes are a very general phenomenon appearing in insulators, metals, and super-conducting compounds [D25].

Quantum criticality is present also above T_c

Also the physics of Mott insulators above T_c reflects quantum criticality. Typically scaling laws hold true for observables. In particular, resistivity increases linearly rather than transforming from T^2 behavior to constant as would be implied by quasi-particles as current carriers. The appearance of so called pseudo-gap [D63] at $T_{c1} > T_c$ conforms with this interpretation. In particular, the pseudo-gap is non-vanishing already at T_{c_1} and stays constant rather than starting from zero as for quasi-particles.

Results from optical measurements and neutron scattering

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

Optical measurements of copper oxides in non-super-conducting state have demonstrated that optical conductivity $\sigma(\omega)$ is surprisingly featureless as a function of photon frequency. Below the critical temperature there is however a sharp absorption onset at energy of about 50 meV [D46]. The origin of this special feature has been a longstanding puzzle. It has been proposed that this absorption onset corresponds to a direct generation of an electron-hole pair. Momentum conservation implies that the threshold for this process is $E_g + E$, where E is the energy of the "gluon" which binds electrons of Cooper pair together. In the case of ordinary super-conductivity E would be phonon energy.

Soon after measurements, it was proposed that in absence of lattice excitations photon must generate two electron-hole pairs such that electrons possess opposite momenta [D46]. Hence the energy of the photon would be $2E_g$. Calculations however predicted soft rather than sharp onset of absorption since pairs of electron-hole pairs have continuous energy spectrum. There is something wrong with this picture.

Second peculiar characteristic [D48, D42, D31] of high T_c super conductors is resonant neutron scattering at excitation energy $E_w = 41$ meV of super conductor. This scattering occurs only below the critical temperature, in spin-flip channel and for a favored momentum exchange $(\pi/a, \pi/a))$, where a denotes the size of the lattice cube [D48, D42, D31]. The transferred energy is concentrated in a remarkably narrow range around E_w rather than forming a continuum.

In [D20] is is suggested that e-e resonance with spin one gives rise to this excitation. This resonance is assumed to play the same role as phonon in the ordinary super conductivity and e-e resonance is treated like phonon. It is found that one can understand the dependence of the second derivative of the photon conductivity $\sigma(\omega)$ on frequency and that consistency with neutron scattering data is achieved. The second derivative of $\sigma(\omega)$ peaks near 68 meV and assuming $E = E_g + E_w$ they found nearly perfect match using $E_g = 27$ meV. This would suggest that the energy of the excitations generating the binding between the members of the Cooper pair is indeed 41 meV, that two electron-hole pairs and excitation of the super conductor are generated in photon absorption above threshold, and that the gap energy of the Cooper pair is 27 meV. Of course, the theory of Carbotte *et al* does not force the "gluon" to be triplet excitation of electron pair. Also other possibilities can be considered. What comes in mind are spin flip waves of the spin lattice associated with stripe behaving as spin 1 waves.

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

2.4.2 TGD Inspired Vision About High T_c Superconductivity

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

The interpretation of critical temperatures

The two critical temperatures T_c and $T_{c_1} > T_c$ are interpreted as critical temperatures. The recent observation that there exists a spectroscopic signature of high T_c super-conductivity, which prevails up to T_{c_1} [D15], supports the interpretation that Cooper pairs exist already below T_{c1} but that for some reason they cannot form a coherent super-conducting state.

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

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

critical temperature.

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

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

4. The reconnections for the flux tubes of neighboring almost dipole fields occur with some probability $p(T)$ and make possible finite conductivity. At T_c the system the fluctuations of the flux tubes become large and also $p(T, L)$, where L is the distance between stripes, becomes large and the reconnection leads to a formation of long flux tubes of length of order coherence length at least and macroscopic supra currents can flow. One also expects that the reconnection occurs for practically all flux tubes of the dipole field. Essentially a percolation type phenomenon [D11] would be in question. Scaling invariance suggests $p_c(T, L) = p_c(TL/\hbar)$, where L is the distance between stripes, and would predict the observed $T_c \propto \hbar/L$ behavior. Large value of $\hbar$ would explain the high value of T_c.

This model relates in an interesting manner to the vision of Zaanen [D60] expressed in terms of the highway metaphor visualizing stripes as quantum highways along which Cooper pairs can move. In antiferromagnetic phase the traffic is completely jammed. The doping inducing electron holes allows to circumvent traffic jam due to the Fermi statistics generates stripes along which the traffic flows in the sense of ordinary conductivity. In TGD framework highways are replaced with flux tubes and the topology of the network of highways fluctuates due to the possibility of reconnections. At quantum criticality the reconnections create long flux tubes making possible the flow of supra currents.

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

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

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

Various lattice effects such as superconductivity-induced phonon shifts and broadenings, possible isotope effects in T_c (questionable), the penetration depth, infrared and photoemission spectra have been observed in the cuprates [D6]. A possible interpretation is that ordinary phonons are replaced by 1-D phonons defined by the transversal excitations of stripes but do not give rise to the binding of the electrons of the Cooper pair but to reconnection of flux tubes. An alternative proposal which seems to gain experimental support is that spin waves appearing near antiferromagnetic phase transitions replace phonons.

More precise view about high T_c superconductivity taking into account recent experimental results

There are more recent results allowing to formulate more precisely the idea about transition to high T_c super-conductivity as a percolation type phenomenon. Let us first summarize the recent picture about high T_c superconductors.

1. 2-dimensional phenomenon is in question. Supra current flows along preferred lattice planes and type II super-conductivity in question. Proper sizes of Cooper pairs (coherence lengths) are ξ =1-3 nm. Magnetic length λ is longer than $\xi/\sqrt{2}$.

2. Mechanism for the formation of Cooper pairs is the same water bed effect as in the case of ordinary superconductivity. Phonons are only replaced with spin-density waves for electrons with periodicity in general not that of the underlying lattice. Spin density waves relate closely to the underlying antiferromagnetic order. Spin density waves appear near phase transition to antiferromagnetism.

3. The relative orbital angular mentum of Cooper pair is L=2 ($x^2 - y^2$ wave), and vanishes at origin unlike for ordinary s wave SCs. The spin of the Cooper pair vanishes.

Consider now the translation of this picture to TGD language. Basic notions are following.

1. Magnetic flux tubes and possibly also dark electrons forming Cooper pairs.

2. The appearence of spin waves means sequences of electrons with opposite spins. The magnetic field associated with them can form closed flux tube containing both spins. Assume that spins-are orthogonal to the lattice plane in which supracurrent flows. Assume that the flux tube branches associated with electron with given spin branches so that it is shared with both neighboring electrons.

3. Electrons of opposite spins at the two portions of the closed flux tube have magnetic interaction energy. The total energy is minimal when the spins are in opposite directions. Thus the closed flux tube tends to favor formation of Cooper pairs.

4. Since magnetic interaction energy is proportional to $h_{eff} = n \times h$, it is expected stabilize the Cooper pairs at high temperatures. For ordinary super-conducti- vity magnetic fields tends to de-stabilize the pairs by trying to force the spins of spin singlet pair to the same direction.

5. This does not yet give super-conductivity. The closed flux tubes associated with paired spins can however reconnect so that longer flux closed flux tubes are formed. If this occurs for entire sequences, one obtains two flux tubes containing electrons with opposite spins forming Cooper pairs: this would be the "highway" and percolation would corresponds to this process. The pairs would form supracurrents in longer scales.

6. The phase phase transitions generating the reconnections could be percolation type phase transition.

This picture might apply also in TGD based model of bio-superconductivity.

1. The stability of dark Cooper pairs assume to reside at magnetic flux tubes is a problem also now. Fermi statistics favors opposite spins but this means that magnetic field tends to spit the pairs if the members of the pair are at the same flux tube.

2. If the members of the pair are at different flux tubes, the situation changes. One can have $L = 1$ and $S = 1$ with parallel spins (ferromagnetism like situation) or $L = 2$ and $S = 0$ state (anti-ferromagnetism like situation). $L > 0$ is necessary since electrons must reside at separate flux tubes.

Nematics and high T_c superconductors

Waterloo physicists discover new properties of superconductivity is the title of article (see `http://tinyurl.com/jfz3l45`) popularizing the work of David Hawthorn, Canada Research Chair Michel Gingras, doctoral student Andrew Achkar and post-doctoral student Zhihao Hao published in Science [D33] (see `http://tinyurl.com/zycahrx`). There is a dose of hype involved. As a matter of fact, it has been known for years that electrons flow along stripes, kind of highways in high T_c superconductors.

This effect is known as nematicity and means that electron orbitals break lattice symmetries and align themselves like a series of rods. Nematicity in long length scales occurs a temperatures below the critical point for super-conductivity. In the above mentioned work cuprate CuO_2 is studied. For non-optimal doping the critical temperature for transition to macroscopic superconductivity is below the maximal critical temperature. Long length scale nematicity is observed in these phases.

In the article by Rosenthal *et al* [D47] (see `http://tinyurl.com/h34347f`) it is however reported that nematicity is in fact preserved above critical temperature as a local order -at least up to the upper critical temperature, which is not easy to understand in the BCS theory of superconductivity. One can say that the stripes are short and short-lived so that genuine superconductivity cannot take place.

These two observations lend further support for the TGD inspired model of high T_c superconductivity and bio-superconductivity. It is known that antiferromagnetism is essential for the phase transition to superconductivity but Maxwellian view about electromagnetism and standard quantum theory do not make it easy to understand how. Magnetic flux tube is the first basic new notion provided by TGD. Flux tubes carry dark electrons with scaled up Planck constant $h_{eff} = n \times h$: this is second new notion. This implies scaling up of quantal length scales and in this manner makes also super-conductivity possible.

Magnetic flux tubes in antiferromagnetic materials form short loops. At the upper critical point they however reconnect with some probability to form loops with look locally like parallel flux tubes carrying magnetic fields in opposite directions. The probability of reverse phase transition is so large than there is a competion. The members of Cooper pairs are at parallel flux tubes and have opposite spins so that the net spin of pair vanishes: $S = 0$. At the first critical temperature the average length and lifetime of flux tube highways are too short for macroscopic super-conductivity. At lower critical temperature all flux tubes re-connect permantently average length of pathways becomes long enough.

This phase transition is mathematically analogous to percolation in which water seeping through sand layer wets it completely. The competion between the phases between these two temperatures corresponds to quantum criticality in which phase transitions $h_{eff}/h = n_1 \leftrightarrow n_2$ take place in both directions ($n_1 = 1$ is the most plausible first guess). Earlier I did not fully realize that Zero Energy Ontology provides an elegant description for the situation [L14] [K75]. The reason was that I thought that quantum criticality occurs at single critical temperature rather than temperature interval. Nematicity is indeed detected locally below upper critical temperature and in long length scales below lower critical temperature.

Explanation for the spectral signatures of high T_c superconductor

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

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

2. Second characteristic [D48, D42, D31] of high T_c super conductors is resonant neutron scattering at excitation energy $E_w = 41$ meV of super conductor also visible only below the critical temperature.

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

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

Model for Cooper pairs

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

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

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

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

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

1. Electromagnetic flux tubes for which induced Kähler field is non-vanishing carry also classical color fields. Cooper pairs could be color singlet bound states of color octet excitations of electrons (more generally leptons) predicted by TGD and explaining quite impressive number of anomalies [K101]. These states are necessarily dark since the decay widths of gauge bosons do not allow new light fermions coupling to them. The size of these states is of order electron size scale $L(127)$ for the standard value of Planck constant. For the non-standard value of Planck constant it would be scaled up correspondingly. For $r = \hbar/\hbar_0 = 2^{14}$ the size would

be around 3.3 Angströms and for $r = 2^{24}$ of order 10 nm. Color binding could be responsible for the formation of the energy gap in this case and would distinguish between ordinary two-electron states and Cooper pair. The state with minimum color magnetic energy corresponds to spin triplet state for two color octed fermions whereas for colored fermion and anti-fermion it corresponds to spin singlet (pion like state in hadron physics).

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

Estimate for the gap energy

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

$$\begin{aligned} E_g &= \hbar\omega_D exp(-1/X) \ , \\ \omega_D &= (6\pi^2)^{1/3} c_s n^{1/3} \\ X &= n(E_F)U_0 = \frac{3}{2}N(E_F)\frac{U_0}{E_F} \ , \\ n(E_F) &= \frac{3}{2}\frac{N(E_F)}{E_F} \ . \end{aligned} \tag{2.4.1}$$

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

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

$$\begin{aligned} E_g &= \hbar\omega exp(-1/X) \ , \\ \omega &= kc_s n \ . \end{aligned} \tag{2.4.2}$$

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

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

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

$$exp(-1/X) = \frac{E_g}{E_w} \quad (2.4.3)$$

giving $X = 2.39$.

The interpretation in terms of transversal oscillations suggests the dispersion relation

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

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

Estimate for the critical temperatures and for $\hbar$

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

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

$$T_{c1} \leq \frac{h^2}{8m_e}(\frac{n_c}{g})^2 \ . \quad (2.4.4)$$

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

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

$$T_{c1} \simeq \frac{r^2(1-p_h)^2}{9x^2} \times 6.3 \ meV \ . \quad (2.4.5)$$

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

$$p_h = \frac{p_d}{p_s} \ . \quad (2.4.6)$$

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

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

$$\frac{T_c}{T_{c1}} = 32\pi^2 \frac{m_e a}{\hbar_0} x^2 g^2 \frac{p_s}{(1-(p_d/p_s)^2)^2} \frac{x_c}{r} \ . \quad (2.4.7)$$

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

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

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

Coherence lengths

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

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

Why copper and what about other elements?

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

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

A new phase of matter in the temperature range between pseudo gap temperature and T_c?

Kram sent a link to a Science Daily popular article titled "High-Temperature Superconductor Spills Secret: A New Phase of Matter?" (see `http://tinyurl.com/49vnvsu`: see also `http://tinyurl.com/yb7rs3fs`). For more details see the article in Science [D36].

Zhi-Xun Shen of the Stanford Institute for Materials and Energy Science (SIMES), a joint institute of the Department of Energy's SLAC National Accelerator Laboratory and Stanford University, led the team of researchers, which discovered that in the temperature region between the pseudo gap temperature and genuine temperature for the transition to super-conducting phase there exists a new phase of matter. The new phase would not be super-conducting but would be characterized by an order of its own which remains to be understood. This phase would be present also in the super-conducting phase.

The announcement does not come as a complete surprise for me. A new phase of matter is what TGD inspired model of high T_c superconductivity indeed predicts. This phase would consist of Cooper pairs of electrons with a large value of Planck constant but associated with magnetic flux tubes with short length so that no macroscopic supra currents would be possible.

The transition to super-conducting phase involves long range fluctuations at quantum criticality and the analog of a phenomenon known as percolation (see `http://tinyurl.com/oytvosv`) [D11]. For instance, the phenomenon occurs for the filtering of fluids through porous materials.

At critical threshold the entire filter suddenly wets as fluid gets through the filter. Now this phenomenon would occur for magnetic flux tubes carrying the Cooper pairs. At criticality the short magnetic flux tubes fuse by reconnection to form long ones so that supra currents in macroscopic scales become possible.

It is not clear whether this prediction is consistent with the finding of Shen and others. The simultaneous presence of short and long flux tubes in macroscopically super-conducting phase is certainly consistent with TGD prediction. The situation depends on what one means with super-conductivity. Is super-conductivity super-conductivity in macroscopic scales only or should one call also short scale super-conductivity not giving rise to macroscopic super currents as super-conductivity. In other words: do the findings of Shen's team prove that the electrons above gap temperature do not form Cooper pairs or only that there are no macroscopic supra currents?

Whether the model works as such or not is not a life and death question for the TGD based model. One can quite well imagine that the first phase transition increasing $\hbar$ does not yet produce electron Compton lengths long enough to guarantee that the overlap criterion for the formation of Cooper pairs is satisfied. The second phase transition increasing $\hbar$ would do this and also scale up the lengths of magnetic flux tubes making possible the flow of supra currents as such even without reconnections. Also reconnections making possible the formation of very long flux tubes could be involved and would be made possible by the increase in the length of flux tubes.

2.4.3 Speculations

21-Micrometer mystery

21 micrometer radiation from certain red giant stars have perplexed astronomers for more than a decade [D18]. Emission forms a wide band (with width about 4 micrometers) in the infrared spectrum, which suggests that it comes form a large complex molecule or a solid or simple molecules found around starts. Small molecules are ruled out since they produce narrow emission lines. The feature can be only observed in very precise evolutionary state, in the transition between red giant phase and planetary nebular state, in which star blows off dust that is rich in carbon compounds. There is no generally accepted explanation for 21-micrometer radiation.

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

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

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

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

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

3. A possible explanation is as a radiation associated with the transition to high T_c super conducting phase. There are two sources of photons. Radiation could perhaps result from the de-excitations of wormhole BE condensate by photon emission. $\lambda = 20.5$ micrometers is precisely what one expects if the space-time sheet corresponds to $p \simeq 2^k$, $k = 173$ and assumes that excitation energies are given as multiples of $E_w(k) = 2\pi/L_e(k)$. This predicts

excitation energy $E_w(173) \simeq 61.5$ meV. Unfortunately, this radiation should correspond to a sharp emission line and cannot explain the wide spectrum.

Are living systems high T_c superconductors?

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

Interestingly, Cu is one of the biologically most important trace elements [D2]. For instance, copper is found in a variety of enzymes, including the copper centers of cytochrome c-oxidase, the Cu-Zn containing enzyme superoxide dismutase, and copper is the central metal in the oxygen carrying pigment hemocyanin. The blood of the horseshoe crab, Limulus polyphemus uses copper rather than iron for oxygen transport. Hence there are excellent reasons to ask whether living matter might be able to build high T_c superconductors based on copper oxide.

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

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

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

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

2.5 Quantitative Model Of High T_c Super-Conductivity And Bio-Super-Conductivity

I have developed already earlier [K9, K10, K38, K39] a rough model for high T_c super conductivity [D57, D59, D60, D25, D15, D63]. The members of Cooper pairs are assigned with parallel flux tubes carrying fluxes which have either same or opposite directions. The essential element of the model is hierarchy of Planck constants defining a hierarchy of dark matters.

1. In the case of ordinary high T_c super-conductivity bound states of charge carriers at parallel short flux tubes become stable as spin-spin interaction energy becomes higher than thermal energy.

   The transition to super-conductivity is known to occur in two steps: as if two competing mechanisms were at work. A possible interpretation is that at higher critical temperature Cooper pairs become stable but that the flux tubes are stable only below rather short scale: perhaps because the spin-flux interaction energy for current carriers is below thermal energy. At the lower critical temperature the stability would is achieved and supra-currents can flow in long length scales.

2. The phase transition to super-conductivity is analogous to a percolation process in which flux tube pairs fuse by a reconnection to form longer super-conducting pairs at the lower critical

temperature. This requires that flux tubes carry anti-parallel fluxes: this is in accordance with the anti-ferro-magnetic character of high T_c super conductivity. The stability of flux tubes very probably correlates with the stability of Cooper pairs: coherence length could dictate the typical length of the flux tube.

3. A non-standard value of h_{eff} for the current carrying magnetic flux tubes is necessary since otherwise the interaction energy of spin with the magnetic field associated with the flux tube is much below the thermal energy.

There are two energies involved.

1. The spin-spin-interaction energy should give rise to the formation of Cooper pairs with members at parallel flux tubes at higher critical temperature. Both spin triplet and spin singlet pairs are possible and also their mixture is possible.

2. The interaction energy of spins with magnetic fluxes, which can be parallel or antiparallel contributes also to the gap energy of Cooper pair and gives rise to mixing of spin singlet and spin triplet. In TGD based model of quantum biology antiparallel fluxes are of special importance since U-shaped flux tubes serve as kind of tentacles allow magnetic bodies form pairs of antiparallel flux tubes connecting them and carrying supra-currents. The possibility of parallel fluxes suggests that also ferro-magnetic systems could allow super-conductivity.

   One can wonder whether the interaction of spins with magnetic field of flux tube could give rise to a dark magnetization and generate analogs of spin currents known to be coherent in long length scales and used for this reason in spintronics (`http://tinyurl.com/5cu3qh`). One can also ask whether the spin current carrying flux tubes could become stable at the lower critical temperature and make super-conductivity possible via the formation of Cooper pairs. This option does not seem to be realistic.

In the following the earlier flux tube model for high T_c super-conductivity and bio-super-conductivity is formulated in more precise manner. The model leads to highly non-trivial and testable predictions.

1. Also in the case of ordinary high T_c super-conductivity large value of $h_{eff} = n \times h$ is required.

2. In the case of high T_c super-conductivity two kinds of Cooper pairs, which belong to spin triplet representation in good approximation, are predicted. The average spin of the states vanishes for antiparallel flux tubes. Also super-conductivity associated with parallel flux tubes is predicted and could mean that ferromagnetic systems could become super-conducting.

3. One ends up to the prediction that there should be a third critical temperature T^{**} not lower than $T^{**}_{min} = 2T^*/3$, where T^* is the higher critical temperature at which Cooper pairs identifiable as mixtures of $S_z = \pm 1$ pairs emerge. At the lower temperature $S_z = 0$ states, which are mixtures of spin triplet and spin singlet state emerge. At temperature T_c the flux tubes carrying the two kinds of pairs become thermally stable by a percolation type process involving re-connection of U-shaped flux tubes to longer flux tube pairs and supra-currents can run in long length scales.

4. The model applies also in TGD inspired model of living matter. Now however the ratio of critical temperatures for the phase transition in which long flux tubes stabilize is roughly by a factor 1/50 lower than that in which stable Cooper pairs emerge and corresponds to thermal energy at physiological temperatures which corresponds also the cell membrane potential. The higher energy corresponds to the scale of bio-photon energies (visible and UV range).

2.5.1 A More Detailed Flux Tube Model For Super-Conductivity

The following little calculations support the above vision and lead to quite predictive model.

2.5.2 Simple Quantitative Model

It is best to proceed by building a quantitative model for the situation.

1. Spin-spin interaction energy for electron pair with members de-localized at parallel magnetic flux tubes must be deduced from the standard expression for the magnetic field created by the second charge and from the expression for the magnetic interaction energy of magnetic moment with external magnetic field.

   The magnetic field created by dipole μ outside the dipole is given by

$$B = \frac{\mu_0}{4\pi a^3} \times (3nn \cdot \mu - \mu) \ . \tag{2.5.1}$$

   The factor $\frac{\mu_0}{4\pi}$ can be taken equal to $1/4\pi$ as unity in the units in which $\mu_0 = \epsilon_0 = c = 1$ holds true. n is direction vector associated with the relative position vector a.

   The magnetic interaction energy reads as $E = -\mu \cdot B$ and in the case of identical magnetic moments reads as

$$E = \frac{1}{4\pi a^3} \times (-3\mu_1 \cdot n\mu_2 \cdot n + \mu_1 \cdot \mu_2) \ . \tag{2.5.2}$$

2. The magnetic dipole moment of electron is $\mu = -(ge/2m)S$, $S = \hbar/2$, $g \simeq 2$. For proton analogous expression holds with Lande factor $g = 5.585694713(46)$.

A simple model is obtained by assuming that the distance between the members of Cooper pair is minimal so that the relative position vector is orthogonal to the flux tubes.

1. This gives for the spin-spin interaction Hamiltonian the expression

$$H_{s-s} = \frac{1}{4\pi a^3} \times (\frac{ge\hbar}{2m})^2 \times O \ , \quad O = -3(m_1)_x(m_2)_x + m_1 \cdot m_2 \ . \tag{2.5.3}$$

   m_i refers to spin in units of $\hbar$. x referes to the direction in the plane defined by flux tubes and orthogonal to them. m_x can be expressed in terms of spin raising and lowering operators as $m_x = (1/2)(m_+ + m_-)$, $m_\pm = m_x \pm im_y$. This gives

$$(m_1)_x(m_2)_x = \frac{1}{4}\sum_{i=\pm,j=\pm}(m_i)_1(m_j)_2 \ . \tag{2.5.4}$$

   $m_1 \cdot m_2$ can be expressed as $(1/2) \times [(m_1+m_2)^2 - m_1^2 - m_2^2]$. In the case of spin 1/2 particles one can have spin singlet and spin triplet and the value of $m_1 \cdot m_2$ is in these cases given by $m_1 \cdot m_2(singlet) = -3/4$ and $m_1 \cdot m_2(triplet) = 1/4$

   The outcome is an expression for the spin-spin interaction Hamiltonian

$$\begin{aligned} & H_{s-s} = E_{s-s} \times O \ , \quad E_{s-s} = \frac{1}{4\pi a^3} \times (ge\hbar/2m)^2 \times O \ , \\ & O = O_1 + O_2(S) \ , \quad O_1 = -\frac{3}{4}\sum_{i=\pm,j=\pm}(m_i)_1(m_j)_2 \ , \\ & O_2(singlet) = -\frac{3}{4} \ , \quad O_2(triplet) = \frac{1}{4} \ . \end{aligned} \tag{2.5.5}$$

2. The total interaction Hamiltonian of magnetic moment with the magnetic field of flux tube can be deduced as

$$
\begin{aligned}
& H_{s-flux} = -(\mu_Z)_1 B_1 - (\mu_Z)_2 B_2 = \tfrac{ge}{\hbar 2m}(m_1)_z B_1 + (m_2)_z B_2 \\
& = E_{s-flux} \times ((m_1)_z + \epsilon (m_2)_z) \ , \quad E_{s-flux} = \tfrac{ge\hbar B}{2m} \ .
\end{aligned} \tag{2.5.6}
$$

3. For the diagonalization of spin-spin interaction Hamiltonian the eigenbasis of S_z is a natural choice. In this basis the only non-diagonal terms are O_1 and E_{s-flux}. O_1 does not mix representations with different total spin and is diagonal for the singlet representation. Also the $S_z(tot) = 0$ state of triplet representation is diagonal with respect to O_1: this is clear from the explicit representation matrices of spin raising and lowering operators (the non-vanishing elements in spin 1/2 representation are equal to 1). $S_z(tot) = 0$ states are eigenstates of O_1 with eigenvalue $+3/4$ for singlet and $-3/4$ for triplet. For singlet one therefore has eigenvalue $o = 0$ and for triplet eigenvalue $o = -1/2$. Singlet does not allow bound state whereas triplet does.

   $S_z(tot) = 1$ and $S_z(tot) = -1$ states are mixed with each other. In this case the O_1 has non-diagonal matrix elements equal to $O_1(1,-1) = O_1(-1,1) = 1$ so that the matrix representing O is given by

$$
O = \begin{pmatrix} \frac{1}{4} & 1 \\ 1 & \frac{1}{4} \end{pmatrix} \ . \tag{2.5.7}
$$

   The eigenvalues are $o_+ = 5/4$ and $o_- = -3/4$. Cooper pairs states are linear combinations of $S_z = \pm 1$ states with coefficients with have either same or opposite sign so that a maximal mixing occurs and the average spin of the pair vanishes.

   To sum up, there are two bound states for mere spin-spin interaction corresponding to $o = -1/2$ spin 0 triplet state and $o = -3/4$ state for which spin 1 and spin -1 states are mixed.

4. For spin singlet at parallel flux tubes the spin-flux interaction vanishes: $H(para, singlet) = 0$. Same holds true for $S_z = \pm 1$ states at biologically especially interesting antiparallel flux tubes: $H(anti, S_z = \pm 1) = 0$. For antiparallel flux tubes $S_z = 0$ states in singlet and triplet are mixed by $H(anti, S_z = 0)$. The two resulting states must have negative binding energy so that one obtains 3 bound states altogether and only one state remains unbound. The amount of mixing and thermal stability of possibly slightly perturbed singlet state is determined by the ratio x of the scale parameters of H_{s-flux} and H_{s-s}.

   The explicit form of $H(anti, S_z = 0)$ is

$$
\begin{aligned}
H(anti, S_z = 0) &= -\frac{E_{s-s}}{2} \begin{pmatrix} 1 & x \\ x & 0 \end{pmatrix} \\
x = -\frac{4E_{s-flux}}{E_{s-s}} &= -32\pi \frac{ma^3}{ge\hbar B} \ , \\
E_{s-s} &= \frac{1}{8\pi}(\frac{ge\hbar}{2m})^2 \frac{1}{a^3} \ .
\end{aligned} \tag{2.5.8}
$$

   The eigenvalues $H(anti, S_z = 0)$

$$
E_{\pm} = -\frac{E_{s-s}}{4}(1 \pm \sqrt{1 + 4x^2}) \ . \tag{2.5.9}
$$

   What is remarkable is that both parallel antiparallel flux tubes give rise to 2 bound states assignable to spin triplet. Singlet does not allow bound states.

5. The Planck constant appearing in the formulas can be replaced with $\hbar_{eff} = n\hbar$. Note that the value of the parameter x is inversely proportional to h_{eff} so that singlet approximation improves for large values of h_{eff}.

2.5.3 Fermionic Statistics And Bosons

What about fermionic statistics and bosons?

1. The total wave function must be antisymmetric and the manner to achieve this for spin triplet state is anti-symmetrization in longitudinal degrees of freedom. In 3-D model for Cooper pairs spatial antis-ymmetrization implies $L = 1$ spatial wave function in the relative coordinate and one obtains $J = 0$ and $J = 2$ states. Now the state could be antisymmetric under the exchange of longitudinal momenta of fermions. Longitudinal momenta cannot be identical and Fermi sphere is replaced by its 1-dimensional variant. In 3-D model for Cooper pairs spatial anti-symmetrization implies $L = 1$ spatial wave function in the relative coordinate. Antisymmetry with respect to longitudinal momenta would be the analog for the odd parity of this wave function. Ordinary super-conductivity is located at the boundary of Fermi sphere in a narrow layer with thickness defined by the binding energy. The situation is same now and the thickness should correspond now to the spin-flux interaction energy.

2. Second possibility is more exotic and could be based on antisymmetric entanglement in discrete dark degrees of freedom defined by the sheets of the singular covering assignable to the integer $n = h_{eff}/h$. For $n = 2m$ one can decompose the n discrete degrees of freedom to the discrete analogs of m spatial coordinates q_i and m canonical momenta p_i and assume that the entanglement matrix proportional to a unitary matrix (negentropic entanglement) is proportional to the standard antisymmetric matrix defining symplectic structure and expressible as a direct sum of 2×2 permutation symbols ϵ_{ij}. $J_{p_i,q_i} = -J_{q_i p_i} = 1/\sqrt{2m}$. This matrix is antisymmetric and unitary in standard sense and quaternionic sense.

3. What about bosons? I have proposed that bosonic ions (such as Ca^{++}) associated with single flux tube form cyclotron Bose Einstein condensates giving rise to spontaneous dark magnetization. Bosonic supra currents can indeed run independently along single flux tube as spin currents. Also now the thermal stability of cyclotron states require large h_{eff}. The supra-currents (spin currents) of bosonic ions could be associated with flux tubes and fermionic supra-currents with their pairs. Even dark photons could give rise to spin currents.

   At the formal level the model applies in the case of bosons too. Symmetrization/anti-symmetrization for spin singlets/triplets would be replaced with anti-symmetrization/symmetrization. The analog of Fermi sphere would be obtained for spin singlet states requiring anti-symmetrization in longitudinal degrees of freedom.

2.5.4 Interpretation In The Case Of High T_c Super-Conductivity

It is interesting to try to interpret the results in terms of high T_c super-conductivity (`http://tinyurl.com/yd8vj9g`).

1. The four eigen values of total Hamiltonian are

$$E = E_{s-s} \times \lambda \ ,$$

$$\lambda \in \{\frac{5}{4}, -\frac{3}{4}, -\frac{1}{4}(1 \pm \sqrt{1+4x^2})\} \ . \quad (2.5.10)$$

   Two bound states with different binding energies are obtained which should be an empirically testable prediction in the case of the ordinary high T_c superconductivity since it predicts two critical temperatures. Cooper pairs are apart from possible small mixing with singlet state triplet states. The average spin is however vanishing also for $S_z = \pm 1$ states-

2. Two phase transitions giving rise to Cooper pairs are predicted. The simplest interpretation would be that super-conductivity in short scales is already present below the higher critical temperature and corresponds to the currents carries forming a mixture of $S_z = \pm 1$ states. These supra currents would stabilize flux tubes below some rather short scale. At the lower critical temperature the super-conductivity assignable to $S_z = 0$ spin triplets slightly mixed with singlet would become possible and the scale in which supra-currents can run would increase due to the occurrence of the percolation phenomenon. Below the lower critical temperature the interaction with flux tubes is indeed involved in an essential manner as a mixing of singlet and triplet states. One could perhaps say that $S_z = 0$ states stabilize the flux tube pair.

3. The critical temperatures for the stability of Cooper pairs are predicted to be in ratio $3/1 + \sqrt{1+4x^2}$ roughly equal the upper bound $3/2$ for small x. The critical temperatures are identical for $x = \sqrt{63/4} \simeq 4$. In the ordinary high T_c super-conductivity in cuprates the two critical temperatures are around $T^* = 300$K and $T_c = 80K$. The ratio $T^*/T_c = 3.75$ fails to be consistent with the upper bound $3/2$.

4. If one takes the model deadly seriously despite its strong simplifying assumptions one is forced to consider a more complex interpretation. What comes in mind is that both kind of Cooper pairs appear first and super-conductivity becomes possible at T_c. T^* would correspond to the emergence of $S_z = \pm 1$ mixtures. The critical temperature T^{**} for the emergence $S_z = 0$ pairs would not be lower than $T^{**}_{min} = (2/3) \times 300 = 200$ K. At temperature T_c the flux tubes carrying the two kinds of pairs become thermally stable by a percolation type process involving re-connection of U-shaped flux tubes to longer flux tube pairs and supra-currents can run in long length scales. This model conforms with the interpretation of pseudo-gap in terms o pre-formed Cooper pairs not able to form coherent supra-currents (`http://tinyurl.com/yc543vbl`).

One ends up to the prediction that there should be a third critical temperature T^{**} not lower than $T^{**}_{min} = 2T^*/3$, where T^* is the higher critical temperature at which Cooper pairs identifiable as mixtures of $S_z = \pm 1$ pairs emerge. At the lower temperature $S_z = 0$ states, which are mixtures of spin triplet and spin singlet state emerge.

2.5.5 Quantitative Estimates In The Case Of TGD Inspired Quantum Biology

Using the formulas obtained above one can make rough quantitative estimates and get grasp about bio-super-conductivity as predicted by the model.

1. To get grasp to the situation it is good to consider as starting point electron with nanometer scale $a = a_0 = 1$ nm taken as the distance between flux tubes. For $h_{eff} = n \times h$ value of Planck constant one obtains $E_{s-s} = n^2(a/a_0)^3 \times E_0$. $E_0 = 1.7 \times 10^{-7}$ eV.

   Taking $B = 1$ Tesla one obtains for E_{s-flux} $E_{s-flux} = n \times E_{s-flux,0}$, $E_{s-flux,0} = 6.2 \times 10^{-7}$ eV. For $B = B_{end} = .2$ Gauss suggested as an important value of dark endogenous magnetic field one obtains $E_{s-flux,0} = 2.5 \times 10^{-11}$ eV.

2. It seems reasonable to require that the two interaction energies are of same order of magnitude. Spin-flux interaction energy is rather small. For instance, for B=1 Tesla its magnitude for electron is about $E_{s-flux,0} = 6.2 \times 10^{-7}$ eV so that a large value of h_{eff} seems to be necessary.

3. The hypothesis that bio-photons result in the transformations of dark photons to ordinary photons suggests that the energy scale is in the range of visible and UV photons and therefore above eV. This suggests for electron $h_{eff}/h = n \geq 10^7$. The condition that the value of E_{s-s} is also in the same range requires that a scales like $n^{1/3}$. This would give scaling, which is larger than $10^{7/3} \simeq 215$: this would mean $a \geq 2 \times 10^{-7}$ m which belongs to the range of biologically most important length scales between cell membrane thickness and nucleus size.

4. The hypothesis $\hbar_{eff} = n \times \hbar = \hbar_{gr} = GMm/v_0$ [K88, K75] implies that cyclotron energy spectrum is universal (no dependence on the mass of the charged particle. Same would hold true for the spin-flux interaction energy. Spin spin interaction energy is proportional to h_{eff}^2/m^2a^3, where a is minimum distance between members of the Cooper pair. It is invariant under the simultaneous scaling of h_{eff} and m so that all charged particles can form Cooper pairs and spin currents for flux tubes with same distance and same magnetic field strength. This would correspond to the universality of the bio-photons [K61]. This would be also consistent with the earlier explanation for the finding of Hu and Wu [J26] that proton spin-spin interaction frequency for the distance defined by cell membrane thickness is in ELF frequency scale. The proposal was that dark proton sequences are involved at both sides of the membrane.

   Universality of Cooper pair binding energies implies universality of super-conductivity all fermionic ions can form superconducting Cooper pairs as has been assumed in the models for strange effects of ELF em fields on vertebrate brain, for cell membrane as Josephson junction, and for EEG [K15], and in the model for nerve pulse [K41]. As found, Bose-Einstein condensates of bosonic ions could give rise to spontaneous dark magnetization and spin currents along single flux tube so that bosons would be associated with flux tubes and fermions with pairs of them.

   The value of h_{eff} for proton would satisfy $n \geq 2 \times 10^{10}$. This would guarantee that proton cyclotron frequency for $B = B_{end}$ corresponds to thermal energy 2.5×10^{-2} eV at room temperature.

   Note that I have considered also the option that the values of h_{eff} are such that the universal cyclotron energy scale in magnetic field of $B \simeq .2$ Gauss is in the range of bio-photon energies so that h_{eff} would be by a factor of order 50 higher than in the estimate coming from spin temperature.

5. This observation raises the question whether there are two widely different energy scales present in living matter. The first scale would be associated with spin-spin interaction and would correspond to the energy scale of bio-photons. Second scale would be associated with spin-flux interaction and correspond to the energy scale of resting potential just above the thermal energy at physiological temperatures.

   If this is the case, the parameter x would be of order $x \simeq 10^{-2}$ and spin-spin interaction energy would dominate. The somewhat paradoxical earlier prediction was that Cooper pairs in bio-super-conductivity would be stable at temperatures corresponding to energy of eV or even higher but organisms do not survive above physiological temperatures. The critical temperature for living matter could be however understood in terms of the temperature sensitivity of the dark magnetization at magnetic flux tubes. Although the binding energies of Cooper pairs are in bio-photon energy range this does not help since the quantum wires along, which they can propagate are unstable above room temperatures.

6. From the estimate of order 10^{-7} eV for energy scales for $a = 1$ nm and $B = 1$ Tesla and from the binding energy of Cooper pairs of order 10^{-2} eV it is clear that ordinary high T_c super-conductivity cannot correspond to the standard value of Planck constant: $h_{eff}/h \simeq 10^5$ is required. The interpretation would be that at the higher critical temperature Cooper pairs become stable but flux tubes are not stable. At the lower critical temperature also flux tubes become stable. This would correspond to the percolation model that I have proposed earlier.

   These two energy scales would be the biological counterparts of the two much lower energy scales in the ordinary high T_c super-conductivity. There ratio of these scales would be roughly 50.

2.5.6 Does Also Low Tc Superconductivity Rely On Magnetic Flux Tubes In TGD Universe?

Discussions with Hans Geesink have inspired sharpening of the TGD view about bio-superconductivity (bio-SC), high Tc superconductivity (SC) and relate the picture to standard descriptions in a more detailed manner. In fact, also standard low temperature super-conductivity modelled using BCS theory could be based on the same universal mechanism involving pairs of magnetic flux tubes possibly forming flattened square like closed flux tubes and members of Cooper pairs residing at them.

A brief summary about strengths and weakness of BCS theory

First I try to summarize basics of BCS theory.

1. BCS theory is successful in 3-D superconductors and explains a lot: supracurrent, diamagnetism, and thermodynamics of the superconducting state, and it has correlated many experimental data in terms of a few basic parameters.

2. BCS theory has also failures.

   (a) The dependence on crystal structure and chemistry is not well-understood: it is not possible to predict, which materials are super-conducting and which are not.

   (b) High-Tc SC is not understood. Antiferromagnetism is known to be important. The quite recent experiment demonstrates conductivity- maybe even conductivity - in topological insulator in presence of magnetic field [L9]. This is compete paradox and suggests in TGD framework that the flux tubes of external magnetic field serve as the wires [L9].

3. BCS model based on crystalline long range order and k-space (Fermi sphere). BCS-difficult materials have short range structural order: amorphous alloys, SC metal particles 0-down to 50 Angstroms (lipid layer of cell membrane) transition metals, alloys, compounds. Real space description rather than k-space description based on crystalline order seems to be more natural. Could it be that the description of electrons of Cooper pair is not correct? If so, k-space and Fermi sphere would be only appropriate description of ordinary electrons needed to model the transition to to super-conductivity? Super-conducting electrons could require different description.

4. Local chemical bonding/real molecular description has been proposed. This is of course very natural in standard physics framework since the standard view about magnetic fields does not provide any ideas about Cooper pairing and magnetic fields are only a nuisance rather than something making SC possible. In TGD framework the situation is different.

TGD based view about SC

TGD proposal for high Tc SC and bio-SC relies on many-sheeted space-time and TGD based view about dark matter as $h_{eff} = n \times h$ phase of ordinary matter emerging at quantum criticality [K39].

Pairs of dark magnetic flux tubes would be the wires carrying dark Cooper pairs with members of the pair at the tubes of the pair. If the members of flux tube pair carry opposite B:s, Cooper pairs have spin 0. The magnetic interaction energy with the flux tube is what determines the critical temperature. High Tc superconductivity, in particular the presence of two critical temperatures can be understood. The role of anti-ferromagnetism can be understood.

TGD model is clearly x-space model: dark flux tubes are the x-space concept. Momentum space and the notion of Fermi sphere are certainly useful in understanding the transformation ordinary lattice electrons to dark electrons at flux tubes but the super conducting electron pairs at flux tubes would have different description.

Now come the heretic questions.

1. Do the crystal structure and chemistry define the only fundamental parameters in SC? Could the notion of magnetic body - which of course can correlate with crystal structure and chemistry - equally important or even more important notion?

2. Could also ordinary BCS SC be based on magnetic flux tubes? Is the value of $h_{eff} = n \times h$ only considerably smaller so that low temperatures are required since energy scale is cyclotron energy scale given by E= $h_{eff} = n \times f_c$, $f_c = eB/m_e$. High Tc SC would only have larger h_{eff} and bio-superconductivity even larger h_{eff}!

3. Could it be that also in low Tc SC there are dark flux tube pairs carrying dark magnetic fields in opposite directions and Cooper pairs flow along these pairs? The pairs could actually form closed loops: kind of flattened O:s or flattened squares.

One must be able to understand Meissner effect. Why dark SC would prevent the penetration of the ordinary magnetic field inside superconductor?

1. Could B_{ext} actually penetrate SC at its own space-time sheet. Could opposite field B_{ind} at its own space-time sheet effectively interfere it to zero? In TGD this would mean generation of space-time sheet with $B_{ind} = -B_{ext}$ so that test particle experiences vanishing B. This is obviously new. Fields do not superpose: only the effects caused by them superpose.

   Could dark or ordinary flux tube pairs carrying B_{ind} be created such that the first flux tube portion B_{ind} in the interior cancels the effect of B_{ext} on charge carriers. The return flux of the closed flux tube of B_{ind} would run outside SC and amplify the detected field B_{ext} outside SC. Just as observed.

2. What happens, when B_{ext} penetrates to SC? $h_{eff} \rightarrow h$ must take place for dark flux tubes whose cross-sectional area and perhaps also length scale down by h_{eff} and field strength increases by h_{eff}. If also the flux tubes of B_{ind} are dark they would reduce in size in the transition $h_{eff} \rightarrow h$ by $1/h_{eff}$ factor and would remain inside SC! B_{ext} would not be screened anymore inside superconductor and amplified outside it! The critical value of B_{ext} would mean criticality for this $h_{eff} \rightarrow h$ phase transition.

3. Why and how the phase transition destroying SC takes place? Is it energetically impossible to build too strong B_{ind}? So that effective field $B_{eff} = B_{dark} + B_{ind} + B_{ext}$ experienced by electrons is reduced so that also the binding energy of Cooper pair is reduced and it becomes thermally unstable. This in turn would mean that Cooper pairs generating the dark B_{dark} disappear and also B_{dark} disappears. SC disappears.

Wee after writing the above text came the newest news concerning high Tc superconductivity. Hydrogen sulfide - the compound responsible for the smell of rotten eggs - conducts electricity with zero resistance at a record high temperature of 203 Kelvin (−70 degrees C), reports a paper published in Nature. This super-conductor however suffers from a serious existential crisis: it behaves very much like old fashioned super-conductor for which superconductivity is believed to be caused by lattice vibrations and is therefore not allowed to exist in the world of standard physics! To be or not to be!

TGD Universe allows however all flowers to bloom: the interpretation is that the mechanism is large enough value of $h_{eff} = n \times h$ implying that critical temperature scales up. Perhaps it is not a total accident that hydrogen sulfide H2S - chemically analogous to water - results from the bacterial breakdown of organic matter, which according to TGD is high temperature superconductor at room temperature and mostly water, which is absolutely essential for the properties of living matter in TGD Universe.

As a matter fact, H_2S is used by some bacteria living in deep ocean volcanic vents as a nutrient and also in our own gut: chemically this means that H_2S acts as electron donor in primitive photosynthesis like process to give ATP. That sulphur is essential for growth and physical functioning of plants might be due to the fact that it preceded oxygen based life [F1]. For instance, Cys and met containing sulphur are very important amino-acids.

Indications for high T_c superconductivity at 373 K with $h_{eff}/h = 2$

Some time ago I learned about a claim of Ivan Kostadinov [D55] about superconductivity at temperature of 373 K (100 C) (see `http://tinyurl.com/y9hk83ak`). There is also claims by E. Joe Eck about superconductivity: the latest at 400 K [D24] (see `http://tinyurl.com/yc483hsf`). I am not enough experimentalist to be able to decide whether to take the claims seriously or not.

The article of Kostadinov provides a detailed support for the claim. Evidence for diamagnetism (induced magnetization tends to reduce the external magnetic field inside superconductor) is represented: at 242 transition reducing the magnitude of negative susceptibility but keeping it negative takes place. Evidence for gap energy of 15 mV was found at 300 K temperature: this energy is same as thermal energy $T/2 = 1.5$ eV at room temperature. Tape tests passing 125 A through superconducting tape supported very low resistance (for Copper tape started burning after about 5 seconds).

I-V curves at 300 K are shown to exhibit Shapiro steps (see http://tinyurl.com/y7qkmubj) with radiation frequency in the range [5 GHz, 21 THz]. Already Josephson discovered what - perhaps not so surprisingly - is known as Josephson effect (see http://tinyurl.com/mo8549n). As one drives super-conductor with an alternating current, the voltage remain constant at certain values. The difference of voltage values between subsequent jumps are given by Shapiro step $\Delta V = hf/Ze$. The interpretation is that voltage suffers a kind of phase locking at these frequencies and alternating current becomes Josephson current with Josephson frequency $f_J = ZeV/h$, which is integer multiple of the frequency of the current. This actually gives a very nice test for $h_{eff} = n \times h$ hypothesis: Shapiro step ΔV should be scaled up by $h_{eff}/h = n$. The obvious question is whether this occurs in the recent case or whether $n = 1$ explains the findings.

The data represented by Figs. 12, 13,14 of [D55] (see http://tinyurl.com/y9hk83ak) suggest $n = 2$ for $Z = 2$. The alternative explanation would be that the step is for some reason $\Delta V = 2hf/Ze$ corresponding to second harmonic or that the charge of the charge carrier is $Z = 1$. I have not been able to find any error in my calculation.

1. Fig 12 shows I-V curve at room temperature T=300 K. Shapiro step is now 45 mV. This would correspond to frequency $f = Ze\Delta V/h = 11.6$ THz. The figure text tells that the frequency is $f_R = 21.762$ THz giving $f_R/f \simeq 1.87$. This would suggest $h_{eff}/h = n \simeq f_R/f \simeq 2$.

2. Fig. 13 shows another at 300 K. Now Shapiro step is 4.0 mV and corresponds to a frequency 1.24 THz. This would give $f_R/f \simeq 1.95$ giving $h_{eff}/h = 2$.

3. Fig. 14 shows I-V curve with single Shapiro step equal to about .12 mV. The frequency should be 2.97 GHz whereas the reported frequency is 5.803 GHz. This gives $f_R/f \simeq 1.95$ giving $n = 2$.

Irrespectively of the fate of the claims of Kostadinov and Eck, Josephson effect could allow an elegant manner to demonstrate whether the hierarchy of Planck constants is realized in Nature.

Room temperature superconductivity for alkanes

Super conductivity with critical temperature of 231 C for n-alkanes containing n=16 or more carbon atoms in presence of graphite has been reported (see http://tinyurl.com/hnefqv9).

Alkanes (see http://tinyurl.com/6pm7mz6) can be linear (C_nH_{2n+2}) with carbon backbone forming a snake like structure, branched (C_nH_{2n+2}, $n \geq 2$) in which carbon backbone splits in one, or more directions or cyclic (C_nH_{2n}) with carbon backbone forming a loop. Methane CH_4 is the simplest alkane.

What makes the finding so remarkable is that alkanes serve as basic building bricks of organic molecules. For instance, cyclic alkanes modified by replacing some carbon and hydrogen atoms by other atoms or groups form aromatic 5-cycles and 6-cycles as basic building bricks of DNA. I have proposed that aromatic cycles are superconducting and define fundamental and kind of basic units of molecular consciousness and in case of DNA combine to a larger linear structure.

Organic high T_c superconductivity is one of the basic predictions of quantum TGD. The mechanism of super-conductivity would be based on Cooper pairs of dark electrons with non-standard value of Planck constant $h_{eff} = n \times h$ implying quantum coherence is length scales scaled up by n (also bosonic ions and Cooper pairs of fermionic ions can be considered).

The members of dark Cooper pair would reside at parallel magnetic flux tubes carrying magnetic fields with same or opposite direction: for opposite directions one would have $S = 0$ and for the same direction $S = 1$. The cyclotron energy of electrons proportional to h_{eff} would be scaled up and this would scale up the binding energy of the Cooper pair and make super-conductivity possible at temperatures even higher than room temperature [K39].

This mechanism would explain the basic qualitative features of high T_c superconductivity in terms of quantum criticality. Between gap temperature and T_c one one would have superconductivity in short scales and below T_c superconductivity in long length scales. These temperatures would correspond to quantum criticality at which large h_{eff} phases would emerge.

What could be the role of graphite? The 2-D hexagonal structure of graphite is expected to be important as it is also in the ordinary super-conductivity: perhaps graphite provides long flux tubes and n-alkanes provide the Cooper pairs at them. Either graphite, n-alkane as organic compound, or both together could induce quantum criticality. In living matter quantum criticality would be induced by different mechanism. For instance, in microtubules it would be induced by AC current at critical frequencies [L10].

How the transition to superconductive state could be induced by classical radiation?

Blog and Facebook discussions have turned out to be very useful and quite often new details to the existing picture emerge from them. We had interesting exchanges with Christoffer Heck in the comment section to "Are microtubules macroscopic quantum systems?" (see `http://tinyurl.com/hwnnfcd`) and this pleasant surprise occurred also now.

Recall that Bandyopadhyay's team claims to have detected the analog of superconductivity, when microtubules are subjected to AC voltage [J8, J24] (see `http://tinyurl.com/ze366ny`). The transition to a state resembling superconductivity would occur at certain critical frequencies. For the TGD inspired model see [L7].

The TGD proposal for bio-superconductivity - in particular that appearing in microtubules - is same as that for high T_c superconductivity [K38, K39]. Quantum criticality, large $h_{eff}/h = n$ phases of Cooper pairs of electrons, and parallel magnetic flux tube pairs carrying the members of Cooper pairs for the essential parts of the mechanism. $S = 0$ ($S = 1$) Cooper pairs appear when the magnetic fields at parallel flux tubes have opposite (same) direction.

Cooper pairs would be present already below the gap temperature but possible super-currents could flow in short loops formed by magnetic flux tubes in ferromagnetic system. AC voltage at critical frequency would somehow induce transition to superconductivity in long length scales by inducing a phase transition of microtubules without helical symmetry to those with helical symmetry and fusing the conduction pathways with length of 13 tubulins associated with micro-tubules of type B to much longer ones associated with microtubules of type A by the reconnection of magnetic flux tubes parallel to the conduction pathways.

The phonon mechanism responsible for the formation of Cooper pair in ordinary superconductivity cannot be involved with high T_c superconductivity nor bio-superconductivity. There is upper bound of about 30 K for the critical temperature of BCS superconductors. Few days ago I learned about high T_c superconductivity around 500 K for n-alkanes (see `http://tinyurl.com/hwac9e9`) so that the mechanism for high T_c is certainly different [K39].

The question of Christoffer was following. Could microwave radiation for which photon energies are around 10^{-5} eV for the ordinary value of Planck constant and correspond to the gap energy of BCS superconductivity induce phase transition to BCS super-conductivity and maybe to micro-tubular superconductivity (if it exists at all)?

This inspires the question about how precisely the AC voltage at critical frequencies could induce the transition to high T_c - and bio-super-conductivity. Consider first what could happen in the transition to high T_c super-conductivity.

1. In high T_c super conductors such as copper-oxides the anti-ferromagnetism is known to be essential as also 2-D sub-lattice structures. Anti-ferromagnetism suggests that closed flux tubes form of squares with opposite directions of magnetic field at the opposite sides of square. The opposite sides of the square would carry the members of Cooper pair.

2. At quantum criticality these squares would reconnect to very long flattened squares by reconnection. The members of Cooper pairs would reside at parallel flux tubes forming the sides of the flattened square. Gap energy would consists interaction energies with the magnetic fields and the mutual interaction energy of magnetic moments.

   This mechanism does not work in standard QM since the energies involved are quite too low as compared to thermal energy. Large $h_{eff}/h = n$ would however scale up the magnetic energies by n. Note that the notion of gap energy should be perhaps replaced with collective binding energy per Cooper pair obtained from the difference of total energies for gap phase formed at higher temperature and for superconducting phase formed at T_c by dividing with the number of Cooper pairs.

Another important distinction to BCS is that Cooper pairs would be present already below gap temperature. At quantum criticality the conduction pathways would become much longer by reconnection. This would be represent an example about "topological" condensed matter physics. Now hover space-time topology would be in question.

3. The analogs of phonons could be present as transversal oscillations of magnetic flux tubes: at quantum criticality long wave length "magneto-phonons" would be present. The transverse oscillations of flux tube squares would give rise to reconnection and formation of

If the irradiation or its generalization to high T_c works the energy of photon should be around gap energy or more precisely around energy difference per Cooper pair for the phases with long flux tubes pairs and short square like flux tubes.

1. To induce superconductivity one should induce formation of Cooper pairs in BCS superconductivity. In high T_c super-conductivity it should induce a phase transition in which small square shaped flux tube reconnect to long flux tubes forming the conducting pathways. The system should radiate away the energy difference for these phases: the counterpart of binding energy could be defined as the radiated energy per Cooper pair.

2. One could think the analog of stimulated emission (see `http://tinyurl.com/hwac9e9`). Assume that Cooper pairs have two states: the genuine Cooper pair and the non-superconducting Cooper pair. This is the case in high T_c superconductivity but not in BCS superconductivity, where the emergence of superconductivity creates the Cooper pairs. One can of course ask whether one could speak about the analog of stimulated emission also in this case.

3. Above T_c but below gap temperature one has the analog of inverted population: all pairs are in higher energy state. The irradiation with photon beam with energy corresponding to energy difference gives rise to stimulated emission and the system goes to superconducting state with a lower energy state with a lower energy.

This mechanism could explain the finding of Bandyopadhyay's team [J8, J24] that AC perturbation at certain critical frequencies gives rise to a ballistic state resembling superconductivity (no dependence of the resistance on the length of the wire so that the resistance must be located at its ends). The team used photons with frequency scales of MHz, GHz, and THz. The corresponding photon energy scales are about 10^{-8} eV, 10^{-5}, $10{-}2$ eV for the ordinary value of Planck constant and are below thermal energies.

In TGD classical radiation should have also large $h_{eff}/h = n$ photonic counterparts with much larger energies $E = h_{eff} \times f$ to explain the quantal effects of ELF radiation at EEG frequency range on brain [K35]. The general proposal is that h_{eff} equals to what I have called gravitational Planck constant $\hbar_{gr} = GMm/v_0$ [K75, K88]. This implies that dark cyclotron photons have universal energy range having no dependence on the mass of the charged particle. Bio-photons have energies in visible and UV range much above thermal energy and would result in the transition transforming dark photons with large $h_{eff} = h_{gr}$ to ordinary photons.

One could argue that AC field does not correspond to radiation. In TGD framework this kind of electric fields can be interpreted as analogs of standing waves generated when charged particle has contacts to parallel "massless extremals" representing classical radiation with same frequency propagating in opposite directions. The net force experienced by the particle corresponds to a standing wave.

Irradiation using classical fields would be a general mechanism for inducing bio-superconductivity. Superconductivity would be generated when it is needed. The findings of Blackman and other pioneers of bio-electromagnetism about quantal effects of ELF em fields on vertebrate brain stimulated the idea about dark matter as phases with non-standard value of Planck constant. The precise mechanism for how this happens has remained open. Also these finding could be interpreted as a generation of superconducting phase by this phase transition.

2.5.7 The implications of TGD view about magnetic fields for superconductivity

TGD predicts two kinds of magnetic fields depending on whether flux tubes carry monopole flux or not. In Maxwellian framework flux tubes cannot carry any monopole flux. In TGD based model of high Tc superconductivity [K38, K39] monopole flux tubes current carriers are dark having nonstandard value $h_{eff} = n \times h_0$ of effective Planck constant. Also in bio-superconductivity monopole flux tubes are current carriers. An open question has been whether also ordinary super-conductivity could correspond to monopole flux tubes and I have considered the possibility that this is the case.

The recent progress in understanding the relationship between two kinds of magnetic fields allows to consider more precisely the relationship between these two kinds of super-conductivities. In particular, one can try to understand Meissner effect in ordinary super-conductivity and its absence in the predicted super-conductivity based on monopole flux tubes. The conclusion is that ordinary super-conductivity corresponds to ordinary flux tubes and that Meissner effect has no counterpart in monopole superconductivity.

It is best to start from the ordinary super-conductivity by making an unpleasant question. Meissner effect (see `http://tinyurl.com/hesedf2`) relates to the possible penetration of magnetic field to super-conductor. Supra-current creates a local magnetic field. Why doesn't this magnetic field destroy super-conductivity?

The answer would be in TGD space-time following.

1. The super-conductor consists of parallel cylindrical tubes carrying supra-currents at their boundaries. These currents create magnetic fields rotating around the cylinders but have no component in z- direction. Magnetic fields vanish at the boundaries of the cylinders.

2. Superconductors can be classified to two types. For superconductors of type I (see `http://tinyurl.com/y4wkzcql`) one has $\lambda/\xi < 1/\sqrt{2}$ whereas for superconductors of type II (see `http://tinyurl.com/y279phzb`) one has $\lambda/\xi > 1/\sqrt{2}$. Here λ is the magnetic penetration length, which is roughly the radius of magnetic flux tube. ξ is the coherence length which is roughly the radius of cylinder carrying supra current at its boundary.

   Supra-current generates vortices and in this manner serves as a source for magnetic field inside magnetic flux tube of field possibly penetrating into superconductor. Flux tube must contain at least one current carrying flux tube. This cannot the case for superconductor of type I. Therefore, when ordinary magnetic field penetrates to super-conductor of type I above critical value of B, it must do so in the entire super-conductor . For superconductor of type II magnetic field can penetrate superconductor of type II in a cylinder of radius of order λ containing several current carrying cylinders. In this region the super-conductivity is destroyed since supra currents have component rotating along the cylinder giving rise to a longitudinal magnetic field inside the cylinder.

What about Meissner effect in monopole superconductors?

1. Monopole flux does not require current as its source. Therefore Meissner effect does not prevent super-conductivity by requiring the super-current to be rotational to generate the magnetic field.

2. Also now the presence of supra current inside monopole flux tube serves as a source for an additional rotational contribution to the magnetic field and the rotor of this additional contribution equals to the supra current. Monopole flux tube is deformed as a consequence. This does not however make supra-current rotational.

   Monopole superconductor can be said to be intermediate between types I and II since both coherence length and magnetic length correspond to flux tube radius. A possible interpretation is that monopole superconductivity is at quantum criticality between superconductivities of type I and II.

3. The most plausible option is that the penetration of ordinary magnetic field to monopole super-conductor occur along non-monopole flux tubes at different space-time sheets so that it would therefore not spoil the super-conductivity at the monopole flux tubes.

2.6 Evidence For Electronic Superconductivity In Bio-Systems

There exists some evidence for super-conductivity in bio-systems. DNA should be insulator but under some circumstances it becomes conductor [I14] and perhaps even high T_c super-conductor. Also evidence for Josephson effect has been reported [D34].

2.6.1 DNA As A Conductor?

Barton *et al* [I14] have done several experiments between 1993-1997 related to the conductivity properties of DNA double helix. The conclusion is that DNA double helix has the ability to do chemistry at distance: *"A DNA molecule with a chemical group artificially tethered to one end appears to mediate a chemical change far down the helix, causing a patch of damaged DNA to be mended."* .

What seems to occur is flow of electron current along DNA with very small resistance. Typically the experiments involve electron donator and acceptor separated by a long distance along DNA. When acceptor is radiated it goes to excited state and an electron current flows from donator to acceptor as a consequence. Standard wisdom tells that this should not be possible. The current should flow by quantum tunnelling between adjacent building units of DNA and it should diminish exponentially with distance. For proteins this is known to be the case. In experiments however no distance dependence was observed. Irradiation with visible light was also involved.

There exist a theory which assumes that the current could flow along the interior of double DNA, that is the region between the bases of strand and complementary strand. The electron would be de-localized in bases rings which would form a stack along DNA. The current would flow by tunnelling also now but the tunnelling probability would be so large that distance dependence would be weak. The critics of Barton argue that this model cannot explain all the experiments of Barton and that the model is not in accordance with basic organic chemistry and biology: ordinary sun light should have rather drastic effects on us. Barton admits that they do not understand the mechanism.

TGD suggests a possible explanation of phenomenon in terms of dark atoms or partially dark atoms for which valence electrons are dark.

1. The bases of DNA contain 5 or 6-cycles: both correspond to Fermat polygons. This symmetry suggests dark phase with $G_a \subset SU(2)$ having maximal cyclic group Z_5 or Z_6 so that one would have $n_a = 5$ or $n_a = 6$ depending on the cycle. This identification would provide first principle explanation for why just these cycles appear in living matter. Most naturally organic atoms would be ordinary but some electrons would reside on dark space-time sheets corresponding to $n_a = 5$ or $n_a = 6$ and $n_b = 1$.

2. The scaled up size of the electronic orbital would be roughly $(n_a n^2/Z_{eff}^2)a_0$ and by a factor n_a^2 larger than the size of ordinary orbital. The large distance of valence electrons suggest $Z_{eff} = 1$ as a first guess, which would imply de-localization of electrons in the length scale $625a_0 \sim 312$ nm for Rb and $900a_0 \sim 45$ nm for Rh. For the estimate $Z_{eff} \sim 10$ deduced below the de-localization would occur in length scales 3 nm and 9 nm which is probably quite enough since there is one DNA triplet per one nanometer if the conduction occurs as a sequence of replacements of a hole with electron analogous to the falling down of domino pieces.

3. The fact that the ratio $6/5 = 1.2$ is rather near to the ratio $45/37 = 1.22$ of nuclear charges of Rh and Rb atoms would guarantee that the binding energy of the valence electron for Rh atom with $n_a = 6$ is reasonably near to that for Rb atom with $n_a = 5$. This encourages to think that the mechanism of conductivity involves the ionization of dark valence electron of acceptor atom so that it can receive the dark valence electron of the donor atom. Delocalization makes this process possible.

4. The DNA environment would induce the phase transition of Rh and Ru atoms to partially dark atoms. The binding energy of the dark valence electron is reduced to $E = (n_b/n_a)^2 Z_{eff}^2 E_0/n^2$, where Z_{eff} is the screened nuclear charge seen by valence electrons, $n = 5$ the principal quantum number for the valence electron in the recent case, and $E_0 = 13.6$

eV the ground state energy of hydrogen atom. $Z_{eff} = 1$ would give.02 eV binding energy which is quite too small. If the binding energy reduces to that of a visible photon parameterized as $E = x$ eV one obtains the condition

$$Z_{eff} = n_a n\sqrt{E/E_0} \simeq 5n_a\sqrt{x/13.6} \ .$$

For Rh $x = 2$ would give $Z_{eff} = 11.5$ and $Z_{eff} = 9.6$ for Rb.

2.6.2 DNA As A Super-Conductor?

Also in the model of ORMEs as dark matter led to $n_a = 6, n_b = 1$ in super-conducting phase. This suggests DNA super-conductivity is based on the same mechanism as the explanation of superconductivity assigned with ORMEs. In particular, the energy $E = .05$ eV associated with the critical potential of neuronal membrane could correspond to the gap energy of the DNA super-conductor and this could relate directly to the activation of DNA. As found, the dark variant of a conventional super-conductor with gap energy around 10 K would give rise to a dark superconductor with a gap energy around room temperature. The estimate $E_g = E/n_a^2$ gives 14 K for $n_a = 6$ and 20 K for $n_a = 5$ for the gap energy. DNA carries -2 units of electric charge per single nucleotide and the interpretation could be as one dark Cooper pair per nucleotide. $n_a = 6$ would give the higher critical temperature.

The fact that there is a twist $\pi/10$ per single nucleotide in DNA double strand led to the proposal that DNA pr RNA might serve as a minimal topological quantum computer with computation based on braiding S-matrix and characterized by $n_a = 5$ [K67]. Perhaps dark Cooper pairs having $n_a = 5$ with charge fractionized to five identical fractions along 5-cycles could relate to the topological quantum computation.

DNA strand and its conjugate could form a pair of weakly coupled super-conductors forming kind of a scaled down version for the pairs formed by the inner and outer lipid layers of the axonal membrane or cell interior and exterior. Both DNA strand and double strand corresponds to the secondary p-adic length scale $L_e(71, 2) \simeq 4.4$ Angstroms. The soliton sequences associated with the phase differences of super-conducting order parameter over the Josephson junctions connecting DNA strands, and idealizable as a continuous one-dimensional Josephson junction, could serve as a quantum control mechanism. Josephson junctions could correspond to MEs which propagate with very low effective phase velocity along the DNA strand. The mathematics would be essentially that of a gravitational pendulum [K41]. Soliton like structures associated with DNA have been proposed also by Peter Gariaev [I19].

Aromatic rings and large $\hbar$ phases

Aromatic rings contain odd number of π de-localized electron pairs with atoms in the same plane. The de-localization of π electrons in the ring is used to explain the stability of these compounds [I1]. Benzene is the classical example of this kind of structure. Delocalization and DNA conductivity suggest interpretation in terms $n_a = 5$ or $n_a = 6$ phase and raises the question whether the de-localization of electrons could occur also in the orthogonal direction and whether it could give rise to Cooper pairs.

Aromatic rings consisting of 5 or 6 carbons are very common in biology. DNA basis have been already mentioned. Carbohydrates consist of monosaccharide sugars of which most contain aromatic ring (glucose used as metabolic fuel are exception). Monoamine neurotransmitters are neurotransmitters and neuromodulators that contain one amino group that is connected to an aromatic ring by a two-carbon chain (-CH2-CH2-). The neurotransmitters known a monoamines are derived from the four aromatic amino acids phenylalanine, tyrosine, histidine, tryptophan. Also norepinephrine, dopamine, and serotonin involve aromatic rings As a rule psychoactive drugs involve aromatic rings: for instance, LSD contains four rings.

These observations inspire the question whether the compounds containing aromatic rings serve as junctions connecting pre- and postsynaptic neurons and induce Josephson currents between them. If Josephson radiation codes for the mental images communicated to the magnetic body, the psychoactive character of these compounds could be understood. One can also ask whether these compounds induce quantum criticality making possible generation of large $\hbar$ phases?

Graphene as another example of dark electron phase?

The behavior of electrons in graphene, which is two-dimensional hexagonal carbon crystal with a thickness of single atomic layer, is very strange [D45]. Electrons behave as massless particles but move with a velocity which is 1/300 of light velocity. Graphene is an excellent conductor. TGD can provide a model for these peculiar properties.

1. One can regard graphene as a giant molecule and the hexagonal ring structure suggests that M^4 Planck constant is scaled up by a factor of 6 and that dark free electron pairs are associated with the ring structures. If also CP_2 Planck is scaled up with the same factor, chemistry is not affected although the size scale of electron wave functions is scaled up by a factor of 6. Just as in the case of DNA, the rings containing de-localized free electron pairs could be responsible for the anomalously high conductivity of graphene. If quantum critical super-conductor is in question, the super-conductivity could become possible in lower temperature.

2. Consider now the explanation for the vanishing of the rest mass. The general mass formula predicted by p-adic thermodynamics [K26] states that particle mass squared is given by the thermal average of the conformal weight and that conformal weight and thus also mass squared is additive in bound states:

$$(\sum_i p_i)^2 = \sum_i m_i^2 \tag{2.6.1}$$

The assumption $p_i^2 = m_i^2$ makes sense only for massless partons moving collinearly. In the QCD based model of hadrons only longitudinal momenta and transverse momentum squared are used as labels of parton states, which would suggest that one has

$$\begin{aligned} p_{i,||}^2 &= m_i^2 \ , \\ -\sum_i p_{i,\perp}^2 + 2\sum_{i,j} p_i \cdot p_j &= 0 \ . \end{aligned} \tag{2.6.2}$$

The masses would be reduced in bound states: $m_i^2 \rightarrow m_i^2 - (p_T^2)_i$. This could explain why massive quarks can behave as nearly massless quarks inside hadrons. In the recent case electrons would become massless if one has hadron like many electron states (free electron pairs?) with $p_T^2 = m_e^2$.

3. TGD also predicts the possibility of anomalous time dilation in the absence of gravitational field implying also reduction of light velocity. The simplest example are vacuum extremals corresponding to the warped embedding $\phi = \omega t$ to $M^4 \times S^1$, S^1 a geodesic sphere of CP_2, which have induced metric for which time component of metric is $g_{tt} = 1 - R^2\omega^2$ instead of $g_{tt} = 1$. Light velocity defined from the time taken to get from point A to B is reduced by a factor $\sqrt{g_{tt}}$ from its maximal value. If the space-time sheets carrying the electrons have $g_{tt} = 1/300$, one can understand the reduction of light velocity.

2.6.3 Conducting DNA And Metabolism

Besides charge transfer also energy transfer along DNA could be of importance in living systems.

Could metabolism involve electronic visible-dark phase transitions at DNA level?

If the dark valence electron associated with an ordinary atom is transformed to ordinary electron, the binding energy of the electron increases which means a liberation of a considerable amount of energy. This phase transition could liberate a large amount of metabolic energy in a coherent manner and might be involved with metabolism at molecular level.

Could the transfer of electrons along DNA make possible energy transfer?

One important function made possible by the assumed dropping of electrons to larger space-time sheets is the transfer of not only charge but also energy through long distances and metabolism might well use this mechanism. The typical energy liberated when ATP molecule is used is about .5 eV. In the model of ATP [K22] it is suggested that energy metabolism involves the circulation of protons between atomic ($k = 137$) space-time sheets and magnetic flux tubes of Earth. The dropping of proton from $k = 137$ atomic space-time sheet to much larger space-time sheet liberates this energy as zero point kinetic energy and generation of ATP molecule involves kicking of three protons back to the atomic space-time sheets by using metabolic energy.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

In the following early version of the model assigning metabolic energy quantum to the dropping of protons is considered. In [K39] a model of metabolism associating the metabolic energy quantum to the change of cyclotron energy is discussed.

ATP might provide only the mechanism responsible for the energy transfer over short distances. The dropping of any ion from any space-time sheet to a larger space-time sheet is possible and liberates a definite amount of usable energy. When the smaller space-time sheet corresponds to a super-conducting space-time sheet, the ions or their Cooper pairs can be rapidly transferred as dissipation free supra currents to the region, where the energy is needed. This long distance energy transfer mechanism could be associated with all kinds of linear structures: DNA, proteins, microfilaments, microtubules, axons etc... The magnitude of the energy quantum released would be fixed by the p-adic length scale hypothesis and the mass of the ion or of the Cooper pair. The acceleration in endogenous electric fields provides a mechanism kicking the ions back to the smaller space-time sheets.

Because of their low mass, electrons are exceptional. The dropping of an electronic Cooper pair from $k = 139$ some space-time sheet presumably associated with the hydrogen bonds of length about 3 nm connecting the nucleotides of different DNA strands would liberate a huge energy of about 120 eV. The corresponding UV photon has frequency not far from the miracle frequency associated with $k = 151$ p-adic length scale, which is the first of the four subsequent p-adic miracle length scales corresponding to Gaussian Mersennes. The dropping of electron Cooper pair from the space-time sheet of the DNA strand of thickness of order $4-5$ Angstroms, which presumably corresponds to the secondary electron Compton length $L_e(71,2) \simeq 4.4$ Angstroms, liberates energy of about 15 eV, which in turn corresponds to the p-adic miracle length scale $L_e(157)$. This would mean that all miracle length scales would correspond to some energy unit of energy metabolism [K22] !

An interesting question relates to the possible function of this UV photon. The wavelength $\lambda = L_e(151)$ corresponds to the thickness of the cell membrane. It is also to the minimal length of DNA sequence (10 DNA triplets) with the property that the net winding is a multiple of 2π ($3\times2\pi$). By its reflection symmetry this helical sequence might serve as a subunit of DNA sequence. The ends of this subunit could act as mirrors connected by MEs carrying Bose-Einstein condensed photons propagating back and worth between the mirrors. The energy liberated by the electron as an UV photon could BE condense to this kind of ME.

At least in the case of monocellulars having DNA at cell membrane, the photon could also be reflected between the outer and inner boundary of the cell membrane.

2.6.4 Some Empirical Evidence For Super Conductivity In Bio-Systems

There is indirect evidence for electronic super conductivity in bio-systems. The basic signatures are photon emission and absorption with energies coming as multiples of the potential difference between two weakly coupled super conductors and voltage-current characteristics of Josephson current. The evidence is related to the tunnelling of electrons between a weakly coupled pair of super conductors.

According to [D21], for several biological systems involving nerve or growth processes the square of the activation energy is a linear function of temperature over a moderate range of physiological temperatures. This behavior may be predicted from the hypothesis that the rate of biological process is controlled by single electron tunnelling between micro-regions of super-conductivity. In TGD framework natural candidates for this kind of regions are the lipid layers of cell membranes and cells themselves.

Positive experimental evidence for Josephson effect is reported and discussed in [D34]. The evidence is based on the observation of voltage-current characteristic typical to the Josephson current flowing between weakly coupled super conductors, which are identified as neighboring cells. Also the radiation of photons with energies which are multiples of the potential difference between the weakly coupled super conductors is used as an empirical signature. The potential difference is about 15 nV and in completely different range as the potential difference of order .05 V between the lipid layers of the cell membrane. Various species of organisms can detect weak magnetic fields from.1 to 5 gauss and this is in accordance with the existence of Josephson junction in systems, which are super conductors of type II in critical region between H_{c_1} and H_{c_2}. The detection of magnetic fields could be based on the same mechanism as the operation of SQUIDs.

2.6.5 Microtubular Space-Time Sheets As Super Conductors?

Microtubules are fashionable candidate for a macroscopic quantum system. Microtubules are the basic structural units of cytoskeleton and it has been suggested that cytoskeleton might play the role of nervous system at single cell level and provide the key element for understanding bio-systems as macroscopic quantum systems [J25]. Microtubules are hollow cylindrical tubes with inner and outer radii of 14 nm and 25 nm respectively so that the thickness of the cylinder corresponds roughly to the length scale $\hat{L}(151)$. Microtubules consist of dimers of α and β tubulines having at least two conformations: the position of electron centrally placed in the α-tubulin-β-tubulin juncture probably determines the conformation. Tubulin dimers have size ~ 8 nm not far from the length scale $\hat{L}(157)$. There are 13 columns of tubulin dimers along the microtubule. The skew hexagonal pattern of microbutules exhibits pattern made up of 5 right handed and 8 left handed helical arrangements.

For left handed arrangement 2π rotation corresponds to a distance ~ 64 nm $\sim \hat{L}(163)$ along the length of the microtubule [J37, J7]. It has been suggested [J25] that the electric dipole moments of tubulin dimers form a macroscopic quantum system analogous to a spin system. An alternative possibility is that microtubules might be super conducting. The cylindrical geometry is ideal for the creation of constant magnetic fields inside the tube by helical supercurrents flowing along the surface of the microtubule. The electrons determining the conformation of the tubulin dimer are the most obvious candidates for Cooper pairs. Perhaps the electrons corresponding to a given conformation of tubulin could form de-localized Cooper pairs.

The numbers 5 and 8 correspond to Fermat polygons which suggests that G_a with $n_a = 5 \times 8 = 40$ defining order of maximal cyclic subgroup is involved. $n_a = 40$ was also obtained from the requirement that the 20 amino-acids can be coded by the many-electron states of dark N-hydrogen atom having $n_b = 1$ [K80]. Super-conductivity would correspond to $n_b = 1$ so that by the previous argument the critical temperature would be scaled up by a factor $n_a^2 = 1600$ from that of a conventional super-conductor. The possible problems relate to the thermal stability of light atoms if also nuclei are dark, which is however not expected.

The hypothesis that microtubules are infrared quantum antennas with average length giving rise to .1 eV infrared photon fits nicely with the super conductor idea. The fact that .1 eV is the basic energy scale of wormhole atomic physics explains the average length of microtubules. In case of Cooper pairs there is natural coupling to the Josephson currents related to Josephson junctions between lipid layers of the cell membrane. The coupling of wormhole supra currents to coherent photons contains two contributions. The first contribution is the coupling of the wormhole current to the difference of the gauge potentials describing topologically condensed coherent photons on the two space-time sheets. The second contribution is proportional to the difference of dielectric constants on the two space-time sheets and is non-vanishing even when the topological condensates of coherent photons are identical.

2.6.6 Are Living Systems High T_c Superconductors?

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

Interestingly, Cu is one of the biologically most important trace elements [D2]. For instance, copper is found in a variety of enzymes, including the copper centers of cytochrome c-oxidase, the Cu-Zn containing enzyme superoxide dismutase, and copper is the central metal in the oxygen carrying pigment hemocyanin. The blood of the horseshoe crab, Limulus polyphemus uses copper rather than iron for oxygen transport. Hence there are excellent reasons to ask whether living matter might be able to build high T_c superconductors based on copper oxide.

What are the preferred values of $\hbar$ for bio-superconductors?

The observed stripes would carry large $\hbar$ electrons attracted to them by hole charge. The basic question concerns the value of $\hbar$ which in the general case is given by $\hbar = x_a x_b$. a refers to CD and b to CP_2. $x_i = n_i$ holds true for singular coverings and $x_i = 1/n_i$ for singular factor spaces. n is is the order of maximal cyclic subgroup $Z_n \subset G$, where G defines singular covering or factor space. Number theoretic vision suggests that the integers n_i, which correspond to a n-polygon constructible using only ruler and compass are physically favored. Thus n_i would be a product containing only different Fermat primes $2^{2^n} + 1$ (3, 5, 17, 257, $2^{16} + 1$) and some power of 2.

The first question concerns the value of the Planck constant assignable to electron.

1. The secondary Compton time scale assignable to the CD of electron is scaled up from $T_e(2, 127) \simeq .1$ seconds (actually fundamental biorhythm) to $rT_e(2, 127)$, $r = \hbar/\hbar_0$. The corresponding p-adic length scale is $\sqrt{r}L_e(127) = \sqrt{r} \times 2.4 \times 10^{-12}$ m.

2. The appearance of 50 meV energy scale which can be interpreted in terms of Josephson energy for cell membrane at criticality for nerve pulse generation is too intriguing signal to be dismissed and forces to ask whether the Compton scales $L_e(k)$, $k = 149, 151$ associated with the lipid layer of cell membrane and membrane itself are involved also with non-biological high T_c super-conductivity.

The model for living matter raises the question whether the favored values of $r = n_a n_b$ correspond to 2^{k_d}, where k_d is difference of integers k_i defining Mersenne primes or Gaussian Mersennes. This hypothesis can be tested.

1. $r = 2^{14}$ ($127 - 113 = 14$) would predict effective p-adic length scale $L_e(127 + 14) = 141) = 3.3$ Angstrom so that dark electrons would have atomic size scale. The thickness of the stripes is few atomic sizes and the members of spin 1 Cooper pair in high T_c super-conductors would naturally have distance given by atomic length scale if they are correspond to nearest neighbors in the lattice. This gives rise to a large Coulomb repulsion between electrons which suggests that the electrons at the magnetic flux tube tend to have as large distance as possible.

2. $r = 2^{24}$ ($151 - 127 = 24$) would give $L_e(127 + 24 = 151) = 10nm$ so that dark electron would have size which corresponds to the thickness of the cell membrane. Bio-superconductivity could correspond to this value of $\hbar$. The minimum option is that only the exotic Cooper pairs making possible super-conductivity above T_c and broken by quantum criticality against transition to ordinary electron need have size of order $L_e(151) = 10$ nm. The length of stripes is in the range 1-10 nm and this forces to ask whether this length scale could correspond to the size of Cooper pairs also for high T_c super-conductors.

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

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

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

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

2.7 Exotic Atoms, Wormhole Super Conductivity And Wormhole Magnetic Fields

Exotic atom, wormhole super conductivity and wormhole magnetic fields are purely TGD based concepts and it seems that these concepts might be involved with the transition from organic chemistry to biochemistry. There is certainly much more involved, in particular the long range color and weak forces discussed in [K80].

2.7.1 Exotic Atoms

For ordinary atoms all electrons are condensed on the "atomic" condensation level. One could however think the possibility that some electrons, most probably some valence electrons with high value of principal quantum number n, condense to the lower condensation level, at which atom itself is condensed. This process would give rise to exotic atoms. The exotic counterpart of atom with charge Z would behave chemically as element with $Z - n(val)$, where $n(val)$ is the number of exotic valence electrons. The energy levels of electron at the exotic condensate level should depend only very weakly on the nuclear charge of the parent atom: only the number of valence electrons is what matters. In particular, "electronic" alchemy becomes in principle possible by dropping some electrons on the lower condensate level. One can consider two options depending on whether the dropped electrons are ordinary or dark.

1. *Dropped electrons are not dark*

The model to be represented is the first version about exotic super-conductivity which was based on the idea about wormhole contact as a counterpart of phonon. Much later it became obvious that charged wormhole contacts can be in fact be identified as counterparts for charged Higgs field making photons massive. This aspect is not discussed below.

The exotic electrons see the Coulomb field of nucleus with effective charge $n(val)$. This charge and gravitational flux flows from the atomic condensate level via the tiny wormhole contacts located near the boundaries of atomic condensate level. If the electric flux of the wormhole is quantized with proton charge as unit there are $n(val)$ wormhole contacts, with each wormhole carrying one unit of electric charge. Note that the minimal unit of flux is naturally 1/3 of elementary charge and the detection of electric flux of this size would be a triumph of the theory. In order to be able to evaluate the energy levels of this pseudo hydrogen atom one must know something about the mass of the wormhole contacts. The following physical considerations give estimate for the mass.

p-Adic length scale hypothesis states that physically most interesting length/mass scales are in one-one- correspondence with p-adic primes p near prime powers of two ($p \simeq 2^k$, k prime) and p-adic mass scale is given by $m \sim 1/L_e(p)$, where $L_e(p)$ is p-adic length scale expressible in terms of Planck length as $L_e(p) \simeq 10^4\sqrt{p}\sqrt{G}$. The representation of wormhole contact as parton pair suggests that apart from effects related to the binding of wormhole throats to single unit, the inertial mass is just the sum of contributions of parton and antiparton associated with the throats carrying opposite gauge quantum numbers. If the time orientations of the space-time sheets involved are opposite, the energies can sum up to zero and the wormhole contact carries no mass. Otherwise the mass is sum of the two masses and the dominant contribution to their mass is determined by the length scale associated with the smaller space-time sheet and thus proportional to $1/\sqrt{p_1}$. In atomic length scales this would give mass of order 10^4 eV and in the length scale corresponding to room temperature mass would be of order 10^{-2} eV. Atoms ($k = 137$) can feed they electromagnetic gauge fluxes directly to "lower" p-adic condensate levels (such as $k = 149$) rather than $k = 139$ to minimize the contribution of wormhole masses to energy.

The small mass of wormhole implies that for atoms with sufficiently high Z it could be energetically favorable to drop electrons to the lower condensate level. Very light wormhole contacts are described by d'Alembert operator associated with the induced metric of the 3-dimensional surface describing the boundary of atomic surface and having one time like direction.

Wormhole contacts are free to move along the boundary of the atomic 3-surface. If wormhole contacts are very light but not exactly massless, it is clear that wormhole contacts behave as bosons restricted to this surface and that state they condense on ground state. For very light but not massless wormhole contacts the lowest state has energy equal to rest mass of the wormhole and next state has energy of order $\pi/a \sim 10^4\ eV$, where a is the radius of atom. Therefore very light wormhole contacts BE condense on the ground state and give rise to a constant charge distribution on the spherical shell surrounding atom. For exactly massless wormhole contacts the zero energy state is not possible and localization of massless wormhole contacts on surface of atomic size would require energy of order $10^4\ eV$. In the interior of this shell electrons are free and in exterior they move in the field of this charge distribution and form bound states. The energies of the electrons at "lower" space-time sheet depend only weakly on the value of Z (only via the dependence of the size of atomic 3-surface on Z) so that the spectral lines associated with the exotic atoms should be in certain sense universal.

The dropping of electrons of heavy atoms, such as Gold or Pb, to the lower space-time sheet, might be energetically favorable or require only a small energy and be induced by, say, absorption of a visible light. Once single electron is dropped it becomes more favorable for second electron to drop since the potential well in the final state is now deeper. The fact, that wormhole contacts form BE Einstein condensate, gives transition probability proportional to N^2 instead of N, N being the number of wormhole contacts already present. In this manner even cascade like process could become possible leading to drop of all valence electrons to the lower space-time sheet. One could even end up from heavy metal such as lead to pseudo-Xenon noble gas evaporating instantaneously!

2. Could exotic valence electrons be dark?

The basic objection against the proposed model is that the proposed wormhole mechanism has no experimental support. If temperature is same at the space-time sheets carrying the dropped electrons, it is not possible to have high T_c super-conductivity for conventional mechanisms.

The valence electrons could however be also dark, which would mean that at some radius atomic electric gauge fluxes flow to a dark space-time sheet and is shared to n_b sub-fluxes so that the each sheet carries flux n_{val}/n_b. For $n_a/n_b > 1$ the fractionization of the radial electric gauge flux could make the states of valence electrons thermally unstable. $n_a/n_b > 1$ would however favor the formation of Cooper pairs and thus high T_c variant of conventional super-conductivity with critical temperature scaled up by n_a^2.

The presence of Ca, Na and K ions in cells and their importance for the functioning of cell membrane could be also due to the fact that these ions are formed when some of the valence electrons transform to dark electrons and become super-conducting. An alternative explanation is that also the nuclei in question are dark and n_a/n_b is so high that atomic binding energies for valence electrons are below thermal threshold and cold plasma of dark ions is formed. These electrons could form Cooper pairs for large enough n_a/n_b. Magnetic flux sheets are excellent candidates for these space-time sheets. The observed ions would result via a phase transition of these ions to ordinary ones. Chemically the resulting elements would behave like noble gas. This kind of mechanism might be involved also with the formation of high T_c super-conductors.

2.7.2 Mono-Atomic Elements As Dark Matter And High T_c Super-Conductors?

The ideas related to many-sheeted space-time began to develop for a decade ago. The stimulation came from a contact by Barry Carter who told me about so called mono-atomic elements, typically transition metals (precious metals), including Gold. According to the reports these elements, which are also called ORMEs ("orbitally rearranged monoatomic elements") or ORMUS, have following properties.

1. ORMEs were discovered and patented by David [H7] [H7] are peculiar elements belonging to platinum group (platinum, palladium, rhodium, iridium, ruthenium and osmium) and to transition elements (gold, silver, copper, cobalt and nickel).

2. Instead of behaving as metals with valence bonds, ORMEs have ceramic like behavior. Their density is claimed to be much lower than the density of the metallic form.

3. They are chemically inert and poor conductors of heat and electricity. The chemical inertness of these elements have made their chemical identification very difficult.

4. One signature is the infra red line with energy of order .05 eV. There is no text book explanation for this behavior. Hudson also reports that these elements became visible in emission spectroscopy in which elements are posed in strong electric field after time which was 6 times longer than usually.

The pioneering observations of David Hudson [H7] - if taken seriously - suggest an interpretation as an exotic super-conductor at room temperature having extremely low critical magnetic fields of order of magnetic field of Earth, which of course is in conflict with the standard wisdom about super-conductivity. After a decade and with an impulse coming from a different contact related to ORMEs, I decided to take a fresh look on Hudson's description for how he discovered ORMEs [H7] with dark matter in my mind. From experience I can tell that the model to be proposed is probably not the final one but it is certainly the simplest one.

There are of course endless variety of models one can imagine and one must somehow constrain the choices. The key constraints used are following.

1. Only valence electrons determining the chemical properties appear in dark state and the model must be consistent with the general model of the enhanced conductivity of DNA assumed to be caused by large $\hbar$ valence electrons with $r = \hbar/\hbar_0 = n$, $n = 5, 6$ assignable with aromatic rings. $r = 6$ for valence electrons would explain the report of Hudson about anomalous emission spectroscopy.

2. This model cannot explain all data. If ORMEs are assumed to represent very simple form of living matter also the presence electrons having $\hbar/\hbar_0 = 2^{k11}$, $k = 1$, can be considered and would be associated with high T_c super-conductors whose model predicts structures with thickness of cell membrane. This would explain the claims about very low critical magnetic fields destroying the claimed superconductivity.

Below I reproduce Hudson's own description here in a somewhat shortened form and emphasize that must not forget professional skepticism concerning the claimed findings.

Basic findings of Hudson

Hudson was recovering gold and silver from old mining sources. Hudson had learned that something strange was going on with his samples. In molten lead the gold and silver recovered but when "I held the lead down, I had nothing". Hudson tells that mining community refers to this as "ghost-gold", a non-assayable, non-identifiable form of gold.

Then Hudson decided to study the strange samples using emission spectroscopy. The sample is put between carbon electrodes and arc between them ionizes elements in the sample so that they radiate at specific frequencies serving as their signatures. The analysis lasts 10-15 seconds since for longer times lower electrode is burned away. The sample was identified as Iron, Silicon, and Aluminium. Hudson spent years to eliminate Fe, Si, and Al. Also other methods such as

Element	Ca	Fe	Si	Al	Pd	Rh
$T_B/^oC$	1420	1535	2355	2327	>2200	2500
Element	Ru	Pt	Ir	Os	Ag	Au
$T_B/^oC$	4150	4300	> 4800	> 5300	1950	2600

Table 2.1: Boiling temperatures of elements appearing in the samples of Hudson.

Cummings Microscopy, Diffraction Microscopy, and Fluorescent Microscopy were applied and the final conclusion was that there was nothing left in the sample in spectroscopic sense.

After this Hudson returned to emission spectroscopy but lengthened the time of exposure to electric field by surrounding the lower Carbon electrode with Argon gas so that it could not burn. This allowed to reach exposure times up to 300 s. The sample was silent up to 90 s after which emission lines of Palladium (Pd) appeared; after 110 seconds Platinum (Pt); at 130 seconds Ruthenium (Ru); at about 140-150 seconds Rhodium; at 190 seconds Iridium; and at 220 seconds Osmium appeared. This is known as fractional vaporization.

Hudson reports the boiling temperatures for the metals in the sample having in mind the idea that the emission begins when the temperature of the sample reaches boiling temperature inspired by the observation that elements become visible in the order which is same as that for boiling temperatures.

The boiling temperatures for the elements appearing in the sample are given by **Table 6.2**.

Hudson experimented also with commercially available samples of precious metals and found that the lines appear within 15 seconds, then follows a silence until lines re-appear after 90 seconds. Note that the ratio of these time scales is 6. The presence of some exotic form of these metals suggests itself: Hudson talks about mono-atomic elements.

Hudson studied specifically what he calls mono-atomic gold and claims that it does not possess metallic properties. Hudson reports that the weight of mono-atomic gold, which appears as a white powder, is 4/9 of the weight of metallic gold. Mono-atomic gold is claimed to behave like super-conductor.

Hudson does not give a convincing justification for why his elements should be mono-atomic so that in following this attribute will be used just because it represents established convention. Hudson also claims that the nuclei of mono-atomic elements are in a high spin state. I do not understand the motivations for this statement.

Remark: More than decade after writing this text (I am writing this 2018) I realized that Hudson's claim about high spin nuclei could make sense in TGD framework. If some valence nucleons inside nucleus, say neutrons in the halo, are dark - just as valence electrons in the model for the findings of Hudson - in the sense of having non-standard value $h_{eff}/h_0 = n$ of Planck constant, the unit for the quantization of angular momentum increases for them. The most plausible identification of the ordinary Planck constant is as $h = 6h_0$ [L13, L21] so that the unit of angular momentum would become $(n/6)\hbar/2$ for these exotic nuclei, and one could understand the large values of nuclear angular momenta.

Claims of Hudson about ORMEs as super conductors

The claims of Hudson that ORMES are super conductors [H7] are in conflict with the conventional wisdom about super conductors.

1. The first claim is that ORMEs are super conductors with gap energy about $E_g = .05$ eV and identifies photons with this energy resulting from the formation of Cooper pairs. This energy happens to correspond one of the absorption lines in high T_c superconductors.

2. ORMEs are claimed to be super conductors of type II with critical fields H_{c1} and H_{c2} of order of Earth's magnetic field having the nominal value $.5 \times 10^{-4}$ Tesla [H7]. The estimates for the critical parameters for the ordinary super conductors suggests for electronic super conductors critical fields, which are about .1 Tesla and thus by a factor $\sim 2^{12}$ larger than the critical fields claimed by Hudson.

3. It is claimed that ORME particles can levitate even in Earth's magnetic field. The latter claim looks at first completely nonsensical. The point is that the force giving rise to the levitation is roughly the gradient of the would-be magnetic energy in the volume of levitating super conductor. The gradient of average magnetic field of Earth is of order B/R, R the radius of Earth and thus extremely small so that genuine levitation cannot be in question.

Minimal model

Consider now a possible TGD inspired model for these findings assuming for definiteness that the basic Hudson's claims are literally true.

1. In what sense mono-atomic elements could be dark matter?

The simplest option suggested by the applicability of emission spectroscopy and chemical inertness is that mono-atomic elements correspond to ordinary atoms for which valence electrons are dark electrons with large value of $r = \hbar/\hbar_0$. Suppose that the emission spectroscopy measures the energies of dark photons from the transitions of dark electrons transforming to ordinary photons before the detection by de-coherence increasing the frequency by r. The size of dark electrons and temporal duration of basic processes would be zoomed up by r.

Since the time scale after which emission begins is scaled up by a factor 6, there is a temptation to conclude that $r = 6$ holds true. Note that $n = 6$ corresponds to Fermat polygon and is thus preferred number theoretically in TGD based model for preferred values of $\hbar$ [K81]. The simplest possibility is that the group G_b is trivial group and $G_a = A_6$ or D_6 so that ring like structures containing six dark atoms are suggestive.

This brings in mind the model explaining the anomalous conductivity of DNA by large $\hbar$ valence electrons of aromatic rings of DNA. The zooming up of spatial sizes might make possible exotic effects and perhaps even a formation of atomic Bose-Einstein condensates of Cooper pairs. Note however that in case of DNA $r = 6$ not gives only rise to conductivity but not super-conductivity and that $r = 6$ cannot explain the claimed very low critical magnetic field destroying the super-conductivity.

2. Loss of weight

The claimed loss of weight by a factor $p \simeq 4/9$ is a very significant hint if taken seriously. The proposed model implies that the density of the partially dark phase is different from that of the ordinary phase but is not quantitative enough to predict the value of p. The most plausible reason for the loss of weight would be the reduction of density induced by the replacement of ordinary chemistry with $r = 6$ chemistry for which the Compton length of valence electrons would increase by this factor.

3. Is super-conductivity possible?

The overlap criterion is favorable for super-conductivity since electron Compton lengths would be scaled up by factor $n_a = 6, n_b = 1$. For $r = \hbar/\hbar_0 = n_a = 6$ Fermi energy would be scaled up by $n_a^2 = 36$ and if the same occurs for the gap energy, T_c would increase by a factor 36 from that predicted by the standard BCS theory. Scaled up conventional super-conductor having $T_c \sim 10$ K would be in question (conventional super-conductors have critical temperatures below 20 K). 20 K upper bound for the critical temperature of these superconductors would allow 660 K critical temperature for their dark variants!

For large enough values of r the formation of Cooper pairs could be favored by the thermal instability of valence electrons. The binding energies would behave as $E = r^2 Z_{eff}^2 E_0/n^2$, where Z_{eff} is the screened nuclear charge seen by valence electrons, n the principal quantum number for the valence electron, and E_0 the ground state energy of hydrogen atom. This gives binding energy smaller than thermal energy at room temperature for $r > (Z_{eff}/n)\sqrt{2E_0/3T_{room}} \simeq 17.4 \times (Z_{eff}/n)$. For $n = 5$ and $Z_{eff} < 1.7$ this would give thermal instability for $r = 6$.

Interestingly, the reported .05 eV infrared line corresponds to the energy assignable to cell membrane voltage at criticality against nerve pulse generation, which suggests a possible connection with high T_c superconductors for which also this line appears and is identified in terms of Josephson energy. .05 eV line appears also in high T_c superconductors. This interpretation does not exclude the interpretation as gap energy. The gap energy of the corresponding BCS super-conductor would be scaled down by $1/r^2$ and would correspond to 14 K temperature for $r = 6$.

Also high T_c super-conductivity could involve the transformation of nuclei at the stripes containing the holes to dark matter and the formation of Cooper pairs could be due to the thermal instability of valence electrons of Cu atoms (having $n = 4$). The rough extrapolation for the critical temperature for cuprate superconductor would be $T_c(Cu) = (n_{Cu}/n_{Rh})^2 T_c(Rh) = (25/36)T_c(Rh)$. For $T_c(Rh) = 300$ K this would give $T_c(Cu) = 192$ K: accoding to Wikipedia cuprate perovskite has the highest known critical temperature which is 138 K. Note that quantum criticality suggests the possibility of several values of (n_a, n_b) so that several kinds of super-conductivities might be present.

ORMEs as partially dark matter, high T_c super conductors, and high T_c super-fluids

The appearance of .05 eV photon line suggest that same phenomena could be associated with ORMEs and high T_c super-conductors. The strongest conclusion would be that ORMEs are T_c super-conductors and that the only difference is that Cu having single valence electron is replaced by a heavier atom with single valence electron. In the following I shall discuss this option rather independently from the minimal model.

1. ORME super-conductivity as quantum critical high T_c superconductivity

ORMEs are claimed to be high T_c superconductors and the identification as quantum critical superconductors seems to make sense.

1. According to the model of high T_c superconductors as quantum critical systems, the properties of Cooper pairs should be more or less universal so that the observed absorption lines discussed in the section about high T_c superconductors should characterize also ORMEs. Indeed, the reported 50 meV photon line corresponds to a poorly understood absorption line in the case of high T_c cuprate super conductors having in TGD framework an interpretation as a transition in which exotic Cooper pair is excited to a higher energy state. Also Copper is a transition metal and is one of the most important trace elements in living systems [D2]. Thus the Cooper pairs could be identical in both cases. ORMEs are claimed to be superconductors of type II and quantum critical superconductors are predicted to be of type II under rather general conditions.

2. The claimed extremely low value of H_c is also consistent with the high T_c superconductivity. The supra currents in the interior of flux tubes of radius of order $L_w = .4\ \mu$m are BCS type supra currents with large $\hbar$ so that T_c is by a factor 2^{14} ($127 - 113 = 14$ is inspired by the Mersenne hypothesis for the preferred p-adic length scales) higher than expected and H_c is reduced by a factor 2^{-10}. This indeed predicts the claimed order of magnitude for the critical magnetic field.

3. The problem is that $r = 2^{14}$ is considerably higher that $r = 6$ suggested by the minimum model explaining the emission spectroscopic results of Hudson. Of course, several values of $\hbar$ are possible so that internal consistency would be achieved if ORMEs are regarded as a very simple form of living matter with relatively small value of r and giving up the claim about the low value of critical magnetic field.

4. The electronic configurations of Cu and Gold are chemically similar. Gold has electronic configuration $[Xe, 4f^{14}5d^{10}]6s$ with one valence electron in s state whereas Copper corresponds to $3d^{10}4s$ ground state configuration with one valence electron. This encourages to think that the doping by holes needed to achieve superconductivity induces the dropping of these electrons to $k = 151$ space-time sheets and gives rise to exotic Cooper pairs. Also this model assumes the phase transition of some fraction of Cu nuclei to large $\hbar$ phase and that exotic Cooper pairs appear at the boundary of ordinary and large $\hbar$ phase.

   More generally, elements having one electron in s state plus full electronic shells are good candidates for doped high T_c superconductors. Both Cu and Au atoms are bosons. More generally, if the atom in question is boson, the formation of atomic Bose-Einstein condensates at Cooper pair space-time sheets is favored. Thus elements with odd value of A and Z

possessing full shells plus single s wave valence electron are of special interest. The six stable elements satisfying these conditions are ^{5}Li, ^{39}K, ^{63}Cu, ^{85}Rb, ^{133}Cs, and ^{197}Au.

2. "Levitation" and loss of weight

The model of high T_c superconductivity predicts that some fraction of Cu atoms drops to the flux tube with radius $L_w = .4$ μm and behaves as a dark matter. This is expected to occur also in the case of other transition metals such as Gold. The atomic nuclei at this space-time sheet have high charges and make phase transition to large $\hbar$ phase and form Bose-Einstein condensate and superfluid behavior results. Electrons in turn form large $\hbar$ variant of BCS type superconductor. These flux tubes are predicted to be negatively charged because of the Bose-Einstein condensate of exotic Cooper pairs at the boundaries of the flux tubes having thickness $L_e(151)$. The average charge density equals to the doping fraction times the density of Copper atoms.

The first explanation would be in terms of super-fluid behavior completely analogous to the ability of ordinary superfluids to defy gravity. Second explanation is based on the electric field of Earth which causes an upwards directed force on negatively charged BE condensate of exotic Cooper pairs and this force could explain both the apparent levitation and partial loss of weight. The criterion for levitation is $F_e = 2eE/x \geq F_{gr} = Am_pg$, where $g \simeq 10$ m^2/s is gravitational acceleration at the surface of Earth, A is the atomic weight and m_p proton mass, E the strength of electric field, and x is the number of atoms at the space-time sheet of a given Cooper pair. The condition gives $E \geq 5 \times 10{-}10Ax$ V/m to be compared with the strength $E = 10^2 - 10^4$ V/m of the Earths electric field.

An objection against the explanation for the effective loss of weight is that it depends on the strength of electric field which varies in a wide range whereas Hudson claims that the reduction factor is constant and equal to 4/9. A more mundane explanation would be in terms of a lower density of dark Gold. This explanation is quite plausible since there is no atomic lattice structure since nuclei and electrons form their own large $\hbar$ phases.

4. The effects on biological systems

Some monoatomic elements such as White Gold are claimed to have beneficial effects on living systems [H7]. 5 per cent of brain tissue of pig by dry matter weight is claimed to be Rhodium and Iridium. Cancer cells are claimed to be transformed to healthy ones in presence of ORMEs. The model for high T_c super conductivity predicts that the flux tubes along which interior and boundary supra currents flow has same structure as neuronal axons. Even the basic length scales are very precisely the same. On basis of above considerations ORMEs are reasonable candidates for high T_c superconductors and perhaps even super fluids.

The common mechanism for high T_c, ORME- and bio- super-conductivities could explain the biological effects of ORMEs.

1. In unhealthy state superconductivity might fail at the level of cell membrane, at the level of DNA or in some longer length scales and would mean that cancer cells are not anymore able to communicate. A possible reason for a lost super conductivity or anomalously weak super conductivity is that the fraction of ORME atoms is for some reason too small in unhealthy tissue.

2. The presence of ORMEs could enhance the electronic bio- superconductivity which for some reason is not fully intact. For instance, if the lipid layers of cell membrane are, not only wormhole-, but also electronic super conductors and cancer involves the loss of electronic super-conductivity then the effect of ORMEs would be to increase the number density of Cooper pairs and make the cell membrane super conductor again. Similar mechanism might work at DNA level if DNA: s are super conductors in "active" state.

5. Is ORME super-conductivity associated with the magnetic flux tubes of dark magnetic field $B_d = 0.2$ Gauss?

The general model for the ionic super-conductivity in living matter, which has developed gradually during the last few years and will be discussed in detail later, was originally based on the assumption that super-conducting particles reside at the super-conducting magnetic flux tubes of Earth's magnetic field with the nominal value $B_E = .5$ Gauss. It became later clear that the explanation of ELF em fields on vertebrate brain requires $B_d = .2$ Gauss rather than $B_E = .5$ Gauss [K15]. The interpretation was as dark magnetic field $B_d = .2$ Gauss. The model of EEG led also to the hypothesis that Mersenne primes and their Gaussian counterparts define preferred p-adic length scales and their dark counterparts. This hypothesis replaced the earlier $r = 2^{11k}$ hypothesis.

For $r = 2^{127-113=14}$ the predicted radius $L_w = .4\ \mu$m is consistent with the radius of neuronal axons. If one assumes that the radii of flux tubes are given by this length scale irrespective of the value of r, one must replace the quantization condition for the magnetic flux with a more general condition in which the magnetic flux is compensated by the contribution of the supra current flowing around the flux tube: $\oint(p - eA) \cdot dl = n\hbar$ and assume $n = 0$. 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.

The most natural interpretation would be that these flux tubes topologically condense at the flux tubes of B_E. Both bosonic ions and the Cooper pairs of electrons or of fermionic ions can act as charge carriers so that actually an entire zoo of super-conductors is predicted. There is even some support for the view that even molecules and macromolecules can drop to the magnetic flux tubes [K22].

Nuclear physics anomalies and ORMEs

At the homepage of Joe Champion [H19] information about claimed nuclear physics anomalies can be found.

1. The first anomaly is the claimed low temperature cold fusion mentioned at the homepage of Joe Champion. For instance, Champion claims that Mercury (Z=80), decays by emission of proton and neutrons to Gold with Z=79 in the electrochemical arrangement described in [H19].

2. Champion mentions also the anomalous production of Cadmium isotopes electrochemically in presence of Palladium reported by Tadahiko Mizuno.

The simplest explanation of the anomalies would be based on genuine nuclear reactions. The interaction of dark nuclei with ordinary nuclei at the boundary between the two phases would make possible genuine nuclear transmutations since the Coulomb wall hindering usually cold fusion and nuclear transmutations would be absent (Trojan horse mechanism). Both cold fusion and reported nuclear transmutations in living matter could rely on this mechanism as suggested in [K94, L2, K79].

Possible implications

The existence of exotic atoms could have far reaching consequences for the understanding of bio-systems. If Hudson's claims about super-conductor like behavior are correct, the formation of exotic atoms in bio-systems could provide the needed mechanism of electronic super-conductivity. One could even argue that the formation of exotic atoms is the magic step transforming chemical evolution to biological evolution.

Equally exciting are the technological prospects. If the concept works it could be possible to manufacture exotic atoms and build room temperature super conductors and perhaps even artificial life some day. It is very probable that the process of dropping electron to the larger space-time sheet requires energy and external energy feed is necessary for the creation of artificial life. Otherwise the Earth and other planets probably have developed silicon based life for long time ago. Ca, K and Na ions have central position in the electrochemistry of cell membranes. They could actually correspond to exotic ions obtained by dropping some valence electrons from $k = 137$ atomic space-time sheet to larger space-time sheets. For instance, the $k = 149$ space-time sheet of lipid layers could be in question.

The status of ORMEs is far from certain and their explanation in terms of exotic atomic concept need not be correct. The fact is however that TGD predicts exotic atoms: if they are not observed TGD approach faces the challenge of finding a good explanation for their non-observability.

2.7.3 Wormholes And Super-Conductors

Charged wormhole contacts behave like super conductor

Wormhole contacts are bosons and suffer Bose-Einstein condensation to the ground state at sufficiently low temperatures. Their masses are very small and they are mobile in the directions tangential to the surface of atom. Very light but not exactly massless wormhole contacts look therefore ideal candidates for super conducting charge carriers. The em current of wormhole contacts at the "lower" space-time sheet however corresponds to opposite current on the atomic space-time sheet so that actually motion of dipoles is in question (dipole moment is extremely small). Kind of "apparent" super conductivity is in question, which looks real, when one restricts attention to either space-time sheet only. It should be noticed that the dropping of electrons to lower space-time sheets is not absolutely necessarily for wormhole super conductivity since wormhole contacts can appear as genuine particles. For instance, magnetic fields created by rotating wormhole contacts on the boundaries of magnetic flux tubes are possible.

What is required for macroscopic wormhole super conductivity is the formation of a join along boundaries/flux tube condensate at the atomic space-time sheet: JABs would be replaced also with magnetic flux tubes in the case that Kähler does not allow boundaries. This implies that wormhole contacts move freely in the outer surfaces defined by this condensate. Wormhole contacts condense on ground state since there is large energy gap: for very light wormholes and condensate of size L the order of magnitude for the gap is about π/L. Wormhole contacts can appear as super conducting "charge carriers" also at lower condensate levels. The energy gap allows objects with size of order $10^{-5} - 10^{-4}$ meters in room temperature: later it will be suggested that the largest macroscopic quantum systems in brain are of this size. If the thermalization time for between degrees of freedom associated with different space-time sheets is long, wormhole contacts can form metastable BE condensates also in longer length scales.

It has recently become clear that wormhole contacts can be seen as space-time counterparts for Higgs type particles [K26] so that nothing genuinely new would be involved. Coherent states of wormhole contacts could appear also in the description of the ordinary super-conductivity in terms of coherent states of Cooper pairs and charged Higgs type particles making sense in the zero energy ontology [K72]. Mathematically the coherent states of wormholes and Cooper pairs are very similar so that one can indeed speak about wormhole super-conductivity. For instance, both states are described by a complex order parameter. One can of course ask whether charged wormhole contacts and Cooper pairs could be seen as dual descriptions of super-conductivity. This need not be the case since standard Higgs mechanism provides an example of a presence of only wormhole contact Bose-Einstein condensate.

Wormhole magnetic fields as templates for bio-structures?

Wormhole magnetic fields are structures consisting of two space-time sheets connected by wormhole contacts (a more detailed treatment will be found in later chapters). The space-time sheets do not contain ordinary matter and the rotating wormhole contacts near the boundaries of the space-time sheets create magnetic fields of same strength but of opposite sign at the two space-time sheets involved. An attractive possibility is that not only ordinary but also wormhole magnetic fields could correspond to defects in bio super conductors and that they serve as templates for the formation of living matter. DNA and the hollow microtubular surfaces consisting of tubulin molecules are excellent examples of structures formed around defects of type II super conductor. The stripe like regions associated with the defects of superconductor could in turn correspond to wormhole magnetic or Z^0 magnetic fields serving as templates for the formation of cell membranes, epithelial cell sheets and larger structures of same kind.

Super conducting space-time sheets indeed form p-adic hierarchy and same holds true for the sizes of defects characterized by the coherence length ξ in case of super conductors of type II and by the magnetic penetration depth λ in case of super conductors of type I. The assumption that defects correspond to wormhole magnetic fields means that defect is a two-sheeted structure with wormhole magnetic field at larger sheet k cancelling the original magnetic field in the region of defect whereas the upper sheet contains the field as such. If upper sheet k_1 is super-conductor and the penetrating field is below the critical field $B_c(k)$, the field can penetrate only to the sheet k in the region near boundaries of the higher level space-time sheet such that the field strength is so large (by flux conservation) that it exceeds the critical value. This is achieved by the presence of supra currents near the boundaries of the smaller space-time sheet k.

In the case of super conductor of type II penetration occurs as flux tubes in the entire space-time sheet k_1, when the field strength is in the critical range (H_{c_1}, H_{c_2}). This hierarchical penetration in principle continues up to atomic length scales and once can say that defects decompose into smaller defects like Russian doll. It might well be that the fractal structure of defects is a basic architectural principle in bio-systems. Also the amplification of magnetic flux can take place: in this case two sheets contain magnetic fields having opposite directions.

Also defects formed by genuine wormhole magnetic fields are possible: in this case no external field is needed to create the defect. This kind of defects are especially interesting since their 3-space projections need not be closed flux tubes. Topologically these defects are closed as required by the conservation of magnetic flux since the magnetic flux flows from space-time sheet to another one at the ends of the defect behaving like magnetic monopoles.

In the case that the space-time sheets of wormhole magnetic field have opposite time orientations, the particles at the two space-time sheets have opposite inertial energies and it is in principle possible to generate these kind of states from vacuum. A possible interpretation for negative energy particles at the second sheet of the field quantum of wormhole magnetic field is as space-time correlates for holes.

An interesting working hypothesis is that wormhole magnetic fields serve as templates for the formation of bio-structures. The motivations are that defect regions could be regarded as realization for the reflective level of consciousness in terms of fermionic Fock state basis and that the surrounding 3-surface is in super conducting state so that also primitive sensory experiencing becomes possible. One could even say that defects formed by wormhole flux tubes are the simplest intelligent and living systems; that the type of super conductor (I or II) gives the simplest classification of living systems and that systems of type I are at higher level in evolution than systems of type II. A possible example of defects of type II are all linear bio-structures such as DNA, proteins, lipids in the cell membrane, microtubules, etc... Examples of defects of type I would be provided by cell membranes, epithelial sheets and the bilayered structures in the cortex.

How magnetic field penetrates in super conductor?

There are motivations for finding a mechanism for the amplification of magnetic fields although the original motivation coming from attempt to explain the claimed levitation of ORMEs in the Earth's magnetic field has disappeared.

1. Magnetic flux is channelled to flux tubes when it penetrates to super-conductors of type II and the strength of the magnetic field is scaled up roughly as λ/ξ in this process.

2. Cells are known to be sensitive for very weak magnetic fields.

3. TGD proposal for the information storage in terms of topological integers related to magnetic fields also requires that the weak magnetic macroscopic fields prevailing inside brain are somehow amplified to stronger fields in microscopic length scales.

The basic mechanism for the amplification is the current of wormhole contacts induced by external magnetic field at given condensate level, which in turn serves as a source for a secondary magnetic field at higher level. Since the mass of the wormhole contact is very small the resulting current of wormhole contacts and thus the induced secondary magnetic field is strong.

1. The relevant portion of the many sheeted space-time consists of "our" space-time sheet and many sheets above it and at the top is the atomic space-time sheet. At "our" space-time sheet external magnetic field induces em surface current of wormhole contacts at this level. This current is concentrated on 2-dimensional surfaces, which corresponds to the boundaries of 3-surfaces at the previous level of the hierarchy. The interaction of wormhole contacts with the magnetic field is via the vector potential associated with the external magnetic field on "our" sheet. To get rid of unessential technicalities it is useful to assume cylindrical geometry at each space-time sheet: cylindrical surfaces with axis in same direction are considered and the radii of these surfaces get smaller in the higher levels of the topological condensate.

2. Let us study what happens to the wormhole contacts on the cylindrical surface in constant magnetic field in the direction of the cylinder of radius R, when the magnitude of the magnetic field increases gradually. One has to solve d'Alembert type wave equation for the scalar field (describing wormhole contacts on cylinder in the vector potential associated with the external magnetic field, which is constant on the cylinder and in direction of the azimutal coordinate ϕ: $A_\phi = BR/2$. Ground states correspond to the with minimum energy solutions. Vector potential gives just constant contribution to the d'Alembert equation and for small enough values of B the constant, non-rotating solution remains energy minimum. When the condition $eA_\phi = m$, $m = 1, 2, ...$ is satisfied one however gets rotating solution with angular momentum $L_z = m$ with same energy as the original vacuum solution! This implies that at the critical values

$$B_{cr,m} = \frac{(2m+1)}{eR^2} \ , \tag{2.7.1}$$

the solution with $L_z = m$ becomes unstable and is replaced with $L_z = m + 1$ to achieve energy minimum.

3. At the higher condensation level the current of wormhole contacts generate a surface current

$$\begin{aligned} K &= n(\#)ev \ , \\ v &= \frac{m}{RE} \ , \end{aligned} \tag{2.7.2}$$

where $n(\#)$ is surface density of the wormhole contacts and $v = R\omega$ is the velocity of rotating wormhole contacts: v is quantized from the quantization of angular momentum. E is the energy of rotating wormhole. This surface current gives rise to axial magnetic field $B = n(\#)ev$ in the interior of the cylinder at the higher condensate level.

4. The magnetic field can penetrate also to the higher levels of the hierarchy via exactly the same mechanism. At higher levels the requirement that magnetic flux is quantized implies relativistic energies for wormhole contacts (see **Fig.** `http://tgdtheory.fi/appfigures/wormholecontact.jpg` or **Fig. ??** in the appendix of this book) and therefore one has $K = n(\#)ev \simeq n(\#)e$. The magnetic fields at various levels have quantized values not depending much on the original magnetic field!

5. In non-relativistic situation one has $v \simeq eBR/m(\#)$ and the relationship $B(higher) = K$ following from Maxwell equations gives

$$\begin{aligned} B(higher) &= \mu_R(p_1, p_2)B(lower) \ , \\ \mu_R(p_1, p_2) &= \frac{e^2 n(\#)R}{m(\#)} \ . \end{aligned} \tag{2.7.3}$$

Non-relativistic wormhole contacts amplify the magnetic field at the larger space-time sheet by a factor $\mu_R(p_1, p_2)$. $\mu_R(p_1, p_2) \sim 10^6$ is required to explain Hudson's claims if penetration takes place in single step: of course multistep process is also possible. It is useful to express the parameters m and R and $n(\#)$ at given p-adic condensation level in terms of the p-adic length scale $L_e(p)$ as

$$\begin{aligned} m(\#) &= \frac{m_0}{L_e(p)} \ \ m_0 << 1 \ , \\ R &= R_0 L_e(p) \ , \\ v &= \frac{m}{m_0 R_0} << 1 \ , \\ n(\#) &= \frac{n_0}{L^2(p)} \ . \end{aligned} \tag{2.7.4}$$

By fractality the dimensionless numbers m_0, R_0, n_0. should not depend strongly on p-adic condensation level. The expression for the amplification factor $\mu_R(p_1, p_2)$ in non-relativistic case reads as

$$\mu_R(p_1, p_2) = \frac{e^2 n_0 R_0}{m_0} . \qquad (2.7.5)$$

Situation of course becomes relativistic for suitably large values of integer m.

Chapter 3

Bio-Systems as Super-Conductors: Part II

3.1 Introduction

This chapter is devoted to further applications of the theory of high T_c superconductors as quantum critical superconductors involving dark matter hierarchy and large values of h_{eff}. The theory is applied to explain the strange findings about ionic currents through cell membrane, exotic neutrino superconductivity and the notion of cognitive neutrino pair are discussed, and the possibility that superconductivity and Bose-Einstein condensates are involved with atmospheric phenomena is considered.

3.1.1 Strange Behavior Of Cellular Water And Quantal Ionic Currents Through Cell Membrane

The fact that cellular water does not leak out of cell in a centrifugal force suggests that some fraction of water inside cell is in different phase. One explanation is that the nuclei of water inside cell are in doubly dark phase whereas electrons are in singly dark phase (having Compton length of 5 nm and perhaps directly "visible" using recent day technology!) as indeed predicted by the model of high Tc superconductivity. This conceptual framework could explain various findings challenging the notions of ionic pumps.

The empirical findings challenging the notions of ionic pumps and channels, nicely summarized by G. Pollack in his book [I29]. provide a strong support for the notions of many-sheeted space-time and ionic super-conductivity.

1. The selectivity of the cell membrane implies that channels cannot be simple sieves and there must be complex information processing involved.

2. The needed number of pumps specialized to particular ions is astronomical and the first question is where to put all these channels and pumps. On the other hand, if the cell constructs the pump or channel specialized to a given molecule only when needed, how does it know what the pump looks like if it has never seen the molecule? The needed metabolic energy to achieve all the pumping and channelling is huge. Strangely enough, pumping does not stop when cell metabolism stops.

3. One can also wonder why the ionic currents through cell membrane look quantal and are same through cell membrane and silicon rubber membrane.

These observations suggest strongly the presence non-dissipative ionic currents and quantum self-organization. The TGD based explanation would be in terms of high T_c electronic and possibly even ionic superconductivity associated with cell membrane made possible by the large h_{eff} phase for nuclei and electrons in the interior of cell. It however seems that thermal stability conditions allow only protonic Cooper pairs in the model of ionic Cooper pairs based on direct generalization of the model of high T_c electronic super conductivity. This does not however mean that quantal ionic currents would be absent. This empirical input also supports a view about homeostasis as a many-sheeted ionic flow equilibrium controlled by larger space-time sheets with the mediation of massless extremals (MEs) serving as space-time correlates for Bose-Einstein condensates of massless bosons (also of scaled down dark electro-weak bosons and gluons).

In the proposed picture one can understand how extremely low densities of ions and their supra currents can control much higher ion densities at the atomic space-time sheets. The liquid crystal nature of the bio-matter is crucial for the model. This vision allows also much better understanding of the effects of ELF em fields on bio-matter. Also the effects of homeopathic remedies and acupuncture known to crucially involve electromagnetic frequency signatures of chemicals can be understood if homeostasis is based on many-sheeted ionic flow equilibrium.

One can argue that pumps in case of basic ions are needed only when the cell interior and exterior are connected by join along boundaries bonds and that this connection is built only for diagnostic purposes in order to measure the concentrations of ions by measuring the ionic currents by their dissipation. The remote metabolism made possible by many-sheeted lasers reduces further the energy costs when pumping actually occurs. The transfer as Josephson current might apply only to the biologically important ions and pumps might be needed to achieve more efficient transfer also in this case. Pumps (active transport) and channels (passive transport) for more complex polar molecules realized as genetically coded proteins are certainly needed.

How noble gases can act as anesthetes?

Chemically inert noble gases are known to act as anesthetes. Somehow these atoms affect neuronal membrane, probably reducing the nerve pulse activity. A possible explanation is in terms of anomalous weak isospin due to the charged color bonds inside nuclei of noble gas generated in the cellular environment. This bonds carry also em charge so that noble gas atom would behave like ion with nuclear charge Z+1 or Z-1. Also the long ranged color force and dark weak force with range L_w=.2 μm associated with noble gas nuclei in dark phase could be part of the solution of the mystery.

Two models of cell membrane

TGD inspires two views about cell membrane: the wiews need not be contradictory. For the first model cell is far from vacuum extremal, for the second model nearly vacuum extremal with classical Z^0 fields in key role.

1. There are several constraints on the first model coming from the TGD based identification of bio-photons as energy conserving decay products of dark photons and one ends up to a new view about metabolism and gneralization to of the notion of Josephson junction so that Josephson energy includes besides electrostatic energy also the difference of cyclotron energies at two sides of the membrane. It seem that that the first model might be enough when generalized along lines inspired by Pollack's findings about the fourth phase of water.

2. It has been clear from the beginning that the nearly vacuum extremals of Kähler action could play key role key role in living systems. The reason is their criticality making them ideal systems for sensory perception. These extremals carry classical em and Z^0 fields related to each other by a constant factor and this could explain the large parity breaking effects characterizing living matter. The assumption that at least some 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. Contrary to the original believe, this model does not require non-standard value of Weinberg angle and this model and first model allow a hybrid.

3.1.2 TGD Inspired Model For High T_c Superconductivity

The following minimal model looks the most realistic model of high T_c superconductivity found hitherto. It also applies to ions and if the proposal that h_{eff} is proportional to the mass of ion, it predicts same binding energies for all Cooper pairs as their spin-spin interaction energy. This hypothesis predicts universal spectrum of bio-photons energies if they result from dark photons and is motivated by the identification of gravitational Planck constant [K91] with h_{eff}.

1. The general idea is that magnetic flux tubes are carriers of supra currents. In anti-ferromagnetic phases these flux tube structures form small closed loops so that the system behaves as an insulator. Some mechanism leading to a formation of long flux tubes must exist. Doping creates holes located around stripes, which become positively charged and attract electrons to the flux tubes.

2. Usually magnetic field tends to destroy Cooper pairs since it tends to flip the spins of electrons of pair to same direction. In TGD flux quantization comes in rescue and magnetic fields favor the formation of Cooper pairs. If one has two parallel flux tubes with opposite directions of magnetic fluxes with large value of $h_{eff} = nh$, $S = 0$ Cooper pairs with even $L \geq 2$ are favored. This situation is encountered in systems near antiferromagnetic phase transition in small scales leading to formation of sequences of flux loops carrying Cooper pairs. Macroscopic super-conductivity results when the loops are reconnected to two long flux tubes with opposite fluxes. If the magnetic fluxes have same sign, $S = 1$ Cooper pairs with odd $L \geq 1$ are favored.

3.1.3 Hierarchies Of Preferred P-Adic Length Scales And Values Of Planck Constant

TGD inspired quantum biology and number theoretical considerations suggest preferred values for $r = h_{eff}/h$. For the most general option the values of h_{eff} are products and ratios of two integers n_a and n_b. Ruler and compass integers defined by the products of distinct Fermat primes and power of two are number theoretically favored values for these integers because the phases $exp(i2\pi/n_i)$, $i \in \{a, b\}$, in this case are number theoretically very simple and should have emerged first in the number theoretical evolution via algebraic extensions of p-adics and of rationals. p-Adic length scale hypothesis favors powers of two as values of r.

The hypothesis that Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1 + i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241..\}$ (the number theoretical miracle is that all the four p-adic length scales sith $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm) define scaled up copies of electro-weak and QCD type physics with ordinary value of h_{eff} 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 [K15]. This hypothesis - to be referred to as Mersenne hypothesis - replaces the earlier rather ad hoc proposal $r = h_{eff}/h = 2^{11k}$ for the preferred values of Planck constant.

3.1.4 Bose-Einstein Condensates At Magnetic Flux Quanta In Astrophysical Length Scales

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

1. There are several levels of dynamics. In topological condensation the internal dynamics of ions is unaffected and h_{eff} has the ordinary value. For instance, the formation of Cooper pairs involves dynamics at $k_d = 24 = 151 - 127$ level of dark matter hierarchy if one assumes that electrons and Cooper pairs have size given by the cell membrane thickess $L(151)$. Also

the dynamics of ionic Cooper pairs remains unaffected in the topological condensation to magnetic flux quanta obeying $k_d > 24$ dynamics.

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

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

4. These B-E condensates might be favored by the large negative spin interaction energies of spins with the magnetic field (proportional to h_{eff}) so that spontaneous magnetization of the magnetic body becomes possible. This kind or process would make possible for the system to gain energy and angular momentum by feeding charged particles to its magnetic body.

3.1.5 Atmospheric Phenomena And Superconductivity

There is a considerable evidence that various electromagnetic time scales associated with the atmospheric phenomena correspond to those associated with brain functioning. If magnetic sensory canvas hypothesis holds true, this is just what is expected. In this section these phenomena are considered in more detail with the aim being to build as concrete as possible a vision about the dynamics involving the dark matter Bose-Einstein condensates at super-conducting magnetic flux quanta, and membrane like structures near vacuum extremals.

In living matter Bose-Einstein condensates of dark matter at magnetic flux quanta near vacuum extremals carrying both em and Z^0 magnetic fields are in fundamental role. Even neutral atoms with net weak isospin spin which is non-vanishing for nuclei for which proton and neutron numbers are different, couple to the classical Z^0 field so that a plasma like state would be in question.

Tornadoes and hurricanes provide the first example of self-organizing systems which might also correspond to systems for which some space-time sheets are near vacuum extremals. Auroras represent a second phenomenon possibly involving supra currents of Cooper pairs and of exotic ions. Lightnings, sprites and elves might also involve higher levels of dark matter hierarchy. p-Adic length scale hypothesis and the hierarchy of Planck constants provide a strong grasp to these far from well-understood phenomena and allow to build rather detailed models for them as well as to gain concrete understanding about how dark matter hierarchy manifests itself in the electromagnetic phenomena at the level of atmosphere.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L5].

3.2 Empirical Support For Ionic Super-Conductivity As A Fundamental Control Mechanism

The notions of ionic channels and pumps associated with cell membrane are central for the standard cell biology [I43]. 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 [I32, I24, I12, I46, I23]. One of the pioneers in the field has been Gilbert Ling [I32], 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 [I29]) gives an excellent layman summary about the paradoxical experimental results[1].

It was a pleasant surprise to find that these experimental findings give direct support for the role of supercurrents and Josephson currents in biocontrol. In fact, the experimental data lead to an archetype model 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 in principle allows to generalize the model also to the control of the densities of neural atoms and molecules at atomic space-time sheets.

3.2.1 Strange Behavior Of The Intracellular Water

The basic strange feature of cellular interior is related to its gelatinous nature and is in fact familiar for everyone. Although 80 percent of hamburger is water, it is extremely difficult to extract this water out. Ling [I24] 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 dipolar nature of biomolecules 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 [I32]. This cohesion gives rise to liquid [F12] [D9] like structure of water implying among other things layered structures and internal electric fields orthogonal to the plane of the layers [I38, I34, I32]. For instance, cell membranes can be understood as resulting from the self-organization of liquid crystals [K11]. The fundamental importance of electret nature of biomatter was also realized by Fröhlich [I33] 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.

3.2.2 Are Channels And Pumps Really There?

Standard neurophysiology relies strongly on the concepts of what might be called hydro-electro-chemistry. The development of the theory has occurred through gradual improvements saving the existing theory.

The development began from the basic observation that cells are stable gelatinous entities not mixing with the surrounding water. This led to the hypothesis that cell membrane takes care that the contents of the cell do not mix with the cell exterior. It was however soon found that cell membrane allows some ions to flow through. The interaction between theory and experiment led gradually to the notions of ion channel and ion pump, which are still central for the standard paradigm of the cell [I43]. 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 [D9] would have probably led to different ideas about how homeostasis between cell interior and exterior is realized [I38, I34, I32].

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 [I29] 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

[1] I am grateful for "Wandsqueen" for sending me the relevant URL address and for Gene Johnson for very stimulating discussions.

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 [I29] ! 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 [K80] 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 as never met the molecule in question: for instance, antibiotic or curare molecule?

To realize how weird the picture based on channels and pumps is, it is useful to imagine a hotel in which there is a door for every possible client letting only that client through but no one else. This strange hotel would have separate door for every five point five milliard humans. Alternatively, the building would be in a continual state of renovation, new doors being built and old being blocked.

There is however an TGD based objection against this slightly arrogant argument. In TGD framework cell is a self-organizing structure and it might be that there is some mechanism which forces the cell to produce these pumps and channels by self-organization. Perhaps the basic characteristic of quantum control in many-sheeted space-time is that it somehow forces this kind of miracles to occur.

Why pumping does not stop when metabolism stops?

One can also wonder how metabolism is able to provide the needed energy to this continual construction of pumps and channels and also do the pumping. For instance, sodium pump alone is estimated to take 45-50 per cent of the cell's metabolic energy supply. Ling has studied the viability of the notion of the ionic pump experimentally [I32] by exposing cell to a coctail 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 [I47] (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 [I46] 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 [I23] 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 [I12] containing no channel proteins demonstrated that the basic features – including step conductance changes, flickering, ion selectivity, and in-activation– characterized also cell membranes containing no ionic channels.

The in-escapable conclusion forced by these results seems to be that the existing 60-year old paradigm is somehow wrong. Ionic currents and the their properties seem to be universal and depend only on very weakly on the properties of the membrane. This conclusion need not apply to the currents of polar molecules for which genetically coded pump and channel proteins certainly exists. Neither does it imply that pumps and channels could not be used to achieve a more efficient transfer of ions. Pump - and channel proteins seem to be a well-established notion and TGD approach suggests that they serve as Josephson junctions.

This however requires a generalization of the ordinary thermodynamical approach to cell membrane by starting from zero energy ontology and replacing Boltzmann weight with the complex square roots. Chemical potentials giving dominant part to the change of energy as it goes through cell membrane is replaced with the difference of cyclotron energy which is in visible and UV range from the condition that dark EEG photons have energies of bio-photons [K15]. One ends up with a generalization of Josephson junction: the generalized Josephson energy includes besides Coulombic energy difference also the cyclotron energy difference. Dark cyclotron contribution raises the energy scale of.05-.1 eV associated with cell membrane to.5-10 eVs and one can understand the nominal value.5 eV of metabolic energy currency.

3.2.3 Could The Notion Of The Many-Sheeted Space-Time Solve The Paradoxes?

The basic paradoxes are related to the universality of the ionic currents challenging the notion of ionic channels and the absence of metabolically driven chemical pumps assignable to cell membrane. Chemical pumps take care that the differences of the chemical potentials associated with the two sides of the cell membrane remain non-vanishing just like ordinary pump preserves a constant pressure difference. Also "electrical pump" taking care that the potential difference between the cell exterior and interior is preserved is needed. The experiments suggest strongly that both chemical pumps and "electrical pump", if present at all, need very low metabolic energy feed.

Many-sheeted space-time (see **Fig.** `http://tgdtheory.fi/appfigures/manysheeted.jpg` or **Fig.** 9 in the appendix of this book) allows following interpretation for the puzzling findings.

1. What have been identified as pumps and channels are actually ionic receptors allowing the cell to measures various ionic currents flowing through membrane.

2. Pumps are not needed because the cell interior and exterior correspond to disjoint space-time sheets. The currents run only when flux tube (JAB) is formed and makes the current flow possible. The fact that the formation of JABs is quantal process explains the quantal nature of the currents. Channels are not needed because the currents run as supercurrents (also

the cyclotron states of bosonic ions define Bose-Einstein condensates) along cell membrane space-time sheet. The absence of dissipation would explain why so little metabolic energy feed is needed and why the ionic currents are not changed when the cell membrane is replaced by some other membrane. JABs could be formed between the space-time sheets representing lipid layers or between cell exterior/interior and cell membrane space-time sheet. The formation of JABs has also interpretation as a space-time correlate for the generation of quantum entanglement.

Note that the most recent TGD view about JABs differs from the original one. The recent belief is that boundaries- and jus JABs- are not allowed by the boundary conditions: space-time sheets with boundary are replaced with their double covers. Furthermore, elementary particles and also larger systems correspond to space-time regions which as lines of generalized Feynman diagrams have Euclidian signature of the induced metric. This suggests that magnetic flux tubes as deformations of cosmic strings have Euclidian signature of metric too. This is quite possible and in the simplest situation would require that string world sheet has Euclidian signature of the induced metric. JABs in this sense would serve as correlates of quantum entanglement between system that they connect together.

Double cover property means that JABs identified as Kähler magnetic flux tubes have cross section, which are closed surfaces, and thus can carry quantized Kähler magnetic flux. These flux tubes would provide correlates for the magnetic fields known to exist in cosmological scales but no possible in standard cosmology due to the fact that needed currents should be coherent in long scales. For monopole fluxes no currents are needed.

3. The universality of the currents suggests that the densities of current carriers are universal. The first interpretation would be in terms of a ordinary-dark-ordinary phase transition. Ordinary charge carriers at space-time sheets associated with cell interior and exterior would be transformed to dark matter particles at the cell membrane space-time sheet and flow through it as supercurrents and then transform back to ordinary particles (reader is encouraged to visualize the different space-time sheets). This phase transition could give for the currents their quantal character instead of the formation of JABs. Of course, the formation of JABs might be prerequisite for this phase transition.

4. The ion densities in cell interior and exterior are determined by flow equilibrium conditions for currents traversing from super-conducting space-time sheets to non-super-conducting space-time sheets and back. Ion densities would be controlled by super-conducting ion densities by an amplification mechanism made possible by the electret nature of the liquid crystal state. The dissipation by the currents at the atomic space-time sheets associated with cell interior and exterior is very weak by the weakness of the electric fields involved and at cell membrane space-time sheet superconductivity means absence of dissipation.

One must of course be cautious in order to not draw too strong conclusions. Besides basic ions cell membrane is non-permeable to various polar molecules such as the basic building bricks of DNA and amino-acids. 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.

Many-sheeted cell

TGD based model of nerve pulse and EEG relies on the notion of the many-sheeted space-time. There is entire hierarchy of space-time sheets so that one can assign to cell and its exterior atomic space-time sheets forming join-along boundaries condensate of units of size of about 10^{-10} meters, lipid layer *resp.* cell membrane space-time sheets with thickness of order $L(149) \simeq .5 \times 10^{-8}$ meters *resp.* $L(151) \simeq 10^{-8}$ meters, and cellular space-time sheets with size of order few microns. These space-time sheets are certainly not the only ones but the most important ones in the model of EEG and nerve pulse.

1. Water molecules at the atomic space-time sheet can form flux tube condensates and the strange properties of water inside the cell can be understood if these lumps in the cell interior have size larger than the flux tubes connecting atomic space-time sheet of cell interior to that of cell exterior. Liquid crystal structure indeed gives rise to layered crystal like structures of water.

2. Cell membrane space-time sheets have size of order cell membrane thickness and are assumed to be super-conducting. The lipid layers of the cell membrane define space-time sheets of thickness of about 50 Angstrom, which could act as parallel super-conductors connected by Josephson junctions.

3. Cellular space-time sheets have size of order cell size and are multi-ion super-conductors. Also they are connected to each other by flux tubes serving as Josephson junctions. Also charged organic molecules could form super-conductors and be transferred by the same mechanism between cell interior and exterior. In TGD framework also classical Z^0 fields are present and Z^0 super-conductivity is possible and could make possible neutral supra currents and control of the densities of the neutral atoms and molecules.

Neuronal and cellular space-time sheets of size of order cell size are assumed to be parts of the magnetic flux tube like structures associated with Earth's magnetic field. Earth's magnetic field inside organisms could contain closed circuits and it is conceivable that the notion of magnetic circulation containing neural circuitry as a sub-circuitry makes sense. Large value of $\hbar$ makes possible high T_c superconductivity. Only protonic Cooper pairs are possible at room temperature besides electronic and neutrino Cooper pairs using the proposed criterion super conductivity. Bose-Einstein condensates of bosonic ions at cyclotron states define also superconductors and at $k = 4$ level of dark matter hierarchy the cyclotron frequencies in Earth's magnetic field correspond to energies above thermal energy. These frequencies are in alpha band for most biologically relevant bosonic ions.

Electronic Josephson currents through cell membrane oscillate with a frequency which is given by the membrane potential $eV = 70\ meV$: this predicts that the emission of infrared photons as a signature of a living cell. Super currents transform to Ohmic currents when they enter to the atomic space-time sheets.

Also present are "many-sheeted circuits" for which currents flow along super-conducting space-time sheets go to atomic space-time sheets where they flow as very weak Ohmic currents, and run back to super-conducting space-time sheets. The currents flowing in closed circuits traversing both cellular and atomic space-time sheets are in flow equilibrium. Because of the high value of the cell membrane electric field, the ionic currents flowing at cell membrane space-time sheets would give rise to high dissipation. The ohmic currents from the cell exterior to interior can however enter to the super-conducting cell membrane space-time sheet and back to the atomic space-time sheet of the cell interior and thus avoid the dissipation.

This picture suggests that the flow of particles between the cell interior and exterior takes mainly via the cell membrane space-time sheet. This would mean that $k = 169$ cell interior space-time sheet has permanent bridges to the $k = 151$ cell membrane space-time sheet, which in turn has only temporary bridges to the $k = 169$ cell exterior space-time sheets.

The character of the ionic currents through cell membrane is highly relevant for the model of the nerve pulse. The development of the model of nerve [K41] [K41] has taken a long time and the original hypothesis about the decisive role of the ionic Josephson currents turned out to be wrong. The recent version of the model assumes that the reduction of charge entanglement between magnetic body and neuron interior made possible by charged W MEs leads to a exotic ionization of the Ca^{++} Bose-Einstein condensate. Exotic $Ca^{++,+}$ Bose-Einstein condensate reduces the membrane resting potential below the threshold for the generation of nerve pulse. The random generation of JABs makes possible flow of ionic currents and leads to the generation of nerve pulse. One cannot exclude the possibility that a portion of em or Z^0 ME drifting along the axon with the velocity of nerve pulse and connecting cell exterior and cell membrane space-time sheets defines the JAB: in the earlier version of the model Z^0 ME was responsible for the reduction of the membrane potential.

Faraday's law of induction in the many-sheeted space-time forces electrical non-equilibrium

Faraday's induction law in many-sheeted space-time gives strong constraints on the electric fields over the cell membrane region at various space-time sheets. Suppose that cellular space-time sheet and some other space-time sheets, say cellular and cell membrane space-time sheet, are in contact so that one can form a closed loops traversing along both space-time sheets. Faraday's law implies that the rotation of electric field around a closed loop traversing first from cell exterior to interior at cellular space-time sheet, going to the atomic space-time sheet and returning back to cell exterior and down to cellular space-time sheet must be equal to the time derivative of the magnetic flux through this loop. Since magnetic flux cannot grow indefinitely, the time average of this potential difference is vanishing. During the generation of nerve pulse the situation might change but only for a finite duration of time (of order millisecond).

Thus in electrostatic equilibrium there must be same exterior-interior potential difference over all space-time sheets in contact with cellular space-time sheets and the variation of potential difference at cellular space-time sheets induces automatically an opposite variation at other space-time sheets. This means that the supercurrents at cellular space-time sheets can indeed control potential differences at other space-time sheets, in particular at atomic space-time sheets. Faraday's law in the many-sheeted space-time also implies that Ohmic currents at atomic space-time sheets cannot destroy the potential difference except for a finite period of time.

Faraday's law makes also possible a gauge interaction between dark and ordinary matter. The changes of dark matter charge densities induce changes of electric field patterns at dark matter space-time and once JABs are formed between dark matter space-time sheet and space-time sheets at lower level of dark matter hierarchy, closed many-sheeted circuits become possible and voltage differences along space-time sheet at different levels of dark matter hierarchy correspond to each other.

Massless extremals (MEs, topological light rays) serve as correlates for dark bosons. Besides neutral massless extremals (em and Z^0 MEs) TGD predicts also charged massless extremals obtained from their neutral counterparts by a mere color rotation (color and weak quantum numbers are not totally independent in TGD framework). The interpretation of the charged MEs has remained open hitherto. Charged W MEs could induce long length scale charge entanglement of Bose-Einstein condensates by inducing exotic ionization of ionic nuclei. State function reduction could lead to a state containing a Bose-Einstein condensate in exotically ionized state.

In this manner the charge inside neuron and thus by Faraday's law membrane potential could be affected by magnetic body. The generation of nerve pulse could rely on the reduction of the resting potential below the critical value by this kind of mechanism inducing charge transfer between cell interior and exterior. The mechanism might apply even in the scale of magnetic body and make possible the control of central nervous system. Also remote mental interactions, in particular telekinesis, might rely on this mechanism.

Flow equilibrium in many-sheeted space-time

The notion of many-sheeted space-time suggests that cell interior and exterior could be regarded as a system in "many-sheeted flow equilibrium" so that the ion densities at atomic space-time sheets are determined by the ion densities at the super-conducting cellular space-time sheets and by the drift velocities by the basic formula $n_1/n_2 = v_2/v_1$ for flow equilibrium.

1. Cell exterior and interior understood as many-sheeted structures are in ionic flow equilibrium holding true for each ion type. The ionic currents run along circuits which traverse along super-conducting space-time sheets, enter into atomic space-time sheets and back to super-conducting space-time sheets.

2. To understand what is involved consider the simplest possible closed circuit connecting atomic and cellular space-time sheets. The ionic supercurrent $I_{i,s}$ flowing from a super-conducting space-time sheet to the atomic space-time sheet is transformed to Ohmic current $I_{i,O}$ in the atomic space-time sheet and in flow equilibrium one has

$$I_{i,s}(int) = I_{i,s} = I_{i,O}(ext) = I_i(membr) \ .$$

3. Ionic supra curent is sum of two terms.

$$I_{i,s} = I_{i,s|J} + I_{i,s|d} \ .$$

The first term is the oscillatory Josephson current associated with the Josephson junction connecting interior and exterior cellular space-time sheet. The second term is direct supercurrent

$$I_{i,s|d} = \frac{1}{m_i} n_{i,s} \nabla\phi = \frac{n_{i,s}K_i}{m_i} \ ,$$

where ϕ is the phase of the super-conducting order parameter, and m_i is the mass of the ion. K_i is the quantized momentum like quantum number associated of superconducting loop (assuming for simplicity that current is constant).

4. Ionic Ohmic current is equal to

$$I_{i,O}(int) = \frac{n_i(int)q_iE_{int}}{k_i(int)} \ ,$$

$$I_{i,O}(ext) = \frac{n_i(ext)q_iE_{ext}}{k_i(ext)} \ .$$

Here k_i is linear friction coefficient. Since cell exterior and interior are in different internal states, k_i is different for cell interior and exterior. E is the weak internal electric field made possible by liquid crystal property which is also different for the interior and exterior. Flow equilibrium conditions give for the ratio of the ion densities in interior and exterior

$$\frac{n_i(int)}{n_i(ext)} = \frac{v_i(ext)}{v_i(int)} = \frac{E_{ext}}{E_{int}}\frac{k_i(int)}{k_i(ext)} \ .$$

Thus in flow equilibrium the ratio of the internal and external ion densities differs from unity and is determined by the ratio of the ionic drift velocities, which are different in cell interior and exterior.

5. The densities of the super-conducting ions at super-conducting space-time sheet determine the corresponding ion densities at the atomic space-time sheet

$$\frac{n_i(int)}{n_{i,s}} = \frac{v_{i,s}}{v_i(int)} = \frac{K_ik_i(int)}{m_iE_{int}} \ ,$$

$$\frac{n_i(ext)}{n_{i,s}} = \frac{v_{i,s}}{v_i(ext)} = \frac{K_ik_i(ext)}{m_iE_{ext}} \ .$$

Obviously, super-conducting ion densities control the ion densities at the atomic space-time sheets. Very weak electric fields E_{ext} and E_{int} and high values of friction coefficients k_i make possible a large amplification of the superconducting densities to the non-super-conducting ionic densities at atomic space-time sheet. Thus the fact that liquid crystals allowing weak but stable electric fields orthogonal to the layer like structure is crucial for the mechanism.

6. Also flow equilibrium requires metabolism to keep the currents at the atomic space-time sheets flowing. There are two options.
i) Assuming that the current flows through cell membrane as an Ohmic current, the power dissipated in the circuit is equal to

$$P = I_i(int)(V_{int} + V_{memb} + V_{ext}) = I_{i,s}(V_{int} + V_{memb} + V_{ext}) \ .$$

Since supercurrents and thus also Ohmic currents are weak and electric fields are weak in cell interior and exterior, also dissipation can be extremely low in these regions. The dominating and problematic term to the dissipation comes from the membrane potential which is very large.
ii) An alternative option is that the current flows flows through cell membrane region as a

supercurrent by going from atomic to cell membrane space-time sheet and returning back to atomic space-time sheet. This gives

$$P = I_{i,s}(V_{int} + V_{ext}) \ .$$

In this manner huge amount of metabolic energy would be saved and it is quite possible that this is the only sensical manner to understand the experimental results of Ling [I32].

Refinements and generalizations

The proposed oversimplified model allows obviously refinements and variants. For instance, current circuits could run from exterior cellular space-time sheet to cell membrane space-time sheet and run only through the cell interior. In this case only the ionic concentrations in the cell interior would be controlled: this does not look a good idea. This option might be necessary in the case that cell exterior cannot be regarded as an electret carrying weak but stable electric field.

Several super-conducting space-time sheets are probably involved with the control and complex super-conducting circuits are certainly involved. The structure of the cell interior suggests a highly organized ohmic circuitry. In particular, cytoskeleton could be important carrier of currents and atomic space-times sheets of the microtubules could be in crucial role as carriers of the ohmic currents: there is indeed electric field along microtubule. The collagenous liquid crystalline networks [I38, I34] are excellent candidates for the carriers of weak ohmic currents in the inter-cellular tissue. Fractality suggests that also structures like proteins, DNA and microtubules are in a similar flow equilibrium controlled by super-conducting ion densities at protein/DNA/microtubule space-time sheets and probably also larger space-time sheets.

Bioelectromagnetic research provides a lot of empirical evidence for the existence of the direct current ohmic circuits, mention only the pioneering work of Becker and the work of Nordenström [J11, J12]. For instance, these direct currents are proposed to be crucial for the understanding of the effects of the acupuncture. The ancient acupuncture, which even now is not taken seriously by many skeptics, could indeed affect directly the densities and supercurrents of ions at super-conducting space-time sheets and, rather ironically, be an example of genuine quantum medicine.

Explanation of the paradoxes in terms of many-sheeted space-time

The qualitative predictions of the flow equilibrium model conform with the experimental facts discussed above.

1. One can understand how a gelatinous lump of matter can be a stable structure if the interior of the cell is in a gelatinous state in length scales larger than the size of the Josephson junctions at atomic space-time sheet. This means that water inside cell consists of coherent lumps larger than the size of Josephson junction and cannot leak to the exterior. If the exterior of the cell forms single large space-time sheet or consists of sheets connected by Josephson junctions with size larger than the typical size for the coherent lumps of water in cell exterior, cell exterior behaves like ordinary mixture of water and chemicals.

2. The amplification mechanism of supercurrents relying crucially on liquid crystal property implies that although liquid crystal pumps and metabolism are needed, the amount of metabolic energy can be extremely small. Absolutely essential is however that ohmic currents run through the super-conducting short circuit provided by the cell membrane space-time sheet.

3. The currents for various ions do not depend at all on the properties of the cell membrane but are determined by what happens on cellular and other superconducting space-time sheets. In flow equilibrium supercurrents and Josephson currents are identical with currents through cell membrane at atomic space-time sheet. The observed quantal nature of the ionic currents supports their interpretation as faithful atomic level images of supercurrents.

4. Since various ionic currents at the cellular space-time sheets dictate the ionic currents at the atomic space-time sheets, the selectivity of the cell membrane would seem to be only an apparent phenomenon. One must however be very cautious here. The self-organizing cell membrane might have the virtue of being co-operative and develop gradually structures

which make it easier to establish the flow equilibrium. For large deviations from the flow equilibrium, ohmic currents are expected to flow through the atomic space-time sheet associated with the cell membrane since super-conducting currents become overcritical and super-conductivity is spoiled. Also the proteinic Josephson junctions between lipid layer space-time sheets might be crucial. Thus the notions of channel and pump proteins might make sense in the far from flow equilibrium regime where the currents though membrane region are dominantly ohmic.

To sum up, one could see super-conducting space-time sheets as controllers of the evolution of the cellular and other biological structures and the model of organism could be specified to some degree in terms of the densities and currents of the super-conducting particles at various space-time sheets besides the values quantized magnetic fluxes associated with various many-sheeted loops. Setting up the goal at controlling space-time sheets would force the atomic space-time sheets to self-organize so that the goal is achieved. This clearly provides a quantum mechanism of of volition. A fascinating challenge is to apply this vision systematically to understand morphogenesis and homeostasis.

Needless to say, the notion of many-sheeted current circuitry would have also revolutionary technological implications since all undesired dissipative effects could be minimized and currents at atomic space-time sheets would be used only for heating purposes! Of course, many-sheeted current circuitries would also make possible quantum computer technologies.

Bio-control as a control of quantum numbers characterizing supercurrents

The magnetic quantum numbers K_i which together with the densities of super-conducting ions characterize the densities of various ions at atomic space-time sheets. Thus magnetic quantum numbers associated with super-conducting circuits formed by magnetic flux tubes indeed characterize biological information as speculated already more than decade ago on basis of mathematical necessity. Direct ohmic currents and supercurrents determine these quantum numbers only partially since in super-conducting circuit integer valued magnetic flux can flow without any induced current in the circuit. In presence of dissipation the currents in super-conducting circuit are minimal needed to guarantee quantized flux through the circuit.

In this picture biocontrol boils down to the changing of the various integers characterizing the phase increments over closed superconducting loops. If nerve pulse involves induction of supra curent compensating the deviation of the magnetic flux in circuit from integer multiple of flux quantum, this can be achieved. The coupling of super-conducting circuits with MEs makes it possible for MEs to affect the magnetic quantum numbers by time varying or constant magnetic fields.

1. If dissipation is slow, supercurrents and thus also ionic concentrations can suffer a large change and the homeostatis of neuron changes for a period determined by the rate of dissipation for supercurrents.

2. The induced a supercurrent could also dissipate rapidly to minimal supercurrent required by the quantization of the magnetic flux: the quantized part of the magnetic flux of external perturbation penetrates to super-conductor and is expected to affect the super-conducting part of the system. This does not of course occur permanently for oscillating em fields. The deviation of the external magnetic flux from a quantized value is coded to a small supercurrent. This mechanism combined with stochastic resonance possible for SQUID type circuits [D32] makes it possible to "measure" extremely weak magnetic fields of MEs by amplifying them to biological effects.

   MEs can also form junctions (possibly Josephson-) between two super-conducting circuits. In this case a constant electric field associated by ME defines the frequency of the induced Josephson current: the weaker the potential difference, the slower the oscillation period. This mechanism might explain why the effects of ELF em fields in living matter occur in intensity windows.

The role of the cell membrane

What is the role of the cell membrane in TGD inspired picture about cell? Very much what it is found to be. Cell membrane recognizes various organic molecules, interacts with them, and possibly allows them to go through. A protein in the cell membrane might act as an effective channel or pump but this function would be only apparent in case of ions. Only if cell membrane space-time sheet has join along boundaries bonds/magnetic flux tubes contacts with the cell interior, can ions and proteins enter cell interior through the membrane space-time sheet. One must also consider very seriously the possibility that cell membrane space-time sheet is a carrier of supercurrents participating in the control of the physics at atomic space-time sheets.

This vision conforms with a computer-ageist view about cell membrane as an interface between computer and clients. Against the fact that tools (proteins) and symbols (DNA) emerge already at atomic length scale, it would indeed seem rather strange that cell would reduce to a bag of water containing mixture of chemicals. This view conforms also with fractality. Skin is the largest connected part of the nervous system and cell membrane could be also seen as the skin of neuron and thus a part of the nervous system of cell, specialized to receive signals from the external world.

In this vision cell is much more like a living, intelligent computer than a sack of ion-rich water, and cell membrane is its interface with the external world. Proteins and biomolecules are messages/messengers, and cell membrane allows them to attach to the receptor only if a number of conditions are satisfied.

In many cases it is not necessary for the messenger to continue its travel to the interior since electromagnetic and electromechanical communications with the cell nucleus are possible by liquid crystal property of cell structures. TGD suggests MEs ("massless extremals") and magnetic flux tubes carrying ionic super-conductors as a universal tool for these communications, and the simplest hypothesis is that the fractally scaled down versions of the communications in the cell length scale are realized also in the interior of the cell and inside cell nucleus, and even at the level of DNA. The interaction of MES and topologically quantized magnetic fields could solve many of the paradoxical features related with the phenomenon of pleiotropy discussed briefly in [K34]. In particular, electromagnetic passwords and commands analogous to computer language commands based on suitable frequency combinations or even amplitude modulated field patterns could be involved. For instance, in case of DNA SQUID type mechanism combined with stochastic resonance could make possible the activation of specified genes by using specific frequency combinations associated with MEs.

3.2.4 Water Memory, Homeopathy, And Acupuncture

Further guidelines for TGD based view about biocontrol and coordination were provided by the empirical evidence for water memory and various effects involved with it [I15] [I16]. In [K19] a detailed mechanism of homeopathy and water memory based on the model of biocontrol in terms of many-sheeted ionic flow equilibrium is discussed.

1. Transfer of homeopathic potency to non-atomic space-time sheets is not enough

Many-sheeted ionic flow equilibrium suggests a possible mechanism of homeopathy: the extremely low densities of homeopathic remedies are at the controlling super-conducting space-time sheets where the control is. Thus homeopathy could be seen as a high precision medicine minimizing the amount of the remedy needed rather than some kind of magic treatment. This cannot be however the whole story. As already explained the study of homeopathic effects suggest an electromagnetic representation of the biomolecules based on frequencies [I8] and it is possible achieve the healing effect by transferring mere frequencies instead of using homeopathic potency.

2. Mechanisms of frequency imprinting and entrainment

According to [I8], the homeopathic remedies seem to be characterized by frequencies varying in the range containing at least the range $10^{-3} - 10^{9}$ Hz suggesting that electromagnetic fields at specific frequencies characterize the homeopathic remedy. These frequencies can be imprinted into water and also erased. Rather remarkably, the removal of Earth's magnetic field erases the imprinted frequencies.

One the other hand, the studies of acupuncture support the existence of certain highly coherent endogenous frequencies [I8] at which em radiation has strong effects. The fact that these frequencies can entrain to exogenous frequencies suggests a mechanism of homeopathy based on entrainment. Effects are observed at pairs of high and low frequencies and the ratio of these frequencies is constant over all acupuncture meridians with a standard derivation of $\pm.15$ per cent. The first branch is at GHz range: in particular the frequencies 2.664 GHz, 1.42 GHz and 384 MHz have unexpected properties. The second branch of frequencies is in ELF range, in particular Schumann frequency 7.8 Hz accompanies 384 MHz.

Consider now the explanation of the observations of Smith and others in in TGD framework using the proposed model assigning to magnetic flux tubes parallel MEs making magnetic flux tube effectively a magnetic mirror.

1. The basic idea is that water forms representations for chemicals it contains in terms of transition frequencies of the chemical which become frequencies of MEs and structures of water generating these MEs by emission and absorption processes. Also representations of representations are possible. The molecule of a homeopathic potency is characterized by characteristic frequencies associated with its transitions as well as ELF frequencies. Of course, also transitions of a complex formed by molecule of the potency and water molecule could be involved.

   Water represents the transition frequencies of the potency molecule as transition frequencies of water molecules or of structures which correspond to space-time sheets of various sizes. This conforms with the fact that frequency imprinting disappears after thorough drying and returns when water is added and that also bulk water without any potency allows frequency imprinting. In the frequency range studied by Smith rotational transition frequencies of water and of the space-time sheets containing water in liquid crystal form provide a good candidate for a representational mechanism. ELF frequencies correspond now to the magnetic transitions of these space-time sheets behaving like point like objects in Earth's magnetic field.

2. The simplest assumption is that the ELF branch of the frequency spectrum corresponds to the magnetic transition frequencies in Earth's magnetic field whereas the high frequency branch corresponds to the characteristic frequencies $f = c/L$ of MEs parallel to the magnetic flux tubes. This assumption conforms with the crucial role of Earth's magnetic field in the erasure of the imprinted frequencies. Also the importance of 7.8 Hz Schumann frequency for the heart chakra [I8] can be understood.

   The singly ionized Ca, Ar, and K (all 7.5 Hz for $B = .5 \times 10^{-4}$ Tesla) and Cl (8.5 Hz) have cyclotron transition frequencies near to Schumann frequency. For LC water blobs the ELF frequencies are below 1 Hz and the requirement that water blob has size smaller than radius of magnetic flux tube of Earth's magnetic field allows ELF frequencies down to $1/f \sim 1000$ years so that all biologically relevant length scales are covered. Quite interestingly, the frequency f_h corresponding 1000 years is 20 Hz by the scaling law suggested by Smith and corresponds to the lower bound for audible frequencies and that also language involves subneuronal mimicry by LC water blobs. A fascinating possibility is that subneuronal LC water blobs could be responsible for all biorhythms and be involved also with our long term memories.

3. Frequency entrainment for both ELF and high frequency branches can be understood if both the thickness and length of the magnetic flux tubes are subject to a homeostatic control. The assumption that the total magnetic energy of the flux tube remains constant during the frequency entrainment together with the magnetic flux quantization implies that the ratio S/L of the area S of the magnetic flux tube to its length L remains constant during entrainment. Thus the ratios f_h/f_{ELF} of the magnetic transition frequencies to characteristic frequencies of MEs would be homeostatic invariants in agreement with the empirical findings. The value of the ratio is in good approximation $f_h/f_{ELF} = 2 \times 10^{11}$.

4. The electromagnetic signature of the homeopathic potency corresponds to MEs stimulated by the electromagnetic transitions associated with the potency molecule. Since these frequencies are also transition frequencies for water molecules or space-time sheets contain water in liquid crystal form a resonant interaction is possible and em fields of MEs can be amplified/replicated by the transitions associated with these structures.

5. According to [I8], coherence propagates with a light velocity whereas coherent domain of size L diffuses with a velocity given by the scaling law $v \propto Lf$. In TGD the natural interpretation for the velocity of coherence propagation is as a signal velocity inside ME (possibly representing external em field). v is in turn associated with the motion of ME transversal to some linear structure along it: this effect is not possible in Maxwell's theory since particle-field duality is not realized at the classical level. The velocities are reported to be of order few meters per second and of the same order of magnitude as nerve pulse conduction velocity and phase velocities for EEG waves. This relationship is of the same form as the scaling law which relates together the phase velocity of EEG wave (velocity of EEG ME in TGD framework) and the size L of corresponding structure of brain or body. For instance, scaling law relates the size L for brain structures and corresponding magnetic sensory canvas with much larger size $L_c = c/f$ [K43]. Scaling law would give $v/c = f_{ELF}/f_h$ and velocity of order mm/s for the motion of transversal MEs along magnetic flux tubes: this velocity is considerably smaller velocity than m/s reported in [I8].

A detailed model for various homeopathic effects is discussed in [K19]. The model leads to a generalization of the view about many-sheeted DNA with magnetic mirrors transversal to DNA coding the electromagnetic structure of the organism and allows to understand introns as chemically passive but electromagnetically active genes. Magnetic mirrors provide also a recognition mechanism fundamental for the functioning of the bio-system: consider only the ability of amino-acids to find corresponding RNA triplets, the self assembly of tobacco mosaic virus and the functioning of the immune system. Magnetic mirrors can also serve as bridges between sender and receiver of intent in remote healing and viewing and these processes could be seen as scaled-up version of those occurring routinely endogenously.

3.3 The Roles Of Josephson Radiation, Cyclotron Radiation, And Of Magnetic Body

Before representing any detailed model for hearing, it is good to summarize the vision about the roles of Josephson radiation, cyclotron radiation, and of magnetic body on basis of the proposed general view about qualia and sensory receptors. The representation below is somewhat out of date and the updated and considerably more detailed view can be found in [L4].

3.3.1 The Role Of Josephson Currents

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

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

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

1. If Josephson currents are present during the entire action potential, the entire range of Josephson photons down to frequencies of order 2 kHz range is emitted for the standard value of $\hbar$. The reason is that lower frequencies corresponds to cycles longer than the duration of the action potential. The continuum of Josephson frequencies during nerve pulse makes it possible to induce cyclotron transitions at the magnetic body of neuron or large structure. This would make possible to communicate information about spatial and temporal behavior of the nerve pulse pattern to the magnetic body and build by quantum entanglement a sensory map.

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 3.1: 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.

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

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

from the standard one. For $p = .0295$ one obtains $(r(u), r(d), r(e) = (24.42, 49.85, 15.95)$. The cyclotron frequencies for quarks and electron with masses m(u)=2 MeV, m(d)=5 MeV, and m(e)=.5 MeV are given by **Table 3.1** for the two options. If one assumes that B_{end} defines the upper bound for field strength then he standard option would require both d quark and electron. Gor $d$quark with kHz CD the upper bound for cyclotron frequencies would be 20 kHz which corresponds to the upper limit of audible frequencies.

4. Besides cyclotron frequencies also the harmonics of the fundamental frequencies assignable to quark and electron CDs could be used and in case of musical sounds this looks a highly attractive option. In this case it is now however possible to select single harmonics as in the case of cyclotron transitions so that only the rate of nerve pulses can communicate single frequency. Lorentz transform sub-CD scales up the frequency scale from the secondary p-adic time scale coming as octave of 10 Hz frequency. Also the scaling of $\hbar$ scales this frequency scale.

3.3.2 What Is The Role Of The Magnetic Body?

The basic vision is that magnetic body receives sensory data from the biological body- basically from cell membranes and possibly via genome - and controls biological body via genome. This leaves a huge amount of details open and the almost impossible challenge of theoretician is to guess the correct realization practically without any experimental input. The following considerations try to clarify what is involved.

Is magnetic body really needed?

Libet's findings and the model of memory based on time mirror hypothesis suggests that magnetic body is indeed needed. What is the real function of magnetic body? Is it just a sensory canvas? The previous considerations suggest that it is also the seat of geometric qualia, in particular the pitch of sound should be coded by it. It would be relatively easy to understand magnetic body as a relatively passive sensory perceiver defining sensory map. If one assumes that motor action is like time reversed sensory perception then sensory and motor pathways would be just sensory pathways proceeding in opposite time directions from receptors to the various layers of the magnetic body. Brain would perform the information processing.

Certainly there must exist a region in which the motor and sensory parts of the magnetic body interact. What comes in mind is that these space-time sheets (or actually pairs of space-time sheets) are parallel and generate wormhole contacts between them. This interaction would be assignable to the region of the magnetic body could receive positive energy signals from associative sensory areas and send negative energy signals to motor motor neurons at the ends of motor pathways wherefrom they would propagate to premotor cortex, supplementary motor cortex and to frontal lobes where the abstract plans about motor actions are generated.

Is motor action time reversal of sensory perception in zero energy ontology?

One could argue that the free will aspect of motor actions does not conform with the interpretation as sensory perception in reversed direction of time. On the other hand, also percepts are selected -say in binocular rivalry [J21]. Only single alternative percept need to be realized in a given branch of the multiverse. This makes possible metabolic economy: for instance, the synchronous firing at kHz frequency serving as a correlate for the conscious percept requires a lot of energy since dark photons at kHz frequency have energies above thermal threshold. Similar selection of percepts could occur also at the level of sensory receptors but quantum statistical determinism would guarantee reliable perception. The passivity of sensory perception and activity of motor activity would reflect the breaking of the arrow of time if this interpretation is correct.

What magnetic body looks like?

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

1. The vision about genome as the brain of cell would suggest that active and passive DNA strands are analogous to motor and sensor areas of brain. This would suggests that sensory data should be communicated from the cell membrane along the passive DNA strand. The simplest hypotesis is that there is a pair of flux sheet going through the DNA strands. The flux sheet through the passive strand would be specialized to communicate sensory information to the magnetic body and the flux sheet through the active strand would generate motor action as DNA expression with transcription of RNA defining only one particular aspect of gene expression. Topological quantum computation assignable to introns and also electromagnetic gene expression would be possible.

2. The model for sensory receptor in terms of Josephson radiation suggests however that flux tubes assignable to axonal membranes carry Josephson radiation. Maybe the flux tube structures assigned to DNA define the magnetic analog of motor areas and flux tubes assigned with the axons that of sensory areas.

3. A complex structure of flux tubes and sheets is suggestive at the cellular level. The flux tubes assignable to the axons would be parallel to the sensory and motor pathways. Also microtubules would be accompanied by magnetic flux tubes. DNA as topological quantum computer model assumes and the proposed model of sensory perception and cell membrane level suggests transversal flux tubes between lipids and nucleotides. The general vision about DNA as brain of cell suggest flux sheets through DNA strands.

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

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

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

1. If the external world is represented at part of the magnetic body which is stationary, the rotation of head or body would not affect the sensory representation. This part of the magnetic body would be obviously analogous to the outer magnetosphere, which does not rotate with Earth.

2. The part of the magnetic body at which the sensory data about body (posture, head orientations and position, positions of body parts) is represented, should be fixed to body and change its orientation with it so that bodily motions would be represented as motions of the magnetic , which would be therefore analogous to the inner magnetosphere of rotating Earth.

3. The outer part of the personal magnetic body is fixed to the inner magnetosphere, which defines the reference frame. The outer part might be even identifiable as the inner magnetosphere receiving sensory input from the biosphere. This magnetic super-organism would have various life forms as its sensory receptors and muscle neurons. This would give quantitative ideas about cyclotron frequencies involved. The wavelengths assignable to the frequencies above 10 Hz would correspond to the size scale of the inner magnetosphere and those below to the outer magnetosphere. During sleep only the EEG communications with outer magnetic body would remain intact.

4. Flux quantization for large value of $\hbar$ poses an additional constraint on the model.

   (a) If Josephson photons are transformed to a bunch of ordinary small $\hbar$ photons magnetic flux tubes can correspond to the ordinary value of Planck constant. If one assumes the quantization of the magnetic flux in the form

   $$\int BdA = n\hbar$$

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

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

   $$\oint (p - ZeA)dl = n\hbar \ , \tag{3.3.1}$$

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

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

$$N = \frac{2m}{RZ^2e^2} \tag{3.3.2}$$

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

$$N_i = \frac{2m_i v_i}{RZ_i \sum_k Z_k v_k e^2} . \tag{3.3.3}$$

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

What are the roles of Josephson and cyclotron photons?

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

1. At least cell membrane defines a Josephson junction (actually a collection of them idealizable as single junctions). DNA double strand could define a series of Josephson junctions possibly assignable with hydrogen bonds. This however requires that the strands carry some non-standard charge densities and currents- I do not know whether this possibility is excluded experimentally. Quarks and antiquarks assignable to the nucleotide and its conjugate have opposite charges at the two sheets of the wormhole flux tube connective nucleotide to a lipid. Hence one could consider the possibility that a connection generated between them by reconnection mechanism could create Josephson junction.

2. The model for the photoreceptors leads to the identification of bio-photons 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 receival of sensory data and motor action.

3. The notion of magnetic sensory canvas suggests a different picture. Josephson radiation induces resonant cyclotron transitions at the magnetic body and induces entanglement of the mental images in brain with the points of the magnetic body and in this manner creates sensory maps giving a third person perspective about the biological body. There would be two kind of sensory maps. Those assignable to the external world and those assignable to the body itself. The Josephson radiation would propagate along the flux tubes to the magnetic body.

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

3.3.3 Magnetic Homeostasis And Magnetic Circulation?

The possible importance of the precise value of the local magnetic field for say memetic code [K18] suggests that living matter has learned to control local magnetic field inside magnetic flux tubes just as it controls salt level of biological water.

Variation of the local strength of B_{end}

B_{end} -which is assigned to the magnetic body of particular body part- should scale as $1/\hbar$ to maintain the constant ratio of Josephson and cyclotron frequencies. This predicts hierarchy of cyclotron frequency scales coming in octaves if one accepts that the preferred levels of dark matter hierarchy come as $r = \hbar/\hbar_0 = 2^{k_d}$ with values of k_d fixed by Mersenne hypothesis introduced in introduction and discussed in detail in [K15]. Cell differentiation could lead to the differentiation of the local value of k_d and the value could vary even inside single cell nucleus.

Also a slight variation of the strength of B_{end} for a given value of r is possible. The condition that the ratios of Josephson frequencies and cyclotron frequencies remain constant means that the scalings of B_{end} and membrane resting potential are identical. Also the relative variation of EEG frequency scale would be same as that of the resting potential. The variation of resting potential is 10 per cent as is also that of EEG frequency scale so that this prediction is correct. Since the resting potential is characteristic of cell type [K15], also the value of B_{end} for corresponding part of magnetic body would be such. In the model of hearing the variation of both k_d decomposing the frequencies into octaves and smaller variations of B_{end} allowing to decompose octaves into smaller intervals would make possible to sense the pitch of the sound [K40]. This sense would be essentially a sensory quale assignable to magnetic body.

Magnetic circulation

There is a rather precise analogy with blood flow since both incompressible velocity field of blood and magnetic field are divergenceless: one can imagine magnetic flux to flow along "B-veins" (magnetic flux tubes) along organism or at least CNS. Variation of the magnetic field strength would be forced by the variation of the thickness of the flux tube since magnetic flux is conserved just as the variation of the thickness of blood veins affects blood flow. Artificial small alteration of local magnetic from outside would only interfere with this control.

For instance, alpha peak drifts in Hz range and this could be due the variation of the value of local magnetic field varies as much as 10 per cent. If this variation is due to the homeostatic variation of the local magnetic field, absolute variation should increase for higher frequencies: at the upper end of gamma band it would be 9 Hz. An alternative explanation for drifting is in terms of amplitude modulation: amplitude modulation of frequency f_1 by frequency f implies that original frequency is split to frequencies $f_1 \pm f$. In this case the amplitude of drifting does not depend on frequency.

The analogy with blood flow suggests that one could speak about B-circulation completely analogous to blood circulation: B-circulation could be crucial for bio-system to act as macroscopic quantum system. B-circulation would naturally accompany neural circuitry. It could be also accompany ordinary blood circulation physically or could form an independent system. The association with blood circulation would provide prerequisites for quantum control of also blood circulation and metabolism. The control could be based on MW frequency Josephson currents associated with ELF em fields inducing conformational changes of proteins coherently in large regions in turn giving rise to needed synchronous biochemical self-organization processes.

Temperature dependence of the local magnetic field strength

EEG frequencies are known to change with [I49] [J39] in the sense that the increase of the temperature raises the peak frequency of the power spectrum. This need not mean that the individual EEG frequencies are affected since the distribution of these frequencies could be affected due to the effects on the ionic conductances.

On the other hand, the equilibrium potentials for various ions are proportional to the temperature. In TGD framework this would predict that also EEG frequency scale is proportional to T so that the effect of temperature could be understood at least partially. Of course, very large drop of temperature known to induce sleep EEG involves dropping of higher EEG bands from the spectrum. The maximal reduction of body temperature have been to about 1 degree C and correspond to 10 per cent reduction of absolute temperature. 10 per cent variation is also characteristic variation of EEG band positions.

As far as nerve pulse generation is considered small reduction of temperature should lead to reduced membrane potential and if the value of the potential inducing nerve pulse does not follow, this would lead to a level of arousal. Maybe this could explain the stimulating effect of cold.

The question is whether cyclotron frequency scale follows the scale of the resting potential. If this is not the case, the communications to the magnetic body suffer from temperature changes since resonance conditions are lost. This could partially explain why a serious hibernation leads to a lower level of arousal. Cyclotron frequency scale can follow the change of the temperature as long as the transversal size scale of the magnetic flux quanta can react on the changes of the temperature and by flux conservation induce a change of the magnetic field strength. It is however highly questionable whether this is possible at distant parts of the magnetic body if it indeed can have the size scale of Earth.

The results of Blackman [J14] suggesting that ELF effects with given frequency disappear when body temperature is not in the range $36-37$ C inspires the hypothesis that quantum critical high T_c superconductivity and almost vacuum extremal property of the cell membrane space-time sheet are possible only in the range 36-37 C. This obviously provides a more plausible explanation for the effect of hibernation. In this picture the extreme importance of temperature regulation for the functioning of organism could be seen as a prerequisite for continual quantum control by magnetic transition frequencies.

Circadial temperature variation can be something like 20 Kelvins, which means relative variation about 10 per cent for poikilotherms, which is of same order as alpha frequency drifting. The relative width of the cyclotron resonance would be from this about 7 per cent ($\Delta f/f = \Delta B/B \propto \Delta T/T$). The relative variation of the membrane resting potential as a function of temperature is predicted to be sam.

Why the increase of the local magnetic field strength by factor of ten does not raise alpha band to heaven?

The increase of the local magnetic field strength by a factor $10-20$ is known to induce stress [J17] and confuse biological timekeeper mechanisms but it certainly cannot raise alpha band above 100 Hz as as a very naïve standard physics based application of the cyclotron frequency hypothesis would suggest.

In standard physics picture one could indeed argue that the increase of the strength of the local magnetic field interferes directly with bio-control and has catastrophic consequences. This is not the case of B_{end} corresponds to so large value of Planck constant that cyclotron energy corresponds to the energy of visible or UV photon and if the local magnetic field corresponds to the ordinary (or just different) value of Planck constant. That the variation local magnetic field has effect can be understood if the flux tubes of the dark magnetic field B_{end} are in contact with the those of the local magnetic field presumably having standard value of Planck constant. This would be classical interaction between visible and dark sectors of "world of classical worlds". One can of course imagine also other interaction mechanisms.

3.3.4 Some Remarks And Questions

Synchronizing effect of Earth's magnetic field

Earth's magnetic field could act as grand synchronizer of biorhythms of even separate organisms. Magnetic homeostasis does not prevent the effects due to the variation of Earth's magnetic field on human consciousness.

The close correlation of various cycles of biological and brain activity, in particular sleep-wake cycle, with periodic circadial variations of the geomagnetic field [J17], is consistent with this. Magnetic storms change temporarily the value of the local magnetic field and also this should have effects on consciousness. The statistics about mental hospitals supports this view [J17]. Also Persinger has proposed that the modulations of Earth's magnetic field caused by geomagnetic perturbations have effect on human consciousness [J17, J33]. Michael Persinger has studied extensively the effects of Schumann resonances on brain and has even explained religious and UFO experiences as correlates of this interaction [J33].

Also the diurnal changes of magnetic field caused by Moon having period of 25 hours are known and this variation seems to provide fundamental biological clock which sets on in absence of the normal 24 rhythm regulated by sunlight. The diurnal variations of the geomagnetic field are also responsible for sleep-awake rhythm: the increased melatonin secretion during dark hours correlate with the variation of Earth's magnetic field.

It is also known that the exposure to magnetic fields 10-20 times geomagnetic field induces stress in rabbits and slowed reaction time in humans; that the absence of geomagnetic field leads to a complete de-synchronization of biorhythms and that the synchronization of ELF biorhythms is coupled to ELF geomagnetic pulsations [J17]. In particular, pineal gland serves as biological timekeeper with cyclotron frequency of Co^{2+} ion defining the basic time unit of .1 seconds.

Dr. Phil Callahan [I2] claims on basis of intensive experimental work that there is a tendency of political strifes and wars to concentrate on regions where Schumann resonances are weak. This would not be surprising since Schumann resonances act as collective bio-rhythms if vertebrate brains are connected to the magnetic body of Earth.

3. What happens to astronaut's magnetic body

There is an old objection against the notion of magnetic body. If the local value of Earth's magnetic field is crucial for the brain functioning, astronauts should experience grave difficulties or at least dramatic changes in the character of consciousness. A possible estimate for the weakening of the local magnetic field is based on the scaling law $B \propto 1/r^3$ for dipole field. In this case a rough estimate for the relative change of the EEG frequency scale is $\Delta f/f = 3\Delta R/R \sim 6$ per cent for satellites moving below the ionosphere. This should affect the state of consciousness.

As a matter fact, there is reported evidence [J19, J38] that cosmonauts spending months in MIR had strange altered states of consciousness involving among other things precognition of the difficulties to be countered by MIR and receiving advices and identification experiences with other people and life forms, even dinosaurs of ancient Earth!

In the many-sheeted space-time the situation looks like following.

1. Only the levels k_d for which the size scale is between the size scale of personal magnetic body and the distance travelled could have been affected.

2. Astronauts could have drawn the magnetic flux sheets connecting them to the magnetic body of Earth and higher level magnetic bodies with them but long period could have led to a loss of the connections to the magnetic body of Earth.

3. At the level of cell nuclei nothing dramatic need happen. Energetically the stretching magnetic flux sheets associated with DNA is not a problem since the energy densities involved are rather tiny. Furthermore, if the flux sheets carry homological monopole flux, they could highly stable against increase of length since they would have magnetic monopole wormhole contacts at their ends.

4. A long period in space without contact with magnetic Mother Gaia might relate to the strange experiences reported by astronauts. One might imagine that the magnetic body of say solar system or even galactic magnetic body replaces Earth's magnetic body as a kind of fundamental reference frame. For instance, the third person perspective could rely on the inner magnetosphere which is at rest with respect to rotating Earth and the outer magnetosphere which does not rotate with Earth would provide even higher level reference system which begins to dominate in this kind of situation.

5. The experiences are consistent with TGD based view about geometric time and possibility of geometric memories extending beyond the duration of individual life cycle. There is also a consistency with Mersenne hypothesis summarized in the introduction and with the vision about long term memory inspired by this hypothesis [K15]. If one takes seriously the report about dinosaurs, which lived for $\sim 10^8$ years ago, the level $k_{eff} = 163 + k_d = 257$, which corresponds to Josephson period of about 10^8 years could have contributed to the conscious experience of astronauts. Therefore $k_d = 94$ characterizes the value of Planck constant as $r = \hbar/\hbar_0 = 2^{k_d}$. $k_{eff} = 257$ is consistent with Mersenne hypothesis. One has $257 = 239 + 18$, where $k_{eff} = 239$ is member of the twin pair $(239, 241)$ of Gaussian Mersennes suggested to be responsible for long term memory. $257-239 = 18$ in turn equals to the difference $107 - 89 = 18$ corresponds to the ratio of hadronic p-adic length scale $k = 107$ and intermediate boson length scale $k = 89$ defined by Mersenne primes. One cannot of course take the individual numbers deadly seriously: what is important the general view about memory based on hierarchy of weak physics assigned to Mersennes and their Gaussian counterparts suggests an explanation for the reported transpersonal memories.

5. What the reduction of Earth's magnetic field means?

The strength of Earth's magnetic field has reduced 50 per cent during last 1.000 years. The fact that an exponential evolution of civilization has occurred during this period, is perhaps not an accident. Surprisingly many magnetic transition frequencies happen to be near to Schumann resonance frequencies which do not depend on the strength of the magnetic field. If the scale of dark magnetic field B_{end} has followed the scale of B_E the the weakening of B_E furing this period has reduced cyclotron frequency spectrum of heavy ions from $3-8$ Hz range to the range $1.5-4$ Hz but leaving the spectrum of Schuman resonances unchanged. Rather remarkably, delta frequencies near 3 Hz correspond to a peak in the frequency spectrum of so called sferics associated with lightning activity [J23].

These observations suggest the emergence of strong interaction between brain and higher levels of the self hierarchy based on spherics and Schumann resonances. Assuming temporal linearity, the reduction of Earth's magnetic field has been 25 per cent after Newton and 5 per cent during last 100 years. Perhaps an exponential development of mathematical consciousness made possible by the activation of cyclotron frequencies of heavy ions with high nuclear and electronic angular momenta and allowing large number of conscious-to-us magnetic transitions, and possibly also involving some kind of fine tuning is taking place.

The weakening of Earth's magnetic field probably relates to a forthcoming change in the polarity of Earth's magnetic field. One might guess that the personal magnetic bodies are not affected appreciably during this period but that the violent change of Earth's magnetic field induces dramatic effects on collective aspects of consciousness at $k_d = 44$ level as the findings of Callahan suggest.

What about spin flips?

The natural question is whether also spin flips to which Larmor frequencies are associated could be important. If anomalous magnetic moment vanishes Larmor frequency differs by a factor 1/2

Ion	(Z, A, S)	f_1/Hz	f_{flip}/Hz	J
Cl	(17, 35, F)	8.5	82.2	3/2
K	(19, 39, F)	7.5	39.1	3/2
Rb	(37, 85, F)	3.5	81.0	5/2
Y	(39, 89, F)	3.4	41.2	1/2
Rh	(45, 103, F)	2.9	26.6	1/2
Ag	(47, 107, F)	2.8	34.2 (39.2)	1/2
Ir	(77, 193, F)	1.6	17.0	3/2
Au	(79, 197, F)	1.5	14.0	3/2

Table 3.2: The ions for which electronic spin vanishes in ground state and minimum spin flip frequency f_{flip} is below 90 Hz. f_{flip} is defined as $f_{min} = 2f_L/J$m, where J is nuclear spin. Ag allows two stable isotopes with almost same abundances and the values of f_{flip} are given for both.

from cyclotron frequency: $f_L = f_c/2$ so that spin flip frequency is same as cyclotron frequency. For atomic nuclei the Larmor frequency tends to be larger than cyclotron frequency as the table of Appendix demonstrates. The effects of em fields in living matter at Larmor frequencies have not been however reported.

The natural expectation is that Larmor frequency behaves in the same manner as cyclotron frequency in the scaling of Planck constant and this is indeed the case since spin scales as $\hbar_{eff}$. This allows to consider the possibility that also spin flip transitions are of interest and perhaps define correlates for sensory qualia.

Spin flip frequencies are in general of order few hundred Hz for $B = .2$ Gauss. The eight ions listed in **Table 3.2** have however exceptionally low Larmor frequencies and, very importantly, the singly ionized states have vanishing electronic spin for all ions except Rh and IR for which electronic configuration corresponds to $J - e = 2/2$ (non-vanishing electronic spin implies that the Larmor frequency of ion is of order $f_L = f_c(e)/2 \simeq 3 \times 10^5$ Hz). This suggests that electromagnetic spin flip transitions for these ions at least could be related to our consciousness. Note that K, Ag and Au have spin flip frequencies near to the harmonics of the fundamental frequencies of exotic super-symplectic representations important in EEG frequency range. Note that the spin flip frequency of K is 39.1 Hz which is in 40 Hz thalamocortical resonance band. The spin flip frequency 82.2 Hz for Cl might relate to the resonance frequency 80 Hz associated with retina.

3.4 Model For Ionic Superconductivity

In this section the model for ionic superconductivity is constructed as a straightforward generalization of the TGD based model of high T_c electronic superconductivity [K9]. There is however a exotic delicacy involved. TGD based model of atomic nucleus predicts that fermionic ions can have bosonic chemical equivalents for which one of the color bonds connecting nucleons to nuclear string is charged. Dark fermionic ions like Na^+, K^+, and Cl^- could appear as Cooper pairs or be exotic ions of this kind having different mass number and be able to form Bose-Einstein condensates.

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

3.4.1 Model For Ionic Superconductivity

TGD leads to a model of electronic super-conductivity based on the notion of magnetic flux tube pair. Exactly the same mechanism is expected to work also in the case of ions and the only differences come from the different mass and charge of ion.

1. The general idea is that magnetic flux tubes are carriers of dark charged particles including

ions and electrons. Usually magnetic field tends to destroy Cooper pairs since it tends to flip the spins of electrons of pair to same direction. In TGD flux quantization comes in rescue and magnetic fields favor the formation of Cooper pairs. If one has two parallel flux tubes with opposite directions of magnetic fluxes with large value of $h_{eff} = n \times h$, $S = 0$ Cooper pairs with even $L \geq 2$ are favored. This situation is encountered in systems near antiferromagnetic phase transition in small scales leading to formation of sequences of flux loops carrying Cooper pairs. Macroscopic super-conductivity results when the loops are reconnected to two long flux tubes with opposite fluxes. If the magnetic fluxes have same sign, $S = 1$ Cooper pairs with odd $L \geq 1$ are favored.

This model applies to both electrons and fermionic ions and if the proposal that h_{eff} is proportional to the mass of ion, it predicts same binding energies for all Cooper pairs as their spin-spin interaction energy. This hypothesis predicts universal spectrum of bio-photons energies if they result from dark photons and is motivated by the identification of gravitational Planck constant [K91] with h_{eff}. In this case binding energies would be in eV range and much above thermal energy at room temperature.

2. Mersenne hypothesis discussed in the introduction is assumed and makes possible precise quantitative predictions using scaling arguments. With the motivation coming from the model of cell membrane as Josephson junction it is also assumed that magnetic field scales as $1/\hbar$ and that the supra currents at the boundaries of flux tubes guarantee that the quantization condition $\oint (p - eA) \cdot dl = 0$ is satisfied. This allows the flux tubes to have a fixed transversal size (cell membrane thickness) irrespective of the value of Planck constant. The original hypothesis was that $B_{end} = 0.2$ Gauss and its p-adically scaled variants powers of two) could define preferred values of endogenous magnetic field. If biophotons result when dark photons with h_{eff} proportional ion mass are ordinary photons, they have a universal energy spectrum in visible and UV range, which directly corresponds to the spectrum of magnetic fields strengths and for flux tubes carrying monopole flux to the spectrum for the thickness of the flux tube. This would suggests effectively continuum of values of B_{end}.

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

3.4.2 Super Conductors Of Exotic Bosonic Counterparts Of Fermionic Ions

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

TGD based nuclear physics [L2] allows this kind of ions. The model indeed predicts the possibility of exotic nuclei for which one or more color bonds connecting nucleons to the nuclear string are charged. These exotic nuclei with electronic states identical to those of genuine ions could save the situation. **Table 3.3** describes how cyclotron frequencies for $B = .2$ Gauss of the most important ions are modified in the simplest replacements with exotic ions. For instance, the notation Mg_-^{++} tells that there is double electronic ionization and electron shell of Argon as usual but that one color bond is negatively charged.

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

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

Table 3.3: The modification of cyclotron frequencies of most important ions are modified by simplest replacements with exotic ions

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

Table 3.4: The first columns give the cyclotron frequencies and cyclotron energies for biologically relevant bosonic ions in $B_{end} = .2 \times 10^{-4}$ Tesla. The third column gives cyclotron energy.

3.4.3 More Quantitative Picture About Bose-Einstein Condensates

Cyclotron frequencies of biologically important ions in the endogenous magnetic field $B_{end} = 0.2$ Gauss are involved with the effects of ELF em fields on vertebrate brain and are also central in the model of EEG [K15]. This motivates a more detailed study of these frequencies. Also the cyclotron frequencies of biologically important molecules are interesting.

Bose-Einstein condensates of bosonic ionized atoms

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

1. **For Li$^+$ the dominating isotope ^{7}Li$^+$ is fermion. ^{6}Li$^+$ is boson and its abundance is 5 per cent. Li$^+$ ions are used as medications in mania and represents mood stabilizer [J3]. A possible explanation is that the cyclotron oscillations of Bose-Einstein condensate of ^{6}Li$^+$ ions serve as a biological clock helping to stabilize the mood. The cyclotron frequency is however 50 Hz and higher than thalamocortical resonance frequency having nominal value 40 Hz.**

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

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

2. **For Mg^{2+} cyclotron energy corresponds to the energy of photon of green light. Chlorophyll is not able to convert nutrients to sugar without magnesium, which**

suggests that cyclotron transitions of Mg BE condensate are at least partially responsible for the green color of plants. Mg BE condensate could control the coherent occurrence of photosynthesis in the size scale of plant.

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

4. Ca^{2+} ions play a unique role in the functioning of living matter. In particular, calcium waves appearing in a wide range of time scales are known to serve a crucial role in nervous system [J32]. Ca^{2+} corresponds to.99 eV cyclotron energy scale, which is twice the energy of metabolic energy quantum. Hence one can ask whether the cyclotron transitions of Ca^{2+} BE condensate could induce a collective emission of metabolic energy quanta and in this manner induce coherent metabolic activity in the scale of entire body.

5. The cyclotron frequencies Mn, Fe, Co, Cu, and Zn are in alpha band and corresponding cyclotron energies are somewhat above metabolic energy quantum. These energy quanta could drive protons from larger space-time sheet to $k = 137$ atomic space-time sheet. 10 Hz frequency is known to define an important biological clock and Co ions could be essential for the functioning of this clock. $n = 3$ multiple of Co^{2+} cyclotron frequency corresponds to the 30 Hz threshold of gamma band known to be important for cognition. Also $3f_c(Fe^{2+}) = 32.2$ Hz and $3f_c(Mn^{2+}) = 34.2$ belong to gamma band. The presence of Bose-Einstein condensates of these ions in length scale of $5L(212) = 141$ km could mean that these bio-rhythms are shared by different organisms inside regions of this size.

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

Cyclotron frequencies and Schumann frequencies

Even in the case that Cooper pairs of fermionic ions are not thermally stable, the cyclotron transitions of fermionic ions like K^+, Cl^-, and Na^+ are expected to be important. In Table 3.5 cyclotron frequencies and energies of some fermionic ions are given. Notice that the cyclotron energy of K^+ ion corresponds to metabolic energy quantum. Quite generally fermionic ions cannot be involved with the generation of Josephson part of EEG.

The first thing to notice is the close relationship of cyclotron frequencies with the lowest resonance frequencies in the spectrum of geo-electromagnetic field starting from 5 Hz, so called Schumann frequencies [F6], are $7.8, 14, 20, 26, 33, 39$ and 45 Hz. 5 Hz corresponds roughly to the threshold 4 Hz of theta frequency range below which EEG spectrum lies during sleep which suggests that wake-up state involves the coupling of brain with geo-electro-magnetic activity. 7.8 Hz corresponds to the threshold for alpha waves associated with wake-up state without cognition; 14 Hz corresponds to threshold of 13 Hz for beta waves accompanying cognitive activities, and 33 Hz is quite near to the threshold 30 Hz for gamma waves known to be important in the temporal coding of sensory data.

Consider now examples of cyclotron frequencies keeping in mind that Schumann frequencies vary typically within 1 Hz interval around their mean values [F6].

1. As already noticed, the frequencies, which are multiples of 15 Hz can be assigned to Ca^{2+} ion. The excitations $n = 3, 5, 7, ..$ correspond to the frequencies

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

Table 3.5: The first columns give cyclotron frequencies and corresponding cyclotron energies for some ions in $B_{end} = .2 \times 10^{-4}$ Tesla for some fermionic ions.

$45, 75, 105, ...$ **Hz. All these frequencies have been observed. The two lowest frequencies correspond to Schumann frequencies 14 and 45 Hz with accuracy of 1 Hz.**

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

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

3. K_+ **has** $A = 39$ **and gives** $f = 7.5$ **Hz, which is theta frequency rather near to the lowest Schumann resonance frequency 7.8 Hz.** K_+ **ion flux could correlate with em fields in the range of the alpha frequencies creating cyclotron resonance. Theta activity dominates during sleep and Adey's observations [J17] demonstrate that 7 Hz ELF field increases reaction times. Second and third transition frequencies are within 1.5 Hz Schumann frequencies 20 and 37.5 Hz.**

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

5. Fe^{2+} **has** $A = 56$ **and corresponds to** 10.7 **Hz.** $3f_c(Fe^{2+}) = 32.2$ **Hz is rather near to Schumann frequency 33 Hz whereas** Co^{2+} **corresponds to** 10 **Hz in excellent accuracy.** Co **has especially large nuclear magnetic moment and serves as a natural magnet.** Fe^{2+} **and/or** Co^{2+} **could be present in magnetic sensory organ possessed also by humans making it possible to navigate using magnetic fields. Yarrow suggests that** Co **makes** B_{12} **magnetic vitamin [J17] so that it can serve**

as fundamental biological clock at frequency very precisely equal to 10 Hz. Co is carried by B_{12} vitamin and is known to be important for normal consciousness: among other things the lack of B_{12} causes fatigue, blurred vision and cognitive problems.

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

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

What about proton's cyclotron frequency?

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

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

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

Bose-Einstein condensates of bosonic molecular ions

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

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

3.5 Atmospheric Phenomena And Super-Conductivity

There is a lot of evidence that various electromagnetic time scales associated with the atmospheric phenomena correspond to those associated with brain functioning.

If magnetic sensory canvas hypothesis holds true, this is just what is expected. In this section these phenomena are considered in more detail with the aim being to build as concrete as possible vision about the dynamics involving the dark matter Bose-Einstein condensates at super-conducting magnetic flux quanta. If almost vacuum extremals are in question, a strong analogy with living matter is implied and both em and Z^0 fields are present. In case of cell membrane this assumption is highly successful.

One particular consequence is that there is a coupling to left handed weak nuclear isospin proportional to neutron proton difference as well as coupling to nuclear electromagnetic charge Z which dominates for heavier nuclei and gives rather large coupling (here it is essential that atomic electrons do not condense at the almost vacuum extremal). This means that the system behaves like plasma such that all particles have same sign of net weak isospin. Either opposite Z^0 charge carried by neutrinos or ionization is necessary in order to achieve stability. Also large parity breaking is implied in macroscopic length scales. One implication would be vortices with a preferred direction of rotation.

3.5.1 Tornadoes As A Macroscopic Quantum Phenomenon Involving Super-Conductivity?

Tornadoes represent a piece of not completely understood atmospheric physics. To mention just two questions which have received no satisfactory answer.

1. What makes possible the ability of tornado to preserve its structure and coherence?

2. What makes possible the coherent rotation of matter inside tornado?

3. How to understand various luminous phenomena associated with the tornadoes [H8, H1, H22] ?

Classical Z^0 forces and the vision about magnetic flux tubes as bio-superconductors suggests a new approach to the physics of tornados possibly providing also answers to these questions. My own attempts to understand tornadoes have been based on three separate approaches. Tornado as a magnetic spiral vortex carrying em and Z^0 magnetic fields, tornado as an analog of a rotating magnetic system known as Searl device, and tornado as a system for which the interactions between visible and dark matter are essential.

The most recent approach to tornadoes and rotating magnetic systems relies on the recent model of cell membrane as almost vacuum extremal and assumption that tornades could be seen in many respects as p-adically scaled up variants of the axonal membrane. The combination of this line of approach with the earlier ones, probably not mutually consistent in every detail, will be discussed in the sequel.

Tornadoes as magnetic spiral vortices near vacuum extremals?

The basic idea is that tornadoes are a phenomenon involving complex many-sheeted space-time topology and classical em and Z^0 magnetic fields in an essential manner making tornadoes macroscopic quantum systems in meteorological length and time scales.

1. A partial answer to the question relating to the stability and coherence is self-organization, which in fact implies in TGD context that tornado has “self” and is conscious in some primitive sense. In standard physics context the ability of tornado to have a well defined macroscopic structure despite the locally chaotic nature of the hydrodynamic flow involved, is not easy to understand. In particular, self-organization does not as such explain the coherent rotation of the matter inside tornado. The almost vacuum extremal property is characteristic aspect of

cell membrane [K15], which suggests that tornado or at least the boundary layer between exterior and interior of tornado corresponds to almost vacuum extremal so that tornado might be perhaps compared to neuronal axons in some respects. Self organization is indeed associated with strong gradients and the boundary layer certainly represents this kind of region.

2. In TGD framework the answer to the question relating to the rotation of matter inside tornado is that tornado or its boundary corresponds to magnetic flux tube with em and Z^0 magnetic fields -or more generally -a more complex structure consisting of magnetic flux quanta, say a hierarchy of hollow flux tubes inside hollow flux tubes.

3. One expects that these Z^0 ions rotate with almost the same rotation velocity and in the same direction in the Z^0 magnetic field associated with the space-time sheet of the tornado. Although rotation velocities can have both signs, coherent motion in single direction can occur stably and large parity breaking favors the other direction of rotation. Z^0 magnetic field is generated if all screening neutrinos do not co-rotate with the matter or if the screening of nuclear Z^0 charge by neutrinos is not complete. Conducting and super-conducting neutrinos are expected to be unable to follow the rotation of the nuclei whereas the neutrinos below Fermi surface should co-rotate with matter so that Z^0 magnetic field can be generated. Situation is completely analogous to that of an electric conductor.

4. Neutral atoms and molecules are highly charged Z^0 ions with effective charge proportional to nuclear charge if electrons do not condense on almost vacuum extremal. The quantization of em and Z^0 magnetic field of tornado to flux tubes suggests strongly itself and the classical orbits of Z^0 ions in the average Z^0 magnetic field correspond to Z^0 magnetic flux tubes with a helical shape. In the case of tornado these flux tubes are expected to have spiral like structure implied by garden hose instability and provide an example of spiral waves which seem to be a very general phenomenon in excitable media. Just like the flux tubes of the magnetic field, also Z^0 magnetic flux tubes are expected to be super-conducting. One of the first proposals of TGD inspired view about supra phase was that also super-fluidity might involve Z^0 magnetic vortices [K85] but at that time I did not realize that almost vacuum extremals- which I was of course well aware- might be in question.

5. Also the vortices of any hydrodynamic flow could involve Z^0 magnetic boundary layers at least: in particular, the mechanism inducing transition from super-fluidity to ordinary fluid flow is generation of Z^0 magnetic vortices at critical velocities which are much lower than those predicted by hydrodynamical arguments [K85]. The leakage mechanism of radial em or Z^0 supra currents from magnetic flux tubes might be involved with the dissipation and also with sono-luminescence [C1]. Also TGD inspired cosmology and classical view about gravitational fields relies on the approximation that cosmologies can be idealized with vacuum extremals [K103].

To build a more quantitative picture one needs some information about the model for almost vacuum extremals.

1. In the model of cell membrane as almost vacuum extremal electrons are not assumed to condense at the almost vacuum extremal space-time sheets since this would not be consistent with atomic physics. Nuclei however feed their Z^0 charges to these space-time sheets. Neutral atoms for $N-Z>0$ have left-handed weak isospin equal to $(Z-N)/2$ and same vectorial charge proportional to $sin^2(\theta_W)Z$. The classical Z^0 field is for vacuum extremal proportional to em field and this allows to use only em field and effective em charge expressible as

$$Q_{eff} = -\frac{Z-N}{2p} + 2Z + q_{em} \ , \ p = sin^2(\theta_W) \ . \qquad (3.5.1)$$

Z denotes proton number, N neutron number, and q_{em} the charge due to ionization in units of proton charge. What is remarkable that even neutral atoms have large effective em charge due to the charge of protons. There is also an axial coupling to the classsical Z^0 field causing large parity breaking effects. The value of Weinberg angle for almost vacuum extremals is not expected to be same as for far from vacuum extremals. The model for photoreceptors fixes p to be $p = .0295$ to be compared with $p \simeq .23$ for standard model vacuum. Just fixing the value p predicts correctly the frequencies of peak sensitivity for the four types of photoreceptors [K15].

Radiation at visible photon energies is the signature of tornadoes [H5] difficult to understand in the standard physics framework. Also rotating magnetic systems [H21] exhibit similar strange characteristics. Same applies to sonoluminescence [C1]. One can consider two mechanisms generating radiation at visible and UV frequencies.

1. First mechanism is based on Josephson radiation. The almost vacuum extremal property, the suggested membrane like structure at the boundary of tornado, and the hypothesis that scaled up variant of axonal membrane with an appropriate value of Planck constant could in question suggests that there is also an electric field over the membrane. T TGD based model for rotating objects also predicts radial electric field [K103] and there is also a kinematic effect producing this kind of electric field [K4]. From the vanishing of total Lorentz force one has $E = \omega\rho B$, where B is the strength of the magnetic field, ω the angular velocity of rotation, and ρ is the distance from the rotation axes. For $\omega k/\rho$ outside the rotating magnetic system voltage is same for all flux sheets and voltage is

$$V = k\Delta RB = \omega R\Delta RB \ .$$

   If the value of the analog of membrane potential is same as for cell membrane, one would have electric strength ~ 9.5 V/m for the minimal sized vortex. This condition would relate the magnetic field strength to the basic parameters of the tornado. This kind of assumption is of course somewhat ad hoc and only its success can justify it.

   Superconducting atoms and molecules would be Z^0 ions with effective em charge proportional to the total nuclear charge Z and gain in this electric fields energies comparable in visible and UV range (few eVs) and one expects that the dark Josephson radiation at low frequencies is generated providing the system with the analog of EEG. The leakage of dark Josephson photons and $Z0$ ions to the ordinary space-time sheets and their interaction with atoms and molecules could in turn induce ordinary ionization which might be required also by the stability of the system. This would explaoin the visible light from this kind of systems. The rotation frequency of the system might directly relate to the frequency of dark Josephson radiation. The energy spectrum of radiation would serve as a signature allowing to distinguish the model from models explaing the radiation in terms of atomic transitions.

2. One can consider also second mechanism. The mechanism for the breaking of the ordinary super-conductivity in the case of the magnetic flux tubes is based on the idea that for curved flux tubes ionic current with an overcritical ion velocity leaks along flux tubes from the magnetic flux tubes to non-super-conducting space-time sheets. The reason is simply the inertia of the charged particle. This process implies the generation radiation in case of the ordinary electromagnetic

ions. This process occurs in the reconnection of magnetic flux tubes and more generally, when the curvature of flux tube becomes very large so that the inertia of the particle drives it to a larger space-time sheet. The model applies also to Z^0 magnetic case and if the particles are ordinary em ions, the generation of radiation is expected also now. Of course, also the collisions of neural particles generate also radiation but much more weakly. It is of course possible that stability condition requires also ordinary ionization of atoms.

This mechanism, besides providing a model for dissipation, might explain also the luminous phenomena associated with tornadoes [H8, H1, H22]. Tornadoes are expected to involve also ordinary magnetic fields and corresponding flux tube structures so that also they could give rise to luminous phenomena by the same mechanism as in the case of auroras.

Rotating magnetic systems as dark matter systems analogous to neuronal axon

A useful analogy for the tornado is provided by rotating magnetic system known as Searl device [H21]. This system is reported to starts to spontaneously accelerate at certain critical rotation frequency. The TGD inspired model for the system is discussed in [K4]. Spontaneous acceleration is accompanied by spontaneously occurring concentric cylindrical magnetic walls of thickness $\simeq .5$ cm with mutual distance of $\simeq .5$ m. What is intriguing that the spontaneous acceleration starts at 9.1 Hz rotation frequencyandacceleration continues up to 10 Hz after which the experimentation brecomes impossible due to the problems with the mechanical stability. 10 Hz corresponds to the alpha band of EEG and to the fundamental frequency of electron's CD. There is also a strong parity breaking involved: depending on the direction of rotation the weight of the system either decreases or increases, which suggests that some space-time sheets involved correspond to almost vacuum extremals: this could also explain the problems with stability.

These observations suggest that it might make sense to apply the idea about scaled up cell membrane to the boundary layer and magnetic flux walls associated with the rotating magnetic system. There are several scales and possibly also several values of Planck constant involved.

1. The radius of the rotating magnetic system is about 1 m and corresponds to the p-adic length scale $k = 204$ which corresponds to 1.2 m. This would suggest $k_d = 204 - 163 = 41$. Note that one has $h_{eff} = nh$, where n is product of distinct Fermat primes and power 2^{k_d}. The distance between magnetic walls is about.5 m and would correspond to $k_d = 39$. The thickness of the magnetic walls is about 5 cm corresponding to about $k_d = 32$. It is difficult to say anything definite about the thickness of the boundary layer assignable to the rotating magnetic system. 1 mm is one estimate based on the fact that the cylindrical rollers are at this distance from the central cylinder. This would suggest $k = 184$ and $k_d = 21$. The corresponding dark photon frequencies are 320 Hz, 1280 Hz, .66 MHz, and.32 GHz. Note that the second frequency corresponds to the 1.28 kHz frequency asignable to the CD of quark.

2. The very special role of 10 Hz frequency suggests the value $k_d = 2^{46}$. Note that the time scale of electron's CD is in question. Of course, several dark values of Planck constant are possible.

3. One can also consider the possibility that magnetic walls of thickness 5 cm could be dark matter systems with thickness allowing an interpretation as scaled up counterparts of cell membran of thickness 10 nm. The ratio of these scales is 5×10^6. This would give $k_d = 2^{45}$ not far from the value deduced from 10 Hz critical rotation frequency. Here one must however notice that cell membrane thickness is not affected in the scalings of Planck constant so that also other values of Planck constant are possible.

The idea about a strict scaling of the cell membrane suggests that there is also an electric field orthogonal to the boundary layer. From the vanishing of the total Lorentz force one has $E = \omega\rho B$, where B is the strength of the magnetic field, ω the angular velocity of rotation, and ρ is the distance from the rotation axes. For $\omega = k/\rho$ outside the rotating magnetic system voltage is same for all flux sheets and voltage is $V = k\Delta RB$.

If the value of the analog of membrane potential is same as for the cell membrane, one would have electric strength ~ 9.5 V/m. Superconducting atoms and molecules in in this field would gain energies of UV photons and highly energetic dark Josephson radiation at these frequencies would be generated providing the system with the analog of EEG. If the voltage is same also in the case of cell membrane, dark Josephson radiation at frequencies determined by the value of the Planck constant is generated. The rotation frequency of the system -very near to 10 Hz- might relate to the frequency of Josephson radiation.

Magnetic walls could contain dark matter Bose-Einstein condensates in cyclotron state carrying maximal magnetic field of $B = .05$ Tesla [K4], [H21]. Magnetic walls could serve as angular momentum and energy storages from which the system draws energy by time mirror mechanism (see Fig. `http://tgdtheory.fi/appfigures/cat.jpg` or Fig. ?? in the appendix of this book), which means sending of negative energy phase conjugate photons absorbed by the Bose-Einstein condensate.

One can imagine several interpretation for the ionization of the air.

1. One already discussed explanation for the ionization of air would be in terms of energetic dark atoms and molecules and dark Josephson radiation leaking to the space-time sheets carrying visible mater. For instance, for N_2 and O_2 molecules one has Z_{tot} equal to 15 and 16 respectively, and the energies of UV photons are in few eV scale for cell membrane potential and could ionize molecules [K15].

2. The observed ionization of the air in the vicinity of the rotating system could be also understood in terms of an Ohmic current generated by the radial vacuum electric field implied by the rotating magnetic field. Since the electric field corresponds to a non-vanishing vacuum charge density, this current charges the rotating magnetic system. Current carriers drop from atomic space-time sheets to larger space-time sheets at the boundary of the system liberating their large zero point kinetic energy of order 1 keV. The resulting voltage allows in principle to use the system as an over-unity device by adding load to a wire connecting the system to ground. The model leads to the proposal that rotating magnetic flux quanta provide a fundamental mechanism leading to the generation of plasmoids, which can be regarded as primitive living systems [I36].

Tornadoes as dark matter systems

The identification of tornadoes as large $\hbar$ systems is suggested by the ability to self-organize and preserve the self-organization pattern for relatively long periods of time. Dark matter would imply self organization and make the system living in a primitive sense.

The identification of tornadoes as rotating magnetic systems near vacuum extremals would allow to interpret the luminous phenomena associated with tornadoes [H8, H1, H22] in terms of a plasma resulting by the mechanisms proposed in previous section. The angular momentum stored to dark Bose-Einstein condensates at the magnetic walls would provide angular momentum and energy for the tornado. As a matter fact, the formation of these Bose-Einstein condensates could force the rotation of tornado by angular momentum conservation.

The already discussed model of the boundary layer between rotating magnetic system and external world as a scaled up variant of cell membrane space-time sheet applied to the boundary layer between tornado and external world would make essentially the same predictions if one assumes that the voltage through the layer is same as in the case of the cell membrane. In particular, ionization is expected by the atoms and molecules gaining energies corresponding to photons in visible and UV regions and the resulting ions would in turn generate Josephson photons.

There are several kinds of tornadoes [H5]. For supercell tornadoes called twisters the width is usually below $d = 90$ m but can sometimes extend over 1.6 km. Wind velocity is typically $v_0 = 160$ km/h= 44 m/s at the outer boundary. This gives a rough estimate for the angular velocity at the outer boundary as $\omega = v/d$. The rotation frequency is $f = 1/2\pi \simeq .16 \simeq 2^{-6} \times 10$ Hz in this particular case. For a radius of 1.6 km and same wind velocity one would have $f \simeq 8.8$ mHz $\simeq 2^{-10} \times 10$ Hz By the basic rule the values of k_d vary in the range $[52, 56]$ with p-adic length scales $163 + k_d$ in the range $[215, 218]$. The length scale range would be [40, 113] m. What is encouraging that the lower limit corresponds to the radius of the minimum sized tornado. The upper limit is too small by an order of magnitude. The interpretation suggested by the interpretation in the case of rotating systems is that 114 m would correspond to the thickness of the boundary layer between tornado and exterior world. For the minimal tornado the boundary layer would cover the entire interior.

3.5.2 Auroras As An Astrophysical Quantum Phenomenon?

Auroras are perhaps the most magnificent electromagnetic phenomenon in the atmosphere. The mechanism generating the auroras is not completely understood. What is however known that auroras involve the motion of ions along flux lines of Earth's magnetic field acting effectively as current wires. This suggest the that the ionic currents could be supra currents running along the flux tubes of the magnetic field of Earth or its dark counterpart $B_{end} = 2B_E/5$ suggest to exist on basis of findings about the effects of ELF em fields on vertebrate brain [K15]. Hence auroras could be a directly visible macroscopic quantum phenomenon! In the following a model of auroras based on this vision and explaining the latest findings about them is developed.

Basic facts, ideas and puzzles related to auroras

Auroras occur at heights of 56-970 km along a circle surrounding the magnetic North (South) pole [F15]. Magnetic storms accompany auroras and auroras are especially intense during sunspot maxima. Protons and electrons of the solar wind are known to flow along magnetic flux lines acting effectively as current wires. Some mechanism accelerates electrons and protons during their travel to the pole region where they collide with the ions (mainly oxygen and nitrogen) of the ionosphere and generate visible light. The spectral lines correspond to ionic transitions and each color corresponds to a particular ion dominating at a particular height.

A brief summary of the basic ideas and problems related to the auroras is in order before representing TGD based model.

1. The reconnection of solar magnetic field lines carried by solar wind with the field lines of Earth's magnetic field was proposed by James Dungey as a mechanism explaining the energetics of the auroras. There is indeed increasing empirical support for the view that the reconnection of the magnetic field lines of Sun and Earth accompanies [F15] [F5, F10, F4]. What would happen would be that the reconnected nearby opposite fields lines form a tightly bent U-shaped structure which straightens and acts as a catapult giving recoil energy to the plasma ions flinging in the direction of Earth. The highly energetic protons and electrons of the solar wind would flow towards Earth and collide with the ions of atmosphere and generate the auroras in this manner. The detailed understanding of the reconnection mechanism is lacking and here TGD suggests microscopic topological description relying on magnetic flux tubes.

2. The problem of the reconnection mechanism is how the solar and earthly magnetic flux lines running in opposite directions and carrying opposite currents know of each other and can change their direction so that the lines can meet. In TGD framework the reconnection of the magnetic flux tubes could be seen as a

process changing space-time topology and this process is now one of the basic mechanisms of TGD inspired quantum biology [K83]. At the point of reconnection magnetic field becomes zero in Maxwell's theory and it is thought that the charged particles must be able to leave the flux lines by some unknown mechanism so that demagnetization occurs. TGD in turn suggests that inertial effects force ions flow to larger space-time sheets along join along boundaries bonds.

3. An electric field parallel to the magnetic flux lines has been postulated as the mechanism of acceleration: empirical evidence for the existence of this electric field has been found quite recently [F9]. Two U shaped potential regions with positive *resp.* negative charges have been found at heights 5000-8000 km *resp.* 1500-3000 km. It is convenient to christen lower U shaped region as $\cap$ and the upper one as $\cup$. The negatively charged region feeds electrons to the aurora region and positively charged region sucks them back. There is however no consensus about how this kind of electric field is generated and how it could be stable.

A TGD inspired model for auroras

There are several poorly understood aspects related to the modelling of auroras. TGD approach provides new views to these problems. The following vision is perhaps the most plausible option discovered hitherto.

The basic condition is that cyclotron energies are above thermal energy. This allows to deduce lower bound the value of Planck constant assignable to the magnetic flux quanta. For $B_{end} = .2$ Gauss the cyclotron frequencies of electron and proton are.6 MHz and 300 Hz respectively and the formula $E = .41\times 10^{-14} r \times (f/Hz)$, $r = \hbar/\hbar_0$, allows to deduce the estimate for the minimum value of Planck constant in terms of thermal energy and cyclotron frequency as

$$r = 2^{k_d} \geq \frac{E_{th}}{E} \ , \ \frac{E}{eV} = .41\times 10^{-14}\times \frac{f_c}{Hz}\times \frac{B}{B_{end}} \ . \tag{3.5.2}$$

Here power of two for r is assumed for simplicity. This gives the frequency as

$$\begin{aligned}
k_d(e) &\geq k_d(e,min) = 28.71 + 1.44\times (log(\frac{E_{th}}{eV}) - log(\frac{B}{B_{end}}) \ (electron) \ , \\
k_d(p) &\geq k_d(e,min) + 11 \ (proton) \ , \\
k_d(I) &\geq k_d(p,min) + log(\frac{A}{Z}) \ (ion) \ , \\
\frac{E_{th}}{eV} &= 2.22\times 10^{-4}\times \frac{T}{K} \ .
\end{aligned} \tag{3.5.3}$$

Both electronic and protonic supra currents flow for $k_d > k_d(e,min) + 11$. I refers to ion with charge Z and mass number A.

1. The ionosphere of Earth is at room temperature roughly below 85 km and at temperature 1200 K at upper layers. For B_{end} both electronic and protonic currents incould flow as supra currents if this condition is satisfied for temperature roughly room temperature for $k_d(p) = k_d(e) \geq 34$ below 85 km and for $k_d(p) = k_d(e) \geq 36$ at the upper layers.

2. The reconnection of field lines generalizes to reconnection of magnetic flux tubes. The large inertia of ions in reconnection process from solar wind flux tube can induce their leakage and subsequent transfer to the upper magnetic flux tube in reconnection process. This would accumulate negative charge to the lower and positive charge to the upper U shaped flux tube.

3. The rapid straightening of the lower U shaped flux tube behaving like rubber band provides the mechanism of acceleration and brings ions of solar wind to the ionosphere where the collision with the flux tubes of inner magnetosphere induces the collision of electrons and ions and generates auroras. The liberation of cyclotron energy of electrons in cyclotron transitions of Bose-Einstein condensate of Cooper pairs of electrons and protons, and possibly even of exotic O^+ ions makes possible ionization and electronic excitations of ions involved.

1. Could em currents flow along magnetic flux quanta of solar and Earth's magnetic field as supra currents?

The question is under what conditions the statement that charged particles move along the flux lines of Earth's magnetic field without appreciable dissipation translates in TGD framework to supra currents flowing along the flux tubes of Earth's magnetic field.

1. Consider first the flux tubes of solar wind. The solar wind is made of Hydrogen (95 per cent) and Helium (4 per cent) and Carbon, Nitrogen, Oxygen, Neon, Magnesium, Silicon and Iron ($\simeq$ 1 per cent). The temperature is $T \simeq 15$ eV. The magnetic field has strength ~ 10 nT. Both proton and electron Cooper pairs cyclotron energies a would be above thermal energy at $k_d(p, min) \geq 56$ levels of dark matter hierarchy.
2. Consider next flux tubes in magnetotail. In magnetotail the field strength of Earth's magnetic field is around 30 nT in the lobes of the inner magnetosphere at the night side of Earth and temperature is around $.5$ eV (metabolic energy quantum again). This gives $k_d(p, min) = 50$ to be compared with $k_d(p, min) \geq 56$ for solar wind meaning that the reconnection process involves a phase transition changing the value of Planck constant.
3. An interesting question is whether Bose-Einstein condensates of exotic O^+ ions could be present near polar regions where field is stronger. What is known that cyclotron resonance frequencies of O^+ and H^+ ions appear in the frequency spectrum of electric fields in the aurora regions [F7]. This however requires only $k_d \geq 53$ since magnetic field is much stronger and near to $B_E = .5$ Gauss. What is interesting and perhaps of significance is that O^+ exotic ion would be the heaviest possible ion forming Bose-Einstein condensates and also the dominating one besides proton.

2. Radii of flux quanta

The gyroradius p_T/ZeB, where p_T is momentum transversal to B, of proton *resp.* electron of solar wind in the magnetotail is known to be about 700 km *resp.* 20 km whereas the radii of the magnetic flux tubes would be in the range in 10-100 micrometers for ordinary value of $\hbar$ and minimal magnetic flux. One must of course notice that currents at the boundaries of flux quanta allow to have arbitrary radii of flux quanta and this is the only sensible option in biomatter. One can consider several scaling laws for the the radius of the flux tube.

p-Adic length scale hypothesis suggests that scaling law could be $R \propto \sqrt{r}$, $r = \hbar/\hbar_0$. Also the radii of cyclotron orbits scale as $\sqrt{rn/eB}$, where n labels the cyclotron states. For B_{end} and for $r = 1$ the minimum radius would be about 5 μm. If the flux quantization in standard form is satisfied for B_{end} with $k_d(p, min) = 36$, the radius is about 1 m. For solar wind with $k_d(p, min) = 56$ and $B = 10$ nT this would give minimal radius of about 5 km. For tail with $B = 30$ nT and $k_d(p, min) = 50$ this would give 23 km which is slightly larger than electron's gyroradius. The value of gyroradius gives a condition on n if one assumes that the situation is semiclassical. For proton would have $n \simeq 926$ in tail.

The gyroradii of ions are smaller than the radii of flux tubes if one assumes standard flux quantization. If the radii of flux tubes are comparable than gyroradii, the ions can leak out from solar flux tube in the reconnection process. This would be essential for how the negatively and positively charged regions are generated in the reconnection process.

3. Reconnection mechanism

In TGD framework one can understand how reconnection can occur. The helical structure of the flux tubes implies that they can be in transversal direction to the average magnetic field and this means that flux tubes can meet each other in U-shaped manner. Thus the process of reconnection would be a genuine quantal and topological transition for which the flux quantization would be essential.

It seems natural to expect that the location of the reconnection region is determined from the requirement that the flux tubes of solar wind and Earth's magnetic field have same thickness so that also local magnetic fields have the same strength from flux quantization. In Maxwell's theory this corresponds to the fact that the two magnetic fields sum up to zero. The reconnection process should be also energetically favored.

4. Acceleration mechanism

One can regard Earth's magnetic field as a collection of magnetic flux tubes containing matter and analogous to rubber strings. For instance, the rotation of the magnetic flux tubes could be essential prerequisite for the stability of curved flux tubes. Also the idea about catapult action meaning that the reconnected U shaped magnetic flux tube in East-West plane, briefly $\cap$, rapidly straightens and becomes a flux tube in ionosphere and collides with flux tubes of ionosphere looks natural. $k_d \geq 56 \rightarrow k_d \geq 50$ phase transition would naturally accompany this process.

The collision of flux tubes would in turn induce the collision of ions and electrons inside them and generate auroras. For $k_d = 56$ at solar wind flux tubes the high energy scale $E_c = 15$ keV of the cyclotron energy states of electrons would induce ionization of atoms in the magnetic flux tubes and induce generation of visible light in atomic transitions of ions and also generation of X rays and perhaps even gamma rays. Even when the phase transition to $k_d \geq 50$ state occurs inside ionosphere, the cyclotron energy scale is 1.44 eV, which is in infrared. Here one must of course be careful to notice that this energy is just the minimum energy. One can think that the charged particles of solar wind end to large n cyclotron states at magnetotail and end up to lower energy states by emission of cyclotron radiation. Analogous collision of flux tubes could explain generation of X and gamma rays associated with lightnings.

5. Formation of return current and generation of strong voltage between reconnection region and aurora region

This picture allows also to understand why a return current from aurora region to $\cup$ is formed and what might cause the strong voltage of about 10^4 Volts between the top of $\cap$ and ionosphere.

The formation of the return current of electrons suggests the presence of closed electric field lines so that electric field would not be conservative. These closed field lines would correspond to closed structures formed from magnetic flux tubes carrying electric field. This means that there must be time varying magnetic flux through the surface , call it X^2, orthogonal to Earth's surface and extending from the aurora region in ionosphere to $\cup$. This is the case if the highly curve $\cap$ contracts (recall the rubber band analogy) to a relatively straight flux tube inside ionosphere in magnetic East-West direction. The change of the magnetic flux through X^2 would be the magnetic flux carried by this flux tube. Of course, several flux tubes might be involved.

The generalization of the flux quantization condition to time domain reads as

$$2e\int_0^T VdT = nr\hbar_0 \ ,$$

where T is the time during which flux tube traverses the boundary of ionosphere. The condition follows from Faraday's induction law and magnetic flux quantization, and relates the change of flux to the time and non-conservative voltage around flux loop. If n refers to the flux of single flux tube of Earth's magnetic field in which case it would have radius $R_n = \sqrt{n} \times 23$ km, $n \geq 1$ by the requirement that electron gyroradius is smaller than R_n.

This condition allows to estimate the value of T using the estimate $V = 10^4$ V [F3] for the voltage between recombination region and auroral region. For B_{tail} and $k_d = 56$ this gives $T = n \times 49$ s for the time during which the flux tube traverses the boundary of the ionosphere. In [F9] 200 s time scale is associated with the straightening process on basis of experimental data so that $n = 4$ suggests itself. This would support the idea about quantal process. This would mean radius 46 km safely above the electronic gyroradius 20 km. The velocity of straightening for the flux tube would be $v \sim 2R_1/T \simeq .25$ km/s.

7. Generation of regions of positive and negative charge

The proposed reconnection mechanism provides also insights to the mechanism leading to the generation of negative charge to the top of $\cap$ at height 1500-3000 km above Earth and positive charge to the bottom of $\cup$ at $5000-8000$ km above Earth [F9]. The formation of these regions can be indeed understood: due to the small inertia of electron Cooper pairs of solar wind and the fact that the electronic gyroradius 20 km is smaller than the radius of flux tube of Earth's magnetic field in magnetotail for $k_d = 56$, electrons are not expected to leak out of the flux tube in the reconnection process. Ions are however much more massive and their gyroradius (700 km for proton) is much larger than 20 km so that they are expected to leak out in the reconnection process and end up to $\cap$ thus providing it with a positive charge.

Auroras, meteors, and consciousness?

There are claims that auroras generate audible sounds [F15]. These sounds have not been detected by acoustic means. Magnetic sensory canvas hypothesis could explain this. The magnetic storms accompanying auroras should affect also our personal auditory canvases. In particular, Schumann resonances which could correspond either MEs parallel to the magnetic flux tubes or oscillations of the magnetic flux tubes, are excited. Higher Schumann resonances are in the audible range and could directly give rise to extrasensory perception of sounds.

There is also some other evidence for the sensory canvas hypothesis. Since 16th century it is known that also meteors produce audible sounds. What is mysterious that there is no time lag due to the propagation through the atmosphere. The explanation is that it is very low frequency em waves which propagate to Earth and generate sounds by interacting with the objects at the surface of Earth. Joined by the International Leonid Watch - Croatia (ILWC) project, a group of scientists presented the first instrumental detection of elusive electrophonic meteor sounds. In November 1998, the researchers from the Croatian Physical Society and the University of Kentucky organized an expedition to Mongolia to observe the anticipated Leonid meteor shower and shed some light on the phenomenon [F11]. The complete data analysis revealed two electrophonic (electronically detected) sounds that provided several important clues about the nature of this longstanding astronomical mystery. It became clear that sounds were created when the meteors were crossing night-time ionosphere. The existing theories cannot however completely explain the phenomenon. The energy of meteor does not seem to be high enough to invoke the electric fields needed to explain the electronically recorded sounds, and strangely enough, the frequencies are much lower than expected, in the region 20-40 Hz.

Magnetic flux quanta as carriers of the electromagnetic perturbations might allow a better understanding of the phenomenon. Perhaps the audible sounds, in contrast to the electronically recorded ones which seem to be of much lower frequency, are in fact generated by the direct perturbations of magnetic auditory canvas: this would explain why there is no lag due to the propagation through atmosphere. Electronically recorded sounds could be induced by the em perturbations propagating along magnetic flux ruvwa at Schumann frequencies and the mirrors might act as resonators amplifying the em fields (electrophonic sounds had frequency spectrum in the region of lowest Schumann frequencies). Notice that magnetic flux tubes of length shorter than Earth's circumference would give rise to higher resonance frequencies than Schumann frequencies.

There are also reports that seeing auroras can cause a loss of consciousness. This effect might not be only due to the depth of the aesthetic experience. The effects of magnetic storms on patients of mental hospitals are also well documented. If our sensory representations are indeed realized at magnetic flux tubes structures associated with Earth's magnetic field, one is led to ask whether the dissipative processes associated with auroras destroying ionic supra currents might indeed affect directly our consciousness, inducing even a loss of consciousness.

The magnetic flux tube structures associated with the sensory canvas could also experience the pressure of the solar wind and change their shape during night time. Also this might correlate with the fact that we usually sleep during night time and daytime consciousness differs from nighttime consciousness.

3.5.3 Lightnings, Sprites, Elves, And The Hypothesis Of Magnetic Sensory Canvas

In 1920s, the Scottish physicist C. T. R. Wilson predicted the existence of brief flashes of light high above large thunderstoms [D22, D22]. Almost 70 years later, Bernard Vonnegut of SUNY Albany realized that this prediction could be tested by studying the videos of Earth's upper atmosphere recorded by space shuttle astronauts. William Boeck and Otha Vaughan from NASA decided to look for the evidence and they indeed found it. Also John Winkler and his colleagues had serendipitously observed a flash in moonless night time skies over Minnesota in 1989. These findings inspired two field programs (led by Walter Lyons and Davis Sentman respectively) to study the new phenomena and it soon became clear that the flashes are in fact a common phenomenon in the mesosphere.

Sentman and Lyons found two broad classes of flashes [F14, F16]: sprites and elves. These short lived luminous phenomena are associated with large thunder storms called mesoscale convective systems often covering entire states in the Great Plains of the US in summertime. These migratory regions contain often regions of active convection adjacent to the regions of weaker stratiform convection. Ground flashes with a negative polarity (Earth surface corresponds to the negative electrode) dominate in the active convection regions whereas the less frequent but more energetic flashes with positive polarity (Earth surface corresponds to positive electrode) predominate in the stratiform regions. The great majority of sprites and elves are initiated by ground flashes of the latter type. Elves and very low frequency perturbations from electromagnetically pulsed sources are centered above vertical channels to ground whereas sprites lie above horizontally extensive spider lightnings in the lower portion of the stratiform cloud.

My own interest on these phenomena was stimulated by the article [F8] according to which neither the origin of the blue light accompanying sprites nor the fast rate for the development of sprites are well-understood. The obvious strategy is to find whether the notion of many-sheeted space-time could provide an improved understanding of these phenomena.

The notion of many-sheeted space-time is crucial for TGD based model of brain involving in an essential manner also the notion of the magnetic sensory canvas: the magnetic flux tube structures involved can have size comparable to Earth's size. An interesting question is whether one could somehow relate the notion of sensory magnetic canvas to the electromagnetic phenomena occurring in the atmosphere. Rather encouragingly, the basic dynamical time scales of lightnings, sprites and elves correspond to those associated with brain. This inspires some speculations about how magnetic bodies and atmospheric electromagnetic phenomena might relate.

Lightnings

A good summary about basic facts concerning lightnings [F13], sprites and elves can be found in Wikipedia [F2]. Lightnings are classified to positive and negative lightnings depending on whether the electron current is from ground to cloud or vice versa. The following brief summary gives a rough account of what happens in case of negative lightning for which electron current flows to ground.

An initial discharge, (or path of ionised air), called a "stepped leader", starts from the cloud and proceeds generally downward in a number of quick jumps, typical length 50 meters, but taking a relatively long time (200 milliseconds) to reach the ground. This initial phase involves a small current and is almost invisible compared to the later effects. When the downward leader is quite close, a small discharge comes up from a grounded (usually tall) object because of the intensified electric field.

Once the ground discharge meets the stepped leader, the circuit is closed, and the main stroke follows with much higher current. The main stroke travels at about 0.1 c and has high current for.1 m or so. It may persist for longer periods with lower current.

In addition, lightning often contains a number of restrikes, separated by a much larger amount of time, 30 milliseconds being a typical value. This rapid restrike effect was probably known in antiquity, and the "strobe light" effect is often quite noticeable.

Positive lightning does not generally fit the above pattern.

Positive lightnings are rare but more energetic. The typical voltages, electric fields, and durations of strikes involved with positive *resp.* negative lightnings are 1 GV, 10^5 V/m and 1 ms *resp.*.1 GV, 10^4 V/m and.1 ms. During positive lighting there is a huge amount of VLF and ELF radiations which implies that lightning induces effects in ionospheric scale.

The notions of leader emerging from cloud and streamer emerging from ground and meeting before the strike are well established. The development of leader means that air becomes conductive in a stepwise manner by ionization. Stepped leaders are associated with negative lightnings and dart leaders with positive lightnings. Lightnings are accompanied by X ray bursts with duration $< .1$ ms. with X ray energies up to few hundred keV. The bursts are presumably generated during stepped leader and dart leader phase. Also gamma ray bursts have been observed.

Runaway breakdown is a generally accepted mechanism in the theory for the formation of lightnings. It is assumed that cosmic ray strikes atmospheric molecular and releases extremely energetic electrons having enhanced free path length of tens of centimeters. Electrons are accelerated in the electric field of storm and ionize further molecules and initiate the runaway breakdown at higher which then proceeds downwards. Conductive path with a length of typically 50 m is created. There are however some problems. The rate for the strikes by cosmic rays having sufficient energy is 50/km^2 and too low to explain the number of lightnings during thunderstorm. Also the measured X ray burst intensity is only 5 per cent of the predicted value.

Sprites

Sprites come in several varieties and these complex structures have been dubbed with descriptive names like carrots, angles, jellyfish and A-bombs. The simplest sprites are so called C sprites which have transversal size of order 200 m and height of order 10 km and form structures resembling Fourth of July fireworks. The vertical extension of sprites can be as high as 60 km and there lower end is typically at the height of 30 km (for illustrations of sprites and elves see [F8]).

In Wikipedia [F13] sprites are characterized as follows.

Sprites are now well-documented electrical discharges that occur high above the cumulonimbus cloud of an active thunderstorm. They appear as luminous reddish-orange, neon-like flashes, last longer than normal lower stratospheric discharges (typically around 17 milliseconds), and are usually spawned by discharges of positive

lightning between the cloud and the ground.

Sprites can occur up to 50 km from the location of the lightning strike, and with a time delay of up to 100 milliseconds. Sprites usually occur in clusters of two or more simultaneous vertical discharges, typically extending from 65 to 75 km above the earth, with or without less intense filaments reaching above and below. Sprites are preceded by a sprite halo that forms because of heating and ionisation less than 1 millisecond before the sprite.

The structure of sprite resembles that of a botanic tree consisting of roots (negative end), trunk and branches (positive end). This bi-directional structure of the sprite suggests two separate processes: the first process proceeds upwards and is followed by a second process proceeding downwards. The blue color of the lower part of the sprite (roots) is known to be due to the transitions of N_2^+ ions whereas the red color of the upper part is due to the transitions of N_2 molecules.

Wilson's theory suggests that the process associated with trunk and branches of the tree corresponds to a dielectric breakdown induced by the ionization of molecules by electrons flowing upwards in the electric field generated by the spider lightning. The dipole field associated with the lightning behaves as $1/z^3$ as function of height from the pancake like electronic reservoir located at the thunder cloud at height of order 10 km. Since the dielectric strength (the critical electric field causing the ionization of molecules) is proportional to the density of the molecules, which decreases exponentially with height, the dielectric breakdown is predicted to begin from higher heights above thunder cloud and cause a cascade like electron current.

The expression for the drift velocity of electron in an external electric field is obtained from the condition

$$\frac{m_e v^2}{2} = eEl \ , \quad l = \frac{1}{n\sigma} \ . \tag{3.5.4}$$

Here σ denotes the total scattering cross section for the scattering of electrons on molecules and l denotes the length of the average free path of electron. The condition simply states that the kinetic energy gained in the field between two interactions equals to the work done by the electric field on electron.

Ionization becomes possible when the kinetic energy is above the ionization energy E_{ion} of the molecules of the atmosphere. This condition determines the critical value of the electric field as

$$eE_{cr} = 2E_{ion} n\sigma \ . \tag{3.5.5}$$

The critical value of the electric field is proportional to the density n of the molecules decreasing exponentially with height. The values of the dipole moment p characterizing the electric fields generated by lightnings range from 10 to more than 10^3 coulomb kilometers (for the convenience of the reader we notice that one coulomb corresponds roughly to 10^{19} electronic charges). Assuming the distance scale $z \sim 40$ km, dipole moment $p \sim 10^3$ Ckm, and collision cross section $\sigma \sim Angstrom^2$, one finds that the critical drift velocity is of the same order of magnitude as the observed velocity $.1$ c for the generation of sprite. In [F8] it has been stated that the predicted critical drift velocity tends to be too small.

The negative end of the sprite (roots) accompanied by blue light suggests that the N_2^+ ions created in the electronic ionization run downwards in this region. The mechanism leading to the transitions of N_2^+ ions generating blue light is most naturally the collisions of N_2^+ ions with N_2 molecules. This assumption conforms with the basic facts about sprite formation and structure: the intensity of the blue light is comparable to that of red light, the blue end of the sprite develops later than the red end, the blue emission is at the lower end of the sprite, and the branching of the lower end proceeds downwards. Note that the critical velocity for the ionization of N_2 molecules by collisions with N_2^+ molecules is proportional to $1/\sqrt{M(N_2)n}$ and thus considerably smaller than in case of electron for given values of n and E. This together with the

larger density of N_2 molecules implies that the lower part of the sprite is generated more slowly.

A priori also sprites for which thunder cloud carries positive charge are possible. Only two cases of sprites associated of this kind have been found, and according to [F8] this asymmetry is not yet well-understood. A possible explanation is following. When cloud is negatively charged, the pancake like electronic reservoir located at the thunderstorm provides the seed electrons initiating the ionization cascade providing new current carrying electrons. When the cloud is positively charged, the electrons would propagate downwards from upper part of atmosphere to the direction in which drift velocity decreases. There are however no seed electrons now. There is however a reservoir of positive N_2^+ ions in thunder cloud and they might be able to generate the dielectric breakdown. It is quite possible that the typical seed density is simply too low for this in most cases. These infrequent sprites should have blue or pink-blue upper end ($N_2^+ - N_2$ collisions can also excite N_2 molecules) and should develop with much more slower rate.

If the collisions with the electrons were responsible for the transitions of N_2^+ ions (as believed in [F8]), the intensity of the blue light would be by several orders of magnitude weaker from the fact that the density of N_2^+ ions is of the same order as that of electrons from the requirement of overall charge neutrality, and from the fact that the density of N_2 ions is much higher than that of electrons (there are roughly 1 electron per 10 billion N_2 molecules [F8] at the upper portion of the sprite).

Elves

In Wikipedia [F13] elves are characterize in the following manner.

Elves often appear as a dim, flattened, expanding glow around 400 km (250 miles) in diameter that lasts for, typically, just one millisecond [7]. They occur in the ionosphere 100 km (60 miles) above the ground over thunderstorms. Their colour was a puzzle for some time, but is now believed to be a red hue. Elves were first recorded on another shuttle mission, this time recorded off French Guiana on October 7, 1990. Elves is a frivolous acronym for Emissions of Light and Very Low Frequency Perturbations From Electromagnetic Pulse Sources. This refers to the process by which the light is generated; the excitation of nitrogen molecules due to electron collisions (the electrons having been energized by the electromagnetic pulse caused by a positive lightning bolt).

Elves are thus a phenomenon occurring above ionosphere rather whereas sprites are ionospheric phenomena. This allows to understand why they occur for positive lightings (electrons flow from ground to cloud).

In case of elves the ionization mechanism differs from that for sprites. The radiation from the lightning decays with distance as $1/z$ and this guarantees that the threshold for the breakdown is exceeded as long as lightning current is sufficiently large. The observations show that there is a time lapse of order 10 ms between the lightning and the generation of elve: this lapse is consistent with the propagation of radiation with light velocity. Observations show that peak currents of 70 A or greater are required.

Electronic plasma frequency defined as

$$f_p^2 = \frac{n_e e^2}{m_e} \tag{3.5.6}$$

plays an important role in understanding the electromagnetic phenomena in atmosphere. Plasma frequency defines the cutoff frequency for waves which can propagate inside sprite: what this means is that frequencies lower than f_p are reflected. The observations about reflections of em waves on sprites show that f_p is in the range $2-25$ kHz which means that the density of electrons is in the range 10^4 to 10^6 cm^{-3}, somewhat more dilute than in aurora borealis and slightly above the electron concentration in the daytime E region of the ionosphere. VF and ELF em waves can propagate in the 80-90 km thick wave guide below ionosphere and sprite activity generates ELF waves, which are especially strong at Schumann resonance frequencies and serve as a global signature for them.

Dark matter hierarchy, lightnings, sprites, and elves

What is known about sprites and elves might be marginally understood in the framework of standard physics. The model for the leaders based on runaway breakdown induced by cosmic rays is however inconsistent with l empirical facts and dark Bose-Einstein condensates at the flux tubes of Earth's magnetic field provide an alternative model. This inspires the question whether dark matter hierarchy could manifests itself somehow in these phenomena. The first thing one can do is to look whether the time and length scales involved could be assigned with the basic scales of the dark matter hierarchy.

1. Time scales

Millisecond time scale seems to govern the dynamics of both lightnings, sprites and elves. The net time for the formation of stepped leader is about $\tau = 200$ ms and since length scale involved is 10 km this means that generation of single step corresponds to millisecond time scale $\tau_{step} = 1$ ms. Also the time scales of strikes are in millisecond scale: for instance, sprite halos appears millisecond before sprire, sprite typically last about 17 milliseconds, and elves last for 1 millisecond. Note that millisecond time scale assignable to d quark CD and 100 ms scale corresponds to electron.

The appearance of millisecond time scale for the main strike and appearance of re-strikes brings strongly in mind nerve pulse generation and nerve pulse sequences having similar time scales. Moreover, delta band of EEG resembles corresponding region of sferics and intense VLF and ELF radiation accompanies positive lightnings. The question is whether the similarity of time scales is a mere accident and whether lightnings could be regarded as sequences of scaled up nerve pulse like discharges involving kHz synchrony related to quark CDs and duration of 100 ms related to the CD of electron.

2. Length scales

One could consider at least half seriously the idea that the region between thunder cloud and Earth with thickness $L \sim 10$ km defining the length of leader is analogous to a scaled up dark variant of cell membrane. Similar idea could apply to the $L \sim 100$ km thick region between ionosphere and Earth surface. The length scale of single step about 50 m and its ratio to the distance $L = 10$ km is 2^{11} and could be understood in terms of the ratio τ/τ_{step}. One could wonder whether this ratio corresponds to proton-electron mass ratio.

1. Dark matter hypothesis implies that scaling proportional to r. The value of Planck constant can be deduced as $r = 2^{k_d} \simeq L/d$, where $d = 10$ nm denotes the thickness of the cell membrane. Note that $\sqrt{r}$ proportionality appropriate for p-adic length scales does not work and these scales could be most naturally assigned with CDs. This gives the estimate $k_d = 40$ for thunder cloud and corresponds to Josephson frequency 640 Hz. For ionosphere one obtains $k_d = 47$, which corresponds to the 5 Hz Josephon frequency assigned with wake-up EEG. 50 km defining the maximum distance between sprites and lightning and would correspond to $k_d = 46$ and 10 Hz Josephson frequency with obvious meaning in biology.

2. The length scale 50 m for the step of the leader could correspond to $k_d = 18$ and Josephson frequency of 2.5 GHz.

3. The generation of lightning could proceed from $k_d = 18$ level to higher levels of dark matter hierarchy. This kind of hierarchical development could explain

the sprites and elves as well as strong ELF and VLF is associated with positive lightnings as being to the fact that electron current proceeds upwards and can thus excite $k_d = 40$ ionospheric excitations (sprites) and $k_d = 47$ excitations (elves) above ionosphere.

3. Dark matter hierarchy and generation of leaders

Dark matter hierarchy suggests a new kind of mechanism initiating the development of leaders. The dissipation-free acceleration of cyclotron electron Cooper pairs and of ions at the flux tubes in strong electric field and transfer to the atomic space-time sheets could provide a mechanism generating the typically 50 meter long steps of step leaders. The energy of.5 MeV, which corresponds to electron rest mass, would be reached in a free acceleration of proton or electron Cooper pair in an electric field of $E = 10^4$ V/m associated with negative lightnings over distance 50 meters. This corresponds to electron rest mass so that also the generation of gamma rays could be understood. For dart leaders the same energy would be reached during 5 meter long free acceleration, which raises the question whether dart leaders are step leaders with shorter length of the basic step.

Electronic cyclotron energy scale for $k_d = 40$ level of dark matter hierarchy is about $E_c = 2$ keV. Therefore cyclotron photons emitted in the collisions of electron Cooper pairs at the magnetic flux tubes of Earth could be involved with the generation of highly energetic electrons which in turn induce runaway breakdown. This energy is perhaps too small to explain the energies of highest X rays and of gamma rays.

4. $k_d = 47$ dark matter level and the formation of sprites and elves

The too low drift velocity of electrons drifting to the trunk and branches of sprite from electron reservoir at the bottom of the cloud is a possible problem in the model for the formation of sprites. Almost dissipation free upwards directed acceleration of Cooper pairs of electrons at $k_d = 47$ magnetic flux tubes would allow much higher drift velocities since the free path of electron Cooper pair would be longer. This would reduce the critical value of the electric field and make the process faster.

The density of N_2 molecules is about $10^3/\mu m^3$ at the upper part of the sprite and one can consider the possibility that at least part of these molecules reside at the magnetic flux tubes of the dark counterpart B_{end} of the Earth's magnetic field B_E which is hypothesized to have the value $B_{end} = 2B_E/5$ on basis of the model explaining the effects of ELF em fields on vertebrate brain (see the appendix of [K10] and [K15]). One can even raise the question whether singly charged exotic N_2^+ ions (behaving like neutral atoms electronically) could be present and define cyclotron condensates. The downwards directed dissipation-free acceleration of N_2^+ exotic ions scattering from ordinary N_2^+ ions could induce the transitions of N_2^+ ions responsible for the blue color in the lower part of sprite.

In the case of elves the ionization mechanism is believed to involve radiation from lightning energizing electrons in turn exciting N_2 molecules. The effect would be stronger if Bose-Einstein condensate of exotic N_2^+ ions is excited coherently by the collisions with energized electronic Cooper pairs.

Atmospheric electromagnetic phenomena and consciousness

The hypothesis about magnetic sensory canvas should be related to experimental reality somehow. The electromagnetic phenomena (such as lightnings, auroras sprites, elves) in the atmospheric waveguide are indeed rather promising in this respect.

1. If the magnetic sensory canvas hypothesis holds true one has the right to expect that brain functioning and these electromagnetic phenomena should possess common time scales. Amazingly, the frequency spectra as well as typical durations for the lightnings, sprites and elves correspond to those associated with brain. The typical duration of lightning is about .1 seconds which is the fundamental time scale of sensory consciousness and defines the duration of the memetic code

word. Sprites are generated during one millisecond and typically last 10-100 milliseconds. The spectrum of the spherics associated with the activity of lightnings is in the range 0-25 kHz: this follows from the fact that waves in this frequency range are reflected from ionosphere and propagate in the waveguide defined by the atmosphere. It is perhaps not an accident that this frequency range corresponds to the range of frequencies audible for human brain.

It is also known that hippocampus, which is crucial for long term memories, contains highly ordered magnetite particles (private communication) and responds in complex ways to magnetic perturbations having frequencies in ELF range and amplitudes in picoTesla range. The amplitudes for the perturbations of Earth's magnetic field are also in picoTesla range in theta and alpha range of EEG frequencies. Also alpha waves generate a peak in MEG with amplitude of order picoTesla: presumably this peak corresponds to the lowest Schumann frequency. Also eyes generate static magnetic fields with strength of order 10 picoTesla.

In consistency with the observations of Blackmann and others about the intensity and frequency windows for ELF em fields, these findings encourage to think that brain is indeed sensitive to the perturbations of Earth's magnetic field (note however that the electric fields in these experiments are typically of order $1-10$ V/m [J34] and roughly two orders of magnitude higher). This would mean also a sensitivity to the perturbations of the magnetic flux tube structures defining the hierarchy of magnetic bodies. These perturbation might directly affect conscious experience (not necessarily at our level of hierarchy) giving rise to effective extrasensory perceptions and the effects at the level of brain would represent a reaction to this kind of conscious experience.

2. There should be also interaction between brain and the electromagnetic phenomena in the atmosphere and Schumann resonances which characterize the perturbations of Earth's magnetic field should be of special importance. In fact, the third person aspect of conscious experience might be due to the cyclotron transitions at flux tubes assignable with dark parts of the Earth's magnetic field [K15]. Lightnings, sprites and elves indeed excite Schumann resonances known to affect strongly human consciousness [J33]. Furthermore, the shape of the frequency spectrum for sferics at delta frequencies resembles delta band of EEG [J23]. The generation of Schumann resonances might mean also a direct interaction with the magnetic sensory canvas and one cannot exclude the possibility that atmospheric phenomena could have role in signalling at the higher levels of self hierarchy. Perhaps the peak in MEG at alpha range results from this kind of interaction.

   There are typically few sprites per minute and they generate strong Schumann resonances. One can wonder whether sprites and/or the associated spider lightnings could have correlates at the level of EEG and neurophysiology and perhaps even affect conscious experience, say by causing changes in mood. It should be possible to check whether the EEGs of persons possibly located at different parts of globe display simultaneous correlates for sprites and lightnings.

3. One could go even further and try to test the fractality hypothesis. The ratio of length scales associated with pairs cell membrane-cell, cortex-brain and atmospheric waveguide-Earth are of same order of magnitude. This observation and Mother Gaia hypothesis encourages to consider the possibility that the atmosphere could in some sense be a scaled-up version of cortex, which in turn would be scaled-up version of the cell membrane. For instance, the transversal size of order 200 m of the smallest sprites (so called C sprites) would correspond to the micron length scale in brain length scale and thus the size of smallest neurons whereas this length scale corresponds to nanometer (DNA size scale) at neuronal level. The height of C sprites which is about 10 km corresponds to the length of about 50 microns which in turn reminds of the lengths of cortical neurons.

4. The geometric appearance of sprites brings in mind the geometry of neurons and one can even play with the thought that sprites and lightnings are associated with pre-existing electric flux tube structures in atmosphere so that lightnings, sprites and elves could be phenomena comparable to nerve pulse activity and graded potentials in brain. The geometric structures associated with sprites resembles the axonal and dendritic geometries for cortical neurons.

5. The most fascinating possibility is that sprites and elves are parts of magnetic bodies made temporarily visible. If so, then one could also consider the possibility that magnetic bodies form a self hierarchy analogous to that formed by monocellulars and increasingly complex multicellulars with cell being replaced with brain/physical body of organism. Various organisms would obviously form the lowest level of this self hierarchy and various levels of collective consciousness would be the electromagnetic analog of the multicellular life.

What auroras, tornadoes, ball lightnings, and cold fusion might have in common?

New physics due to a ground state, which is almost vacuum extremal could be the common demonimator of very large class of anomalous phenomena including auroras, tornadoes, ball lightnings, cold fusion, sonofusion, and last but not least - the entire biology!

If the density of the ions inside magnetic flux tubes is constant, garden hose instability for magnetic field suggests itself strongly. Similar instability might be associated with the flux quanta of the em and Z^0 magnetic fields associated with almost vacuum extremals (this is not assumed about sensory canvas) if they contain Z^0 ions which can be electromagnetically neutral. This kind of instability giving rise to spiral helices is the basic assumption in the TGD based model of tornadoes. This suggests super-conductivity analogous to that in the case of cell membrane for almost vacuum extremals, and since rotating systems probably involve also magnetic fields, phenomena analogous to auroras could be involved also now.

It is indeed well known that luminous phenomena resembling those accompanying ball lightnings [F13] are associated also with tornadoes [H8, H1, H22]). Edward Lewis introduces the notion of plasmoid to explain a wide range of phenomena including ball lightnings and tornadoes. He assigns plasmons even with cold fusion (the damage resulting to Palladium target in cold fusion resembles the traces caused by ball lightnings, [C8]) and super-conductivity (sic!). Although Lewis obviously overgeneralizes the notion of plasmoid, one cannot deny that the concept has a strong theoretical appeal in it.

Also sonoluminescence [C1] could involve a phase transition to almost vacuum extremal ground state and the emission of visible light could come from the membrane like boundary layer. The UV photons could generate the observed high temperatures estimated to be as high as 20, 000 K, which corresponds to 2 eV photon energy. In this case the size scale of emitting region is in fact that of cell membrane. The proper identification of essense of plasmons could be the presence of membrane like structures with space-time sheets which are almost vacuum extremals. The presence of magnetic flux quanta far from vacuum extremal is also plausible if one takes the model of quantum biology as a starting point.

The findings of Lewis inspire the following basic ideas about the physics of many-sheeted space-time- some of the allready discussed.

1. The runaway mechanism for ions from the magnetic flux tubes could provide a general mechanism behind luminous phenomena like auroras, lightnings, ball lightnings, sprites, tornadoes, UFOS and various anomalous luminous phenomena such as earth lights in tectonically active areas. Plasmoids could result from Josephson currents alone via the leakage of dark highly energetic particles and dark Josephson photons to visible matter sector. Also analog of nerve pulse could be involved responsible for phenomena like lightning and elves. The un-

identified source of energy in these phenomena might be the energy associated with the dark supra currents.

2. The break-down of the dark super-conductivity could be understood in terms of a supra current leakage to non-super-conducting space-time sheets caused by the inertia of the current carriers. The critical temperature could be determined as the temperature below which the join along boundaries bonds between super-conducting and non-conducting space-time sheets are not formed. The temperature of super-conducting space-time sheets could be much more lower than this temperature but this is not necessary if high $\hbar$ dark matter is in question.

3. The Trojan horse mechanism of cold fusion [K94] involves the notion many-sheeted space-time in an essential manner. Perhaps the dark supra currents running at the magnetic flux tube space-time sheets not containing the nuclear Coulombic fields provide the means to circumvent the Coulomb barrier.

3.6 Appendix

3.6.1 Hierarchy Of Planck Constants And The Generalization Of The Notion Of Embedding Space

In the following the recent view about structure of embedding space forced by the quantization of Planck constant is summarized. The question is whether it might be possible in some sense to replace H or its Cartesian factors by their necessarily singular multiple coverings and factor spaces. One can consider two options: either M^4 or the causal diamond CD. The latter one is the more plausible option from the point of view of WCW geometry.

The evolution of physical ideas about hierarchy of Planck constants

The evolution of the physical ideas related to the hierarchy of Planck constants and dark matter as a hierarchy of phases of matter with non-standard value of Planck constants was much faster than the evolution of mathematical ideas and quite a number of applications have been developed during last five years.

1. The starting point was the proposal of Nottale [E2] that the orbits of the 4 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 [K91] 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 [K92]. 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 embedding 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 [K52].

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 [K89]. 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 [E2] can be understood. Dark matter would resemble to a high degree matter in black holes replaced in TGD framework by light-like partonic 2-surfaces with a minimum size of order Schwartschild radius r_S of order scaled up Planck length $l_{Pl} = \sqrt{\hbar_{gr}G} = GM$. Black hole entropy is inversely proportional to $\hbar$ and predicted to be of order unity so that dramatic modification of the picture about black holes is implied.

6. Perhaps the most fascinating applications are in biology. The anomalous behavior ionic currents through cell membrane (low dissipation, quantal character, no change when the membrane is replaced with artificial one) has a natural explanation in terms of dark supra currents. This leads to a vision about how dark matter and phase transitions changing the value of Planck constant could relate to the basic functions of cell, functioning of DNA and amino-acids, 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 [L2, K52], [L2].

The most general option for the generalized embedding space

Simple physical arguments pose constraints on the choice of the most general form of the embedding space.

1. The fundamental group of the space for which one constructs a non-singular covering space or factor space should be non-trivial. This is certainly not possible for M^4, CD, CP_2, or H. One can however construct singular covering spaces. The fixing of the quantization axes implies a selection of the sub-space $H_4 = M^2 \times S^2 \subset M^4 \times CP_2$, where S^2 is geodesic sphere of CP_2. $\hat{M}^4 = M^4 \backslash M^2$ and $\hat{CP}_2 = CP_2 \backslash S^2$ have fundamental group Z since the codimension of the excluded sub-manifold is equal to two and homotopically the situation is like that for a punctured plane. The exclusion of these sub-manifolds defined by the choice of quantization axes could naturally give rise to the desired situation.

2. CP_2 allows two geodesic spheres which left invariant by $U(2$ *resp.* $SO(3)$. The first one is homologically non-trivial. For homologically non-trivial geodesic sphere $H_4 = M^2 \times S^2$ represents a straight cosmic string which is non-vacuum extremal of Kähler action (not necessarily preferred extremal). One can argue that the many-valuedness of $\hbar$ is un-acceptable for non-vacuum extremals so that only

homologically trivial geodesic sphere S^2 would be acceptable. One could go even further. If the extremals in $M^2 \times CP_2$ can be preferred non-vacuum extremals, the singular coverings of M^4 are not possible. Therefore only the singular coverings and factor spaces of CP_2 over the homologically trivial geodesic sphere S^2 would be possible. This however looks a non-physical outcome.

(a) The situation changes if the extremals of type $M^2 \times Y^2$, Y^2 a holomorphic surface of CP_3, fail to be hyperquaternionic. The tangent space M^2 represents hypercomplex sub-space and the product of the Kähler-Dirac gamma matrices associated with the tangent spaces of Y^2 should belong to M^2 algebra. This need not be the case in general.

(b) The situation changes also if one reinterprets the gluing procedure by introducing scaled up coordinates for M^4 so that metric is continuous at $M^2 \times CP_2$ but CDs with different size have different sizes differing by the ratio of Planck constants and would thus have only piece of lower or upper boundary in common.

3. For the more general option one would have four different options corresponding to the Cartesian products of singular coverings and factor spaces. These options can be denoted by $C-C$, $C-F$, $F-C$, and $F-F$, where C (F) signifies for covering (factor space) and first (second) letter signifies for CD (CP_2) and correspond to the spaces $(\hat{CD}\hat{\times}G_a) \times (\hat{CP}_2\hat{\times}G_b)$, $(\hat{CD}\hat{\times}G_a) \times \hat{CP}_2/G_b$, $\hat{CD}/G_a \times (\hat{CP}_2\hat{\times}G_b)$, and $\hat{CD}/G_a \times \hat{CP}_2/G_b$.

4. The groups G_i could correspond to cyclic groups Z_n. One can also consider an extension by replacing M^2 and S^2 with its orbit under more general group G (say 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 embedding space to another one.

1. How the gluing of copies of embedding space at $M^2 \times CP_2$ takes place? It would seem that the covariant metric of CD factor proportional to $\hbar^2$ must be discontinuous at the singular manifold since only in this manner the idea about different scaling factor of CD metric can make sense. On the other hand, one can always scale the M^4 coordinates so that the metric is continuous but the sizes of CDs with different Planck constants differ by the ratio of the Planck constants.

2. One might worry whether the phase transition changing Planck constant means an instantaneous change of the size of partonic 2-surface in M^4 degrees of freedom. This is not the case. Light-likeness in $M^2 \times S^2$ makes sense only for surfaces $X^1 \times D^2 \subset M^2 \times S^2$, where X^1 is light-like geodesic. The requirement that the partonic 2-surface X^2 moving from one sector of H to another one is light-like at $M^2 \times S^2$ irrespective of the value of Planck constant requires that X^2 has single point of M^2 as M^2 projection. Hence no sudden change of the size X^2 occurs.

3. A natural question is whether the phase transition changing the value of Planck constant can occur purely classically or whether it is analogous to quantum tunnelling. 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_an_b sheets and multiplies YM action action by n_an_b which is equivalent with the $\hbar = n_an_b\hbar_0$ if one effectively compresses the covering to $CD\times CP_2$. One would have $\hbar(CP_2) = \hbar_0/n_b$ and $\hbar = n_an_b\hbar_0$. Note that the descriptions using ordinary Planck constant and coverings and scaled Planck constant but contracting the covering would be alternative descriptions.

   This gives the following formulas $r \equiv \hbar/\hbar_0 = r(M^4)/r(CP_2)$ in various cases.

	$C-C$	$F-C$	$C-F$	$F-F$
r	n_an_b	$\frac{n_a}{n_b}$	$\frac{n_b}{n_a}$	$\frac{1}{n_an_b}$

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} was proposed to define favored as values of n_a in living matter [K15].

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 scaled up electron Compton lengths $L_e(k) = \sqrt{5}L(k)$ with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm) define scaled up copies of electro-weak and QCD type physics with ordinary value of $\hbar$ and that these physics are induced by dark variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$, and the resulting picture finds support from the ensuing models for biological evolution and for EEG [K15]. This hypothesis - to be referred to as Mersenne hypothesis - replaces the rather ad hoc proposal $r = \hbar/\hbar_0 = 2^{11k}$ for the preferred values of Planck constant.

How Planck constants are visible in Kähler action?

$\hbar(M^4)$ and $\hbar(CP_2)$ appear in the commutation and anti-commutation 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 embedding space sector with given values of Planck constants are proportional to the corresponding Planck. 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.

3.6.2 Cyclotron Frequencies And Larmor Frequencies

The appendix emphasizes the difference between the endogenous magnetic field B_{end} explaining the effects of ELF em fields on vertebrate brain and Earth's magnetic field B_E and lists cyclotron and Larmor frequencies of some ions for B_{end}.

The relationship between the values of the endogenous magnetic field and the Earth's magnetic field

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

Dark matter hierarchy leads to a detailed quantitative view about quantum biology with several testable predictions [K15] . The applications to living matter suggests that the basic hierarchy corresponds to a hierarchy of Planck constants coming as $\hbar(k) = \lambda^k(p)\hbar_0$, $\lambda \simeq 2^{11}$ for $p = 2^{127-1}$, $k = 0, 1, 2, ...$ [K15]. Also integer valued sub-harmonics and integer valued sub-harmonics of λ might be possible. Each p-adic length scale corresponds to this kind of hierarchy. Number theoretical arguments suggest a general formula for the allowed values of λ [K81] as $\lambda = n$ where n characterizes the quantum phase $q = exp(i\pi/n)$ characterizing Jones inclusion [K106]. The values of n for which quantum phase is expressible using only iterated square root operation are number theoretically preferred and correspond to integers n expressible as $n = 2^k \prod_n F_{s_n}$, where $F_s = 2^{2^s} + 1$ is Fermat prime and each of them can appear only once. $n = 2^{11}$ obviously satisfies this condition. The lowest Fermat primes are $F_0 = 3, F_1 = 5, F_2 = 17$. The prediction is that also n-multiples of p-adic length scales are possible as preferred length scales. The unit of magnetic flux scales up as $h_0 \rightarrow h = nh_0$ in the transition increasing Planck constant: this is achieved by scalings $L_e(k) \rightarrow nL_e(k)$ and $B \rightarrow B/n$.

$B = .2$ Gauss would correspond to a flux tube radius $L = \sqrt{5/2} \times L_e(169) \simeq 1.58 L_e(169)$, which does not correspond to any p-adic length scale as such. $k = 168 = 2^3 \times 3 \times 7$ with $n = 5$ would predict the field strength correctly as $B_{end} = 2B_E/5$ and predict the radius of the flux tube to be $r = 18$ μm, size of a large neuron. However, $k = 169$ with flux $2h_5$ would be must more attractive option since it would give a direct connection with Earth's magnetic field. Furthermore, the model for EEG forces to assume that also a field $B_{end}/2$ must be assumed and this gives the minimal flux h_5. Note that $n = 5$ is the minimal value of n making possible universal topological quantum computation with Beraha number $B_n = 4cos^2(\pi/n)$ equal to Golden Mean [K67].

An interesting working hypothesis is that B_{end} is the dark companion of the Earth's magnetic field and that the ratio $B_{end} = 2B_E/5$ holds true in the entire magnetosphere as a time average so that B_{end} would define what might be called the dark magnetosphere of Earth.

Table of cyclotron frequencies and magnetic frequencies

A detailed study of the cyclotron frequencies demonstrates that they indeed seem to correspond to important EEG frequencies. The cyclotron frequencies associated with other singly ionized atoms can be obtained by the formula

$$f = \frac{A}{20} \times f(Ca^{2+}) \qquad f(Ca^{2+}) \simeq 15\ Hz \ . \tag{3.6.1}$$

Here the strength of the endogenous magnetic field B_{end} is assumed to be .2 Gauss $= 2 \times 10^{-5}$ Tesla. The

Table 3.6 lists cyclotron frequencies and their lowest multiples for some of the most important ions.

Elementary particle	f_1/Hz	J	f_L/Hz
e	5.6×10^5	1/2	2.8×10^5
p	300	1/2	419
Bosonic ions			
^6Li	50.1	1	88.3
O^{2-}	37.4	0	0
Mg^{++}	25.0	0	0
Ca^{++}	15.0	0	0
Mn^{2+}	11.4	5/2	520
Fe^{2+}	10.8	0	0
Co^{2+}	10.0	7/2	695
Zn^{2+}	9.4	0	0
Se^{2-}	7.6	0	0
Fermionic ions			
$^7Li^+$	42.9	3/2	489
N^+	21.4	1	60.6
F^-	15.8	1/2	395
Na^+	13.0	3/2	333
Al^+	11.1	5/2	546
Si^+	10.7	0	0
P^+	9.7	1/2	170
S^-	9.4	0	0
Cl^-	8.5	3/2	130
K^+	7.5	3/2	58.5
Cr^-	5.7	3/2	71.1
Cu^+	4.8	3/2	333.9
Ag^+	2.8	1/2	17
I^+	2.4	5/2	420
Au^+	1.5	3/2	21

Table 3.6: The first column gives cyclotron frequency in cycles per second for some ions in the endogenous magnetic field $B_{end} = 2B_E/5 = .2$ Gauss explaining the effects of ELF em fields on vertebrate brain ($B_E = .5$ Gauss denotes the nominal of the Earth's magnetic field). The remaining columns give spin or nuclear spin and Larmor frequency f_L.

Part II

TOPOLOGICAL LIGHT RAYS AND WORMHOLE MAGNETIC FIELDS

Chapter 4

Quantum Antenna Hypothesis

4.1 Introduction

One of the basic problems faced by the quantum theories of consciousness is to understand how macroscopic quantum coherence in the brain is realized. Bose-Einstein condensates and coherent states are believed to be crucial in this respect but the great problem is how macroscopic quantum phases could be realized in the wetty, noisy and hot environment provided by brain. In TGD framework the notion of many-sheeted space-time provides a solution to this basic problem. Furthermore, the notion of self as a subsystem able to remain un-entangled is consistent with the fact that macroscopic quantum phases behave like quantum particles. The general views about macroscopic quantum phases predicted by TGD and about their role with regards to consciousness is described in previous chapters. This chapter is devoted to coherent and Bose-Einstein condensed photons which are crucial in the quantum models of brain consciousness relaying on microtubules and seem to be associated with linear structures also in TGD framework. These linear structures include not only microtubules but also axons, DNA and proteins and most of the considerations to follow are quite general and by no means restricted to microtubules.

4.1.1 Massless Extremals And Quantum Antenna Hypothesis

The purpose of this chapter is a more detailed formulation of the quantum antenna hypothesis stating that microtubules generate a macroscopic coherent state of photons. The so called massless extremals are a very general class of zero action non-vacuum extremals of both the Kähler action and the effective action and differentiate clearly between TGD and standard gauge theories, in particular QED. Massless extremals describe the propagation of massless gauge fields in single preferred direction. The polarization for given values of transversal coordinates has a fixed direction. Linear superposition is not possible.

Topological field quantization assigns to each quantum notion its classical counterpart and a very attractive identification of the massless extremals is as the classical counterparts of massless classical quanta such as photons and gravitons. Even the classical counterparts of the virtual particles make sense: in particular, negative energy photons represented by annihilation part of the free photon field seem to have geometric representation as negative energy massless extremals.

Massless extremals (ME) of the effective action can indeed generate coherent states of photons and gravitons.

1. ME:s are characterised by light like vacuum Kähler current J_K. In general but not always this implies light-like em current J_{em} and the standard coupling to the quantized photon field generates a coherent state of photons.

2. The geometry of the 3-surface in question is most naturally cylindrical and microtubules (as also DNA, proteins, etc..) indeed possess this kind of geometry.

There are sharp resonances at frequencies $\omega = n2\pi/L$, where L is the length of the cylindrical 3-surface (say a space-time sheet associated with a microtubule). The BE condensates for the resonance frequency photons provide means of communication for the neuron society and could orchestrate microtubules to form a single macroscopic quantum system. One could also consider the possibility that nerve pulse patters are coded to vacuum currents and in turn coded to patterns of coherent photons. In fact, the model of memetic code leads to the identification of nerve pulse/no nerve pulse as Boolean statement true/false. The coding of the nerve pulse patterns to the patterns of vacuum currents of axonal microtubules could occur naturally. The vacuum currents associated with the radial neuronal microtubules could communicate nerve pulse patterns to cell nucleus and the effects of the anesthetics on neuronal microtubules could mean the cutting of this communication line.

A necessary condition for the macroscopic quantum coherence is the phase locking of the vacuum currents associated with different microtubules. Join along boundaries bonds connecting the massless extremals to a larger space-time sheet serving as a common pacemaker could make possible the phase locking.

4.1.2 Evidence

This picture suggests that microtubules could act as senders and receivers of a coherent light and that visual consciousness should be closely related with the microtubules in accordance with the general philosophy already described. There is indeed some experimental support for identifying the coherent states of photons as associated with vision. It is known that some monocellulars possess elementary vision based on the microtubules [I28]. The length distribution of the microtubules in the rods and cones of the eye is concentrated in the region of the visible wavelengths. Insects are known to perceive certain chemical compounds (such as pheromones) by the maser like emission of infrared light by these chemical compounds [I42]. Also human nose contains so called vomeronasal organ which seems to give rise to an additional unconscious sense of odors with social and sexual meaning. Interesting hypothesis is that also this vision is based on infrared vision.

There is quite unexpected connection with the phenomenon of sonoluminescence suggesting that liquids contain structures of size of order microtubule diameter and that the highly synchronized light flash emitted in the sonoluminescence results from the condensation of water vapor to liquid involving generation of $k = 149$ space-time sheets from $k = 151$ space-time sheets by p-changing phase transition and subsequent creation of light-like vacuum currents at almost empty $k = 151$ space-time sheets leading to the emission of the flash of coherent light.

An additional support for the quantum antenna hypothesis comes from the quite recently observed anomalous dissociation of water molecules to hydrogen and oxygen in room temperature in presence of catalyst and stirring of the liquid. Usually the reaction is driven by thermal photons at temperature of order 3300 K. A possible explanation is that the Z^0 magnetic flux tubes created by the rotating nuclear Z^0 charge are accompanied by space-time sheets carrying light like vacuum currents generating coherent photons, which in turn drive the dissociation reaction.

Biefeld-Brown effect is one of the oldest poorly understood anomalous effects [H4, H10, H16]. What happens is that charged capacitor gains center of mass momentum in the direction orthogonal to the plane of the capacitor plates. Antigravity effect caused by the redistribution of gravitational and/or Z^0 fluxes of the capacitor between various space-time sheets could explain some aspects of the effect. The generation of negative energy space-time sheet with net momentum associated with classical em fields could be also involved with the effect. So called "massless extremals" are optimal candidates for this purpose. This mechanism might be applied by bio-systems to generate coherent motions.

4.1.3 Quantum Antenna Hypothesis And Brain Consciousness

The identification of macroscopic quantum phases possibly serving as quantum correlates of some qualia does not yet help much in understanding brain consciousness. Brain as a neuron society, brain as a music instrument or even entire orchestra and the notion of neural window are metaphors which have served as guidelines in the attempts to guess the general architecture of brain consciousness and might help also the reader to better understand the considerations to follow.

Brain as a neuron society metaphor

The brain as a society of conscious neurons metaphor has surprisingly nontrivial consequences. In particular, a plausible and testable hypothesis for the physical correlates of the sensory qualia becomes possible.

1. Brain as a society of conscious neurons metaphor suggests that our sensory qualia must have a reduction to the neuronal level. For instance, this could mean that our sensory experiences correspond to the sensory experiences associated with the large coherently firing neuron gap junction connected neuron groups in brain.

2. Conscious neurons must be able to communicate their conscious experiences to their fellow neurons. The simplest way to achieve this is to regenerate the original sensory experience to be communicated by sending a message which creates the stimulus resembling the stimulus giving rise to the original sensory experience.

An attractive idea is that the massless extremals (MEs) associated with the microtubules and other linear structures are for the neuron society what radio receivers and stations are for us. Perhaps the idea about the information society at neuronal level does not look so far fetched if one recalls that a communication based on the genetic code takes place already at DNA-protein level. Furthermore, if Nature has invented a communication by means of a coherent light, it probably has invented also the use of several bandwidths by using several microtubule lengths so that very sophisticated communication systems could exists in brain.

Brain as a society of neurons hypothesis has close relationship to other hypothesis with very similar content. Global workspace hypothesis [J13] states essentially that mass media type communication available for large numbers of neurons plays crucial role in the functioning of conscious brain: coherent light is ideal for this purpose. Also brain as hologram idea [J35, J30]. which is abstracted to neuronal window idea in TGD framework, states that some kind of mass media type communication occurs.

The notion of neural window

The idea of neural window suggests that secondary sensory organs see either the classical em field or the coherent light generated by the mind-like space-time sheets representing the objects of the perceptive field, which can be associated with the primary sensory organ or with the secondary sensory organs in thalamus and cortex. This secondary vision, which could make possible imagination in or all sensory modalities, would be made possible by the coherent photons suffered Bose-Einstein condensation on space-time sheets associated with microtubules or with axons (several space-time sheets might be involved) and serving as wave guides. Massless extremals allow to translate the notion of neural window to the notion of quantum hologram.

Music metaphor

Music metaphor which states that each neuron gives rise to characteristic sensory experience like string of piano gives rise to single note, gives strong constraint on the neuronal window idea. The massless extremal associated with axon corresponds to definite axon dependent frequency. In fact, in the proposed model for the quantum correlates of the sensory qualia [K16] sensory qualia are characterized by some frequency of BE condensed photons besides a pattern of cyclotron frequencies.

A related catching metaphor is to regard groups of parallel axonal microtubules as an orchestra producing light instead of sound with various frequencies. The interior containing the light-like em current would be the instrument and the note produced by single tubule would be a superposition of the frequencies $n\omega_0$, $\omega_0 = 2\pi/L$. The Fourier spectrum of the massless extremal would define the characteristics of the instrument. Of course, in long time scales microtubule could vary its length and achieve more impressive performances than single note samba. A good candidate for the player is the microtubule surface controlling the amplitude of the quantum photon field emitted by the interior by modulating the light-like current in the interior.

Brain as an associative net

The previous metaphors are consistent with the basic view about brain is as associative net such that conscious associations at neural level correspond to conscious experiences of presynaptic neurons associated with the experience of the postsynaptic neuron. The experiences of given neuron is always the same and only its intensity varies so that brain is indeed like a music instrument or orchestra. The intensity of experience is coded by the pattern of nerve pulses. The hypothesis about memetic code states following things. Nerve pulse/no nerve pulse corresponds to true/false Boolean statement; the codons of the memetic code consist of 126 bits and have total duration of order .1 seconds, the duration of our cognitive sub-self; single bit corresponds to a duration of order one millisecond, the duration of nerve pulse; codons are represented by temporal sequences of cognitive neutrino pairs to which nerve pulse sequences are coded; cognitive neutrino pairs are in turn coded to conscious experiences in many-to-one way by a unique code analogous to that coding mRNA sequences to polypeptides.

4.1.4 Relationship Of TGD Approach With Microtubular Approach

The role of the microtubules (for a nice introduction see [J18]) is believed to be also important for brain consciousness. In TGD framework however microtubules are only one, rather low-lying, although certainly important, level of the self-hierarchy and microtubular consciousness is not expected to correspond to our consciousness directly. In fact, the identification of our sub-selves (mental images) as "ELF selves" having as their geometrical correlates topological field quanta of em field with size of Earth, supported by various experimental data about the effects of ELF (extremely low frequency) em fields on brain and correlating our sub-selves with certain EEG frequencies, could not be philosophically farther from the reductionistic identification of microtubules as seat of our consciousness proposed by Penrose and Hameroff [J37].

Fröhlich condensates [I33] and microtubular Bose-Einstein condensates of photons have been proposed as the relevant macroscopic quantum phases in the microtubular theory of consciousness. Also in TGD framework macroscopic quantum phases are crucial and serve as quantum correlates of sensory qualia. The basic problem of these theories is how to preserve macroscopic quantum coherence over a time interval of order .1 seconds characterizing our consciousness. In In TGD framework the wake-up time of the microtubular selves (time which they are able to stay p-adically unentangled) of about 10^{-16} seconds typically, is not a problem since microtubular selves are not our immediate sub-selves.

The notion of many-sheeted space-time allows TGD counterparts of both Fröhlich condensates and microtubular photon BE condensates as condensates associated not only with microtubules.

1. Wormhole contacts are unavoidable element of the many-sheeted space-time concept. Wormhole contacts behave in many respects like charged particles and are

described by a complex order parameter and it makes sense to speak about wormhole super conductivity. The connection with Fröhlich's condensate comes as follows. Electric fields penetrate from one space-time sheet to another via wormhole contacts carrying quantized fluxes. Thus the normal component of electric field is essentially the density of wormhole charge given by the modulus squared for the order parameter of the wormhole BE condensate. Vacuum polarization of the space-time sheet amounts to the generation of wormhole BE condensates of opposite gauge flux on the two sides of the polarized space-time sheet. In a well defined sense wormhole contact order parameter is square root of the order parameter of Fröhlich condensate.

2. Living matter behaves as liquid crystal and the electret nature of liquid crystals is crucial for many-sheeted ionic flow equilibrium since the weak but coherent electric fields make possible ohmic currents at atomic space-time sheets transforming to supra currents at superconducting space-time sheets.

3. Vacuum gauge fields with non-vanishing gauge currents are a generic phenomenon in TGD and not possible in standard theories. These c-number currents automatically generate quantum coherent states of photons and gravitons via their coupling to the corresponding quantized boson fields. Massless extremals are ideal in this respect since the generation of coherent photons by the light-like vacuum current occurs resonant like way. Very importantly, massless extremals allow BE condensates of photons in the direction of the light-like vacuum current. This means that massless extremals can serve both as receiving and sending quantum antennae.

4.1.5 MEs And Information Molecules

The notion of information molecule is central for the understanding of biological control. There are however several difficult questions related to the notion of information molecule. TGD inspired view about biocontrol and coordination suggests a general answer to these questions and leads to a general model of biological control based on both MEs and information molecules with massless extremals (MEs) serving as actual information carriers initiating self-organization processes whereas information molecules are in the role analogous to that of computer password.

4.1.6 MEs And Quantum Holography

One can generalize the original solution ansatz for MEs by introducing what might be called local light cone coordinates for M^4_+. Boundary conditions for MEs are satisfied if the boundaries of MEs are light-like 3-surfaces, and thus have the same miraculous conformal properties as the boundary of the future light cone. In fact, the light-likeness of the boundaries of M^4 like space-time sheets provide a universal ways to satisfy boundary conditions for field equations.

The superconformal and super-symplectic symmetries can be used to generalize the construction of the configuration space geometry to take into account the classical non-determinism of Kähler action. Quantum holography in the sense of the quantum information theory allows to interpret MEs both as receiving and sending quantum antennae as well as dynamical holograms with light-like vacuum currents defining the counterpart of the diffraction grating, and making possible the teleportation of quantum em fields. The superconformal and super-symplectic symmetries, which commute with Poincare symmetries apart from quantum gravitational effects, makes the boundaries of MEs natural seats of super-symplectic representations, and since these states are genuine quantum gravitational states defined by statefunctionals in the "world of classical worlds", they are expected to be crucial for understanding higher level consciousness.

MEs induce supra currents in superconducting magnetic circuits by magnetic induction mechanism, serve as Josephson junctions between magnetic flux tubes, and induce magnetic quantum phase transitions. MEs can generate reference waves or their phase conjugates (time reversals) acting on lower level MEs serving as dynamical holograms. The induced coherent light pattern would act as a control command or its time reversed version. Conjugate reference waves could provide an extremely simple basic mechanism of healing by time reversal allowing the living matter to fight against second law. MEs could read DNA strand to the light-like vacuum current by drifting along it and thus code DNA strand/conjugate strand to a hologram or its phase conjugate in turn acting as a control command or its time reversal. Thus living matter could be regarded as a symbiosis in which MEs control superconducting magnetic flux tubes controlling ordinary matter at atomic space-time sheets via many-sheeted ionic flow equilibrium. DNA would represent the ROM of this system.

4.1.7 MEs And The Notion Of Conscious Hologram

The notion of conscious hologram is the last step in the development of ideas related to bioholograms. The basic challenge is to generalize the notion of the ordinary hologram to that of a *conscious* hologram, about which bio-holograms would be examples. The notion of quantum gravitational hologram is defined at the level of geometric, purely physical existence whereas conscious holograms exist at the level of subjective existence defined by the sequence of quantum jumps and giving rise to the self hierarchy. Of course, these two notions of hologram must be closely related.

The notion of conscious hologram combines the saint and sinner aspects of consciousness to single concept: macrotemporal quantum coherence due to the generation of bound state entanglement and giving rise to co-operation on one hand, and the dissipative self-organization giving rise to Darwinian selection and competition on the other hand.

In nutshell, the notion of conscious hologram follows from the topological field quantization. Classical fields and matter form a Feynman 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 ("massless extremals", MEs). Also magnetic flux tubes appear and together with MEs they serve as correlates for bound state quantum entanglement.

The classical fields associated with MEs interfere only at the nodes, where they meet, and one has a hologram like structure with nodes interpreted as the points of a hologram. Thus one avoids the loss of information caused by the interference of all signals everywhere. This aspect is crucial for understanding the role of em fields in living matter and brain. The MEs corresponding to "real photons" are like laser beams entering the hologram and possibly reflected from it. What is new that the nodes can be connected by "virtual photon" MEs also analogous to laser beams. Hence also "self-holograms" with no laser beam from external world are possible (brain without sensory input).

The hologram has a fractal structure: there are space-time sheets at space-time sheets and high frequency MEs propagating effectively as massless particles inside low frequency MEs serving as quantum entangling bridges of even astrophysical length. The particle like high frequency MEs induce "bridges" between magnetic flux tubes and atomic space-time sheets at the receiving end. This makes possible the leakage of supra currents from magnetic flux tubes to atomic space-time sheets analogous to the exposure of film producing hologram. The leakage induces dissipation, self-organization, and primitive metabolism as a cyclic flow of ionic currents between the two space-time sheets, and thus a Darwinian selection of the self-organization patterns results. Under certain conditions the leakage followed by dropping back to the larger space-time sheet can also give rise to a many-sheeted laser. The low frequency MEs are responsible for the bound state entanglement, macroscopic quantum coherence and co-operation whereas high frequency MEs are responsible for self-organization and competion.

The 3-D vision associated with ordinary holograms generalizes to stereo consciousness resulting in the fusion of mental images associated with the points of conscious hologram [K7].

4.1.8 Negative Energy MEs And Bio-Control

Negative energy MEs correspond to space-time sheets with a reversed time orientation. These MEs serve as correlates for bound state entanglement. Low frequency negative energy MEs can contain inside them high frequency MEs propagating along them like negative energy particles. The possibility to quantum jump to a higher energy state by generating negative energy ME gives rise to the pay now-let others pay mechanism of metabolism. This quantum credit card mechanism makes the functioning of the living system extremely flexible. The fact that ELF MEs play an important role in living matter forces to consider the possibility of remote metabolism and the transfer of metabolic energy even in the length scale of Earth (7.8 Hz frequency corresponds to Earth's circumference). The small energy dissipation related to "our" consciousness could perhaps help to solve "brain's energy crisis" [J9] raised by the puzzling observation that the human brain plus body as a whole does not use more energy than smaller brained mammals with a similar body size.

Negative energy MEs are optimal for the realization of intentions. First p-adic ME transformed to a negative energy ME is generated and serves as a geometric correlate of intention. Then quantum jumps of a real system to a higher energy state occurs and in this quantum jumps p-adic ME is transformed to a negative energy ME to take care of the conservation laws.

Right and left brain hemispheres could have different arrows of the geometric time at appropriate p-adic time scales. For instance, negative energy MEs would make possible quantum communications to the direction of the geometric past. The model of non-episodal memory call would involve quantum communication of the question to the geometric past (time-like entanglement and sharing of mental images), and a classical (dissipative) communication of the answer to the geometric future. Negative-positive energy dichotomy could be be realized in an extremely wide range of time scales and to explain, besides the basic mechanism of long term memory, also precisely targeted realization of intentions, sensory-motor dichotomy, and biocycles as dissipation-healing cycles.

Quantum criticality is the basic characteristic of TGD Universe and quantum critical superconductors provide an excellent test bed to develop the ideas related to quantum criticality into a more concrete form. The hypothesis that Planck constants in CD (causal diamond defined as the intersection of the future and past directed light-cones of M^4) and CP_2 degrees of freedom are dynamical possessing quantized spectrum given as integer multiples of minimum value of Planck constant [K81, K80] adds further content to the notion of quantum criticality.

After several alternatives I ended with the conjecture that the value of $\hbar$ is in the general case given by $\hbar = n \times \hbar_0$. Integer n characterizes a sub-algebra of super-symplectic algebra or related algebra with conformal structure characterized by the property that conformal weights are n-multiples of those of the full algebra. The sub-algebra is isomorphic with the full algebra so that a fractal hierarchy of sub-algebras is obtained. One obtains an infinite hierarchy of conformal gauge symmetry breaking hierarchies defined by the sequences of integers n_i dividing n_{i+1}.

The identification in terms of hierarchies of inclusions of hyper-finite factors of type II_1 is natural. Also the interpretation in terms of finite measurement resolution makes sense. As n increases the sub-algebra acting as conformal gauge symmetries is reduced so that some gauge degrees of freedom are transformed to physical ones. The transitions increasing n occur spontaneously since criticality is reduced. A good metaphor for TGD Universe is as a hill at the top of a hill at the top.... In biology this interpretation is especially interesting since living systems can be seen as systems doing their best to stay at criticality using metabolic energy feed as a tool to achieve this. Ironically, the increase of $\hbar$ would mean increase of measurement resolution and evolution!

The only coupling constant of the theory is Kähler coupling constant $\alpha_K = g_K^2/4\pi\hbar$, which appears in the definition of the Kähler function K characterizing the geometry of the configuration space of 3-surfaces (the "world of classical worlds"). The exponent of K defines vacuum functional analogous to the exponent of Hamiltonian in thermodynamics. The allowed value of $\alpha_K = g_K^2/4\pi\hbar$ should be analogous to critical temperature and determined by quantum criticality requirement. There are two possible interpretations for the hierarchy of Planck constants.

1. The actual value of $\hbar$ is always its standard value and value of $\alpha_K = g_K 2/4\pi\hbar$ is always its maximal value $\alpha_K(n = 1$ but there are n space-time sheets contributing the same value of Kähler action effectively scaling up the value of $\hbar_0$ to $n\hbar_0$ scaling down the value of $\alpha_K(1)$ to $\alpha_K(1)/n$. The n sheets would belong to n different conformal gauge equivalence classes of space-time surfaces connecting fixed 3-surfaces at opposite boundaries of CD. This interpretation is analogous to the introduction of the singular covering space of embedding space.

   One can of course ask whether all values $0 < m \leq n$ for the number of "actualized" sheets are possible. A possible interpretation would be in terms of charge fractionization.

2. One could also speak of genuine hierarchy of Planck constants $\hbar = n\hbar_0$ predicting a genuine hierarchy of Kähler coupling strengths $\alpha_K(n) = \alpha_K(n = 1)/n$. In thermodynamical analogy zero temperature is an accumulation of critical temperatures behaving like $1/n$. Intriguingly, in p-adic thermodynamics p-adic temperature is quantized for purely number theoretical reasons as $1/n$ multiples of the maximal p-adic temperature. Note that Kähler function is the analog of free energy. In this interpretation the n sheets are identified.

Phases with different values n behave like dark matter with respect to each other in the sense that they do not have direct interactions except at criticality for the phase transition changing the value of n to its multiple or divisor. In large $\hbar(CD)$ phases various quantum time and length scales are scaled up which means macroscopic and macro-temporal quantum coherence.

Number theoretic complexity argument favors the hypothesis that the integers n 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, might be 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.

Contrary to the original hypothesis inspired by the requirement that gravitational coupling is renormalization group invariant, α_K does not seem to depend on p-adic prime whereas gravitational constant is proportional to L_p^2. The situation is saved by the assumption that gravitons correspond to the largest non-super-astrophysical Mersenne prime M_{127} so that gravitational coupling is effectively RG invariant in p-adic coupling constant evolution [L28].

$\hbar(CD)$ appears in the commutation and anti-commutation relations of various superconformal algebras. 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 Planck constants 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.

A further great idea is that the transition to large $\hbar$ phase occurs when perturbation theory based on the expansion in terms of gauge coupling constant ceases to converge: Mother Nature would take care of the problems of theoretician. The transition to large $\hbar$ phase obviously reduces gauge coupling strength α so that higher orders in perturbation theory are reduced whereas the lowest order "classical" predictions remain unchanged. A possible quantitative formulation of the criterion is that maximal 2-particle gauge interaction strength parameterized as $Q_1Q_2\alpha$ satisfies the condition $Q_1Q_2\alpha \simeq 1$.

TGD thus predicts an infinite hierarchy of phases behaving like dark or partially dark matter with respect to the ordinary matter and each other [K84] and the value of $\hbar$ is only one characterizer of these phases. These phases, especially so large $\hbar$ phase, seem to be essential for the understanding of even ordinary hadronic, nuclear and condensed matter physics [K84, K94, K80]. This strengthens the motivations for finding whether dark matter might be involved with quantum critical super-conductivity.

Cusp catastrophe serves as a metaphor for criticality. In the case of high T_c superconductivity temperature and doping are control variables and the tip of cusp is at maximum value of T_c. Critical region correspond to the cusp catastrophe. Quantum criticality suggests the generalization of the cusp to a fractal cusp. Inside the critical lines of cusp there are further cusps which corresponds to higher levels in the hierarchy of dark matters labeled by increasing values of $\hbar$ and they correspond to a hierarchy of subtle quantum coherent dark matter phases in increasing length scales. The proposed model for high T_c super-conductivity involves only single value of Planck constant but it might be that the full description involves very many values of them.

MEs and dark matter hierarchy

MEs can be regarded as space-time correlates for a hierarchy of particles characterized by different values of Planck constant and the de-coherence phase transition would naturally correspond to the decay of MEs to smaller space-time sheets. Single sheeted MEs correspond to fermions and their super partners and topologically condensed CP_2 type vacuum extremals representing particles involve only single wormhole throat carrying the quantum numbers. Double sheeted MEs connected by wormhole contacts correspond to bosons and their super-partners with the throats of wormhole contacts carrying the quantum numbers. The two sheets have opposite arrow of time and signs of energies.

The ordinary laser light cannot be regarded as a large $\hbar$ phase, which de-coheres to ordinary photons before the interaction with ordinary matter. Very general consistency arguments lead to the working hypothesis that dark matter and dark MEs correspond to λ^k-fold ($k > 0$) coverings of CD (causal diamond) locally ($\hbar(k) = \lambda^k\hbar_0$, $\lambda = 2^{11}$) whereas ordinary laser light would correspond to $k = 0$.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L5].

4.2 Massless Extremals

The so called massless extremals are very general solution of field equations associated with the minimization of Kähler action parameterized by several arbitrary functions. The characteristic feature of the massless extremals is the presence of light-like currents generating coherent states of photons and gravitons. These features suggest that massless extremals might have important role in bio-systems.

4.2.1 Massless Extremals As General Solutions Of Field Equations

Let $k = (k^0, k^3, 0, 0)$ be a light like vector of M^4 and $u = u(m^1, m^2)$ arbitrary function of the Minkowski coordinates m^1 and m^2 in the plane orthogonal to the direction of the

3-vector $(k^3,0,0)$ associated with k. The surfaces defined by the map

$$s^k = f^k(k\cdot m,u) \ , \qquad (4.2.1)$$

where f^k and u are arbitrary functions define massless extremals. They describe the propagation of massless fields in the direction of k: the fields are periodic with a period $\lambda = 2\pi/k$ so that only k and its integer multiples are possible wave vectors. The polarization associated with various induced gauge fields depends on the position in (m^1,m^2)-plane and is in the direction of the gradient of u. Field equations involve tensor contractions of the energy momentum tensor and gauge current but these are proportional to kk and k respectively and vanish by the light-likeness of k. Linear superposition holds true only in a restricted sense since both the propagation direction and the polarization direction in each $(m^1,m^2) = const$ plane is fixed.

What is remarkable that these solutions are not solutions of the ordinary Maxwell equations in vacuum: Kähler current density J_K is in general non-vanishing(!) and proportional to the light like four-momentum k. As a consequence, also a light-like electromagnetic current is in general (but not necessarily) present. The interpretation of the em current J as charged elementary particle current is impossible and the correct interpretation as a vacuum current associated with the induced gauge fields. The finite length of the microtubule plus the requirement that the total vacuum charge vanishes, implies that the Fourier decompositions of the massless fields contain only integer multiples of the basic four-momentum k. The direct detection of the light-like vacuum current inside a microtubule would provide strong support for TGD.

The physical importance of these extremals is suggested by the fact they are in certain sense elementary particle like objects: in fact, the original interpretation was as a model for the exterior space-time of a topologically condensed massless particle. The solution set is also very general involving several arbitrary functions. Although the minimization of the Kähler action favors the formation of Kähler electric fields, massless extremals might well appear as space-time sheets of the effective space-time. These space-time sheets should not contain ordinary charges since their presence implies a transition to the Maxwell phase described in an excellent approximation by the ordinary Maxwell electrodynamics.

Rather remarkably, massless extremals are also solutions of the field equations associated with the low energy effective action. This holds true in the absence of the topologically condensed matter, phenomenologically described using external currents. For instance, the term

$$(T^{\alpha\beta}_{\#} - \frac{1}{16\pi G}G^{\alpha\beta})D_\beta\partial_\alpha h^k \ ,$$

where # refers to the topologically condensed matter, reduces to

$$\frac{1}{16\pi G}G^{\alpha\beta}D_\beta\partial_\alpha h^k \ ,$$

and vanishes identically because Einstein tensor is light like so that contraction with the second fundamental form vanishes. The vanishing of these terms in presence of matter is not possible since the gauge currents and energy momentum tensor associated with the topologically condensed matter are not light-like. Thus massless extremals correspond to vacuum space-time sheets with respect to the ordinary matter. Massless extremals can however interact with the ordinary matter via # contacts.

The fact that vacuum em current and vacuum Einstein tensor do not in general vanish, implies that massless extremals serve as sources of coherent photons and gravitons. It is not very economical to maintain BE condensates all the time. In "dormant" states microtubules could correspond to ME: s with vanishing em fields but non-vanishing Z^0 fields or even vacuum extremals of the effective action with one-dimensional CP_2 projection and having vanishing classical gauge fields. Massless extremals can also reduce to vacuum extremals of the Kähler action in the case that

the CP_2 projection is, in general two-dimensional, Legendre manifold of CP_2. Also in this case massless extremals are however non-vacuum extremals of the effective action.

4.2.2 About The Electro-Weak And Color Fields Associated With Massless Extremals

Space-time sheets carrying em fields carry usually also Z^0 and W fields and it is not possible to speak about em or Z^0 type MEs. It is however possible to speak about neutral and W MEs. The CP_2 projection of ME is 2-dimensional and in a special case it reduces to a geodesic sphere. There are two kinds of geodesic spheres in CP_2.

1. For space-time sheets for which CP_2 projection is $r = \infty$ homologically non-trivial geodesic sphere of CP_2 one has

$$\gamma = (\frac{3}{4} - \frac{sin^2(\theta_W)}{2})Z^0 \simeq \frac{5Z^0}{8} \ .$$

The induced W fields vanish in this case and they vanish also for all geodesic sphere obtained by $SU(3)$ rotation.

2. For homologically trivial geodesic sphere a standard representative is obtained by using for the phase angles of standard complex CP_2 coordinates constant values. In this case 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.

The MEs corresponding to these two geodesic spheres could be called neutral and W MEs and they carry color fields for which the color group $SU(3)$ reduces to some of its $U(1)$ subgroups. Quite generally, the holonomy algebra of color group is Abelian since the induced color field is of the form $g^A_{\alpha\beta} \propto H^A J_{\alpha\beta}$, where H^A denotes color Hamiltonian.

Neutral MEs are excellent candidates for mediating EEG type communications from the biological body to the magnetic body whereas charge entanglement induced by W MEs would be ideal for the realization of motor actions of the magnetic body by generating first superposition of exotically ionized states of atomic nuclei entangling magnetic and biological body [K15]. State function reduction would lead to an exotically ionized state accompanied by dark plasma oscillation pattern. By Faraday law this pattern would induce electric fields at the space-time sheets containing ordinary matter which in turn would generate ohmic currents leading to various physiological effects.

MEs are excellent candidates for the space-time correlates of laser beams. Dark matter hierarchy implies that also MEs can be classified by the level of the dark matter hierarchy involved. A very general argument leads to the conclusion that dark space-time sheets, in particular MEs, at the k^{th} level of the dark matter hierarchy correspond to space-time sheets defining λ^k-fold coverings of M^4 (recall that one has $\hbar(k) = \lambda^k\hbar_0$ and $\lambda \simeq 2^{11}$) [K106, K15]. $k = 0$ MEs would correspond to the ordinary laser light.

4.2.3 How Massless Extremals Generate Coherent States Of Photons?

ME: s can be in "dormant" or active state according to whether the em current associated with the ME is vanishing or not. In active state ME: s generate Bose Einstein condensate type state for ordinary photons. This means in TGD context the emission of (topological) vapor phase photons (CP_2 type extremals), which can condense on other condensate levels. ME: s generate gravitonic BE condensate and the possible biological role of this condensate will be discussed later.

Assuming that the coupling of quantized photon field to the massless extremal is given by regarding the massless extremal as a classical background field one obtains QED with a light like source J^{α}:

$$\begin{aligned} D_{\beta}F^{\alpha\beta} &= eJ^{\alpha} \ , \\ J^{\alpha} &= Jk^{\alpha} \ . \end{aligned} \tag{4.2.2}$$

The system is equivalent with an infinite number of harmonic oscillators each driven by a harmonic external force and a basic exercise in the quantum mechanics shows that the solutions of the field equations give the new oscillator operators as sums of free oscillator operators plus c-number term, which is essentially the Fourier component of the light like current in the direction of the polarization.

In the limit that ME has infinite duration and is a cylindrical structure of finite length L (that is microtubule) one has for $J \propto sin(k_z(t-z))$

$$\begin{aligned} a^{\dagger}(p) &\rightarrow a^{\dagger}(p) + g(p) \ , \\ g(p) &= \sum_n \delta(p^0, k_n^0) K(p, k_n) J(k_n^z, p_T) \ , \\ K(p,k) &= \epsilon(p) \cdot k \frac{1}{i(p_z - k_z)} (exp(ip_z L) - 1) \ , \\ k_n &= nk_0 = \frac{n2\pi}{L}(1,1,0,0) \ . \end{aligned} \tag{4.2.3}$$

Here p denotes the momentum of the photon and k the 4-momentum associated with the Fourier component of a light-like current. $\epsilon(p)$ denotes the polarization of the photon. $J(k_n^z, p_T)$ is essentially the 3-dimensional Fourier transform of the scalar function J. The infrared behavior of $J(k_z, p_T)$ as a function of the transversal momentum p_T can be deduced from the fact that the transverse dimension of the microtubule is small (about 25 nm) as compared to $1/p_T$ so that the Fourier component is in good approximation independent of p_T.

For the frequencies present in the Fourier decomposition of the massless extremal, the ordinary oscillator vacuum is transformed to a coherent state in the corresponding Fourier mode of the quantized photon field. The essential point is that the wave vectors of the radiation field and massless extremal are nonorthogonal. The radiation pattern resembles the ordinary antenna pattern associated with an oscillating current $J(t) = exp(i\omega t)$ in that the intensity of radiation vanishes at angles $\theta = \pi/2$ and $\theta = 0$. For $J \propto sin(k_z(z-t))$ $|K|^2$ has maxima for $\theta = 48.6$ degrees and 131.4 degrees. For an ordinary dipole with $J = sin(\omega t)$, $\omega = 2\pi/L$ the radiation pattern is concentrated at angles $\theta \geq 40$ degrees with maximum and 69.3 degrees and 110.7 degrees.

A more complicated situation corresponds to a group of several massless extremals (say microtubules). If massless extremals are parallel and have same length the previous expression generalizes with superposition of terms

$$g(p) \rightarrow \sum_n exp(i\phi_n) exp(ip_z z_n) exp(ip_T \cdot x_T) g_n(p) \ . \tag{4.2.4}$$

The phase ϕ_n is the phase difference between n: th light like current with respect to some reference current. If the positions of microtubules and/or phases of the individual light like currents are suitably chosen then various terms interfere constructively and macroscopic quantum coherence is obtained at resonant frequencies. Suffice it so say that the needed timing is extremely accurate: less than 10^{-12} seconds! Since p_z is small rather larger transversal distances are allowed by the requirement of constructive interference. In a more general situation also the orientations of microtubules can vary in certain limits. Note that light-like energy momentum generates also gravitonic BE condensates at preferred frequencies.

4.2.4 Massless Extremal Is Accompanied By A Bose-Einstein Condensate Of Parallel Photons

The interaction Lagrangian describing the interaction of photon field with the light-like vacuum current does not couple to the photons collinear with the vacuum current (light-like wave vector has vanishing length squared). Therefore the ground states of the system are degenerate since one can add to any coherent state generated by the vacuum current any number of photons collinear with the vacuum current and topologically condensed inside the massless extremal. This means Bose-Einstein condensation in collinear degrees of freedom.

Collinear Bose-Einstein condensates of photons are crucial for the model of the quantum correlates of the sensory qualia. Sensory quale is characterized partially by the BE condensate of photons associated with the massless extremal parallel to the axon. The existence of the BE condensate makes possible induced emission. For instance, Josephson currents generate photons with frequencies which are multiples of the Josephson frequency. If the potential difference in Josephson junction equals to a multiple of the cyclotron frequency of some super conducting ion, the current flows resonantly in the sense that Josephson current serves as a harmonic perturbation generating quantum jumps and gives rise to a large dissipative current and also quantum jumps in either super conductor. Since the emission rate for photons by the current is proportional to N^2, where N is the number of photons already in the state, the presence of the BE condensate of photons with this frequency amplifies the emission rate. This kind of resonance mechanism is assumed in the model of sensory experience since it elegantly explains why given neuron corresponds to single quale. Since the potential difference over the Josephson junction can correspond to only single cyclotron frequency, the dominance of single quale is unavoidable even when all macroscopic quantum phases are present.

The existing BE condensate increases the probability of topological condensation of coherent photons generated by other massless extremals to the massless extremal. This mechanism could provide inter-neuronal communication mechanism and realize the metaphor about brain as a society of neutrons, the notion of neuronal window idea and also give a more precise content to the music metaphor. In particular, neurons far away from each other could communicate using wavelengths in a narrow wave length range by this mechanism.

The wave vectors of the photons are multiples of $k = \pi/L$. This means that the length of the massless extremal correlates with the maximal allowed wavelength. For ELF photons associated with EEG frequencies of order 10 Hz the length of massless extremal is of order Earth's circumference. This suggests that more general massless extremals with a topology of torus instead of linear topology could characterize the topological field quanta of ELF fields. It is however impossible to say, whether the field equations allow more general solutions resembling massless extremals.

4.2.5 MEs and apparent breaking of Uncertainty Principle

There is a popular article in Science alert (see `http://tinyurl.com/ybm9gcvu`) about finding that light can be squeezed to much smaller volume than the wave length in dimensions transversal to the wave-length by using single-sheeted graphene. The original article by David Alcaraz Aronzo *et al* is published in Science [D37] (see `http://tinyurl.com/ya8u54ax`). A naïve application of Uncertainty Principle suggests that this is impossible since this would mean a very large expectation value of momentum squared in transverse momentum degrees of freedom.

The finding is interesting from the point of view of classical limit of TGD. So called massless extremals (MEs) or topological light rays [K70, K68, K34] are extremely general solutions of field equations (practically independently of the details of the action principle: it is enough that it is general coordinate invariant). The counterparts of MEs are not possible in Maxwellian electrodynamics but TGD allows them because of the extreme non-linearity of the underlying geometric variational principle for which the topological pair of Maxwell's equations involving no currents is identically satisfied.

What MEs are?

MEs are 4- surfaces describing the propagation of massless topological field quanta of induced classical fields characterized by light-like propagation direction and polarization orthogonal to it. Classical 4-momentum is light-like. The propagation occurs with a maximal signal velocity, and there is no dispersion so that the pulse shape is preserved. If there are several pulses they must propagate in the same direction. The propagation of a laser beam in waveguide serves as an analogy. MEs are be ideal for targeted communications and MEs associaged with magnetic flux tubes and carrying dark photons assignable with wormohole contacts play a key role in TGD inspired quantum biology. A possible interpretation is as space-time correlates Bose-Einstein condensate of photons. Photons themselves would correspond to wormhole contacts (actually pairs of them) connecting ME to another space-time sheet, which could be magnetic flux tube or even ME.

MEs have finite size scale in directions orthogonal to the direction of propagation and MEs can be arbitrary thin. I do not see any reason why they could not be thinner than wavelength. The graphene seems to provide a situation in which classical modelling by MEs makes sense.

The QFT limit is obtained from many-sheeted space-time by replacing many-sheeted structure with a region of Minkowski space made slightly curved. Gauge potentials and gravitational fields are sums of the corresponding induced fields at space-time sheets so that the effects of these fields on a test particle sum up although fields themselves are at different space-time sheets. The linear superposition of Maxwell's theory is replaced with a set theoretic union of the space-time sheets in $M^4_2.Theeffectsofthefieldsofspace-timesheetsonthetestparticlesumupjustlikeinsuperpositionoffieldsinMaxw$

For instance, this allows a situation in which one has two MEs describing propagation of signals in opposite directions as far effects on test particles are considered. This gives rise to standing waves not possible in TGD as single sheeted extremals. Lorentz transforms give analogs of em signals propagating with arbitrary velocity smaller than light velocity. Even field patterns for which the QFT limit corresponds to vanishing fields because the effects on test particles are trivial are possible: both sheets however carry non-vanishing fields with non-vanishing energy-momentum density.

Why the apparent breaking of Uncertainty Principle?

Why the apparent breaking of Uncertainty Principle is then possible in TGD? The point is that in TGD particles do not correspond to wavefunctions in a fixed space-time - this is true only at quantum field theory limit of TGD. Instead, they correspond to wave functions in what I call "world of classical worlds" (WCW). 3-space as "world" is in TGD replaced with 3-D surface defining the "world". In zero energy ontology (ZEO) one can identify space-time surfaces as preferred extremals of an action, which in a well-defined sense generalizes the Maxwell action for a point like charged particle. Thanks to holography the space-time surface is characterized by 2 3-surfaces at its opposite ends -initial and final 3-surfaces - located at the opposite boundaries of causal diamond (CD), whose M^4 projection is intersection of future and past directed light-cones and would look like diamond if it were 2-D. The world as 3-D surface or equivalently 4-D surface is the quantum dynamical object and space-time ceases to be a passive arena of dynamics. Uncertainty Principle holds true for wave functions in WCW rather than for induced fields at space-time surfaces. Therefore the apparent breaking of Uncertainty Principle is possible.

4.3 Microtubules As Quantum Antennae

4.3.1 Linear Structures As Quantum Antennae

The many-sheeted space-time concept of TGD indeed allows almost vacuum space-time sheets and these space-time sheets might be crucial for the understanding of the bio-systems. For instance, the weak interaction of these space-time sheets with the ordinary space-time sheets containing matter could provide representations of the external world in the physical properties of the almost vacuum space-time sheets. In particular, mind-like space-time sheets having finite time duration could generate coherent light and coherent light might make communication possible between mind-like space-time sheets and realize the idea of neuronal window discussed briefly in introduction [K12]. The mind-like space-time sheets associated with various linear structures are especially natural candidates for massless extremals serving as quantum antennae. Bio-systems are full of linear structures and the mind-like space-time sheets associated with microtubules, DNA and protein molecules are the most obvious candidates for quantum antennae.

4.3.2 Are Microtubules Accompanied By Massless Extremals?

The interior of the microtubule is by its cylindrical symmetry an ideal place for ME: s whereas the axonal cell membranes must correspond to "Maxwell phase", where ordinary Maxwell equations are satisfied in a good approximation but also a separate space-time sheet is possible candidate for a massless extremal. The function $u(x,y)$ appearing in the general solution is most naturally $u(x,y) = \sqrt{x^2+y^2}$ for microtubules implying radial polarization. The explanation of the macroscopic quantum coherence in the brain would provide crucial support for the TGD based world picture since massless sources and vacuum currents are not possible in the ordinary QED.

There is analogy with the super radiance phenomenon [J22]: in this case however the photons radiated by the microtubule waveguide have momenta parallel to the microtubule so that the mechanism leading to the formation of the macroscopic BE condensate remains to be understood. The theories associating coherent photons with the microtubules typically assume that the coherent photons reside inside the microtubules: this leads to problems since Uncertainty Principle; the direct study of Maxwell equations also suggest that photons should have very large transversal momenta corresponding to the transversal dimension of the microtubule of order 10^{-8} meters. In TGD this difficulty is avoided since only the *sources* of the coherent photons are restricted into the interior of microtubules whereas the photons can exists in vapor phase and condense on various space-time sheets of the topological condensate.

The necessary condition for the formation of the coherent states in the presence of the matter is that ME condensate level does not contain ordinary gauge charges. If ME corresponds to a larger space-time sheet "below" the space-time sheet containing the ordered water, this requires that the gauge charges of the condensed matter do not flow to the interior of the ME space-time sheet. This is achieved if the condensed particles combine by flux tubes together to form a net like structure so that gauge fluxes can run along the flux tubes to the boundary of the ME region, where they can flow down to the ME condensate level. Ordered water is a good candidate for this join along boundaries/flux tube condensate. Microtubules are known to be surrounded by ordered water and also the interior contains ordered water. The axial electric polarization of the microtubular surface suggests that there is a longitudinal electric gauge flux at the condensate level of the ordered water running to/from the ME condensate level at the ends of the microtubule. The wave lengths appearing in the Fourier expansion of J are of form L/n, L being microtubule length.

In the active mode microtubule acts as a quantum antenna creating quantum coherent light unlike the ordinary antenna, which creates incoherent light. Also waveguide mode is possible for the topologically condensed photons but antenna mode is crucial for the generation of the macroscopic coherent states. The following argument

suggests that he dielectric properties of the microtubule surface can change the antenna pattern somewhat. The dipoles of the microtubule are known to be parallel to the axis of the microtubule. The interaction energy of a dipole p with the radiation field is proportional to the quantity $p \cdot E = pEcos(\theta)$ so that the effect of the dielectric is largest, when the wave vector of the photon is orthogonal to the axis of the microtubule. As a consequence, the dipole pattern should concentrate in the forward direction.

The em current in the interior transforms ordinary QED vacuum to a coherent state in the resonating Fourier modes of the photon field. In ME mode the resonance energies come as multiples of $E_0 = 2\pi/L$ and wavelength L/n, where L is the length of the microtubule whereas in VE mode the spectrum is continuous. Biophotons [I40] with energy of order one eV might be regarded as evidence for BE states associated with the shortest microtubules (such as centriole and basal bodies). The average length of the neuronal microtubules is about 10^{-5} m and corresponding IR radiation is more energetic than thermal IR radiation with a wavelength of order 10^{-4} m.

In the ME mode the resonances at energies $E_n = nE_0$, $E_0 = 2\pi/L$, provide ideal communication channels. Microtubules with different lengths provide independent communication channels so that very effective communication in principle becomes possible. This process could orchestrate axonal microtubules as well as the microtubules belonging to different neurons to form a larger macroscopic quantum state. An optimal performance is obtained if the microtubules belonging to same group are parallel and their lengths are quantized with a common multiple. The microtubules of the neighboring neurons indeed tend to be parallel. Axonal microbutules are also parallel whereas the microtubules inside the ordinary cells are in radial configurations. The grey matter in brain has a columnar structure so that axonal microtubules tend to be in the direction of the columns: this should favor the formation of a quantum resonance between different microtubules. Furthermore, the model of [I6], described in Tuscon II, for the microtubule interactions predicts that the microtubules of even far away neurons are parallel. The average length of the neuronal microtubules is about 10^{-5} m and it is known that the response of 3T3 cells to weak IR radiation is maximum at this wavelength. Neurons could be able to tune their microtubules to the desired infrared stations by controlling their orientation and length. The upper bound about 10^{-4} meters for the length of the axonal microtubules can be understood: for the longer microtubules the thermal IR radiation becomes important and makes communication impossible. In long axons this problem is avoided by joining shorter microtubules in series via Microtubule Associated Proteins (MAPs).

Since the time scale for the change of the tubulin polarization is of order 10^{-10} seconds and the period of the IR radiation is of order 10^{-13} seconds, amplitude modulated IR transmissions are possible. The mechanism of the amplitude modulation could be simply a change of the microtubule interior gauge field from active to dormant ME mode. Amplitude becomes vanishing if this field becomes ordinary sourcefree em field or Z^0 field. IR transmissions could be based on some kind of binary code resembling genetic code. There is indeed concrete proposal of Koruga for this code motivated by the geometric structure of the microtubule surface. [I11] , [J18]. One possibility is that the propagating modes of dipole and conformational oscillations perform elementary AM modulations. These modes could correspond to elementary language expressions at the level of the microtubules.

Microtubules can also absorb photons coming from an external source at resonance energies. If Bose-Einstein condensate of N photons in some mode is present, the absorption probability is amplified roughly by the factor N^2 as shown in appendix. This suggests that microtubules containing BE condensate of photons in some mode are able to "see" in some elementary sense. Of course, receiving antenna containing the BE condensate need not be microtubule. Centrioles (T shaped pair of microtubules inside animal cells) could provide cell with infrared eye and there is experimental evidence for this in the case of monocellular organisms [I28]. Also the radial microtubules could have elementary sense of vision. Note that all eukaryotic cells have radial structure of microtubules in their cytosceleton.

4.3.3 How Macroscopic Quantum Coherence Is Generated?

The big problem is the creation of constructive interference between the coherent states associated with different microtubules. The problem looks exceedingly difficult: microtubules should be able to tune up the frequency and phase associated with light like current inside microtubule with those of other microtubules contributing to the coherent state. Frequency tuning, or equivalently length tuning, involves time scales smaller than 10^{-13} seconds in case of infrared light associated with longest microtubules. The simplest solution to come into mind is that there exist some pacemaker keeping the microtubules in rhythm. One can imagine several mechanisms important for the tuning, each involving the special properties of the TGD space-time crucially.

Topological field quantization

TGD space-time surface decomposes into regions characterized by vacuum quantum numbers, which are frequencies and integers related to the time and angle dependences of the phase angles associated with the two complex CP_2 coordinates. Typically one has $\Phi = \omega t + Fourier\ expansion$ so that space-time surface vibrates with frequency ω. This vibration is an ideal candidate for a pacemaker for the physical systems inside a given space-time region. In fact, the vacuum quantum numbers characterize partially also the order parameter of a super conductor. Vacuum frequencies could also be special frequencies for the Maxwell fields.

The increased understanding about topological field quanta as classical and quantum coherence regions of em field is consistent with and generalizes this view. When topological field quanta are joined by join along boundaries bond generated in quantum jump they fuse to form a larger region of classical and quantum coherence. This suggests a general mechanism for how various axons/microtubules can generate phase coherent em fields. What is needed is that there is larger space-time sheet connected by flux tubes to the massless extremals associated with various axons/microtubules. This larger space-time sheet is most naturally the geometrical counterpart of higher level self so that consciousness is what creates synchrony rather than vice versa!

A further important aspect in the generation of synchrony is self-organization. The subsystems of self quantum self-organize and end up to asymptotic self-organization patterns selected by dissipation. These patterns are simple and typically involve spatially repeating patterns and synchronous oscillations (Benard flow is simple example of this). It is consciousness which implies synchrony and coherence whereas in standard approaches to quantum consciousness synchrony and coherence are believed to be prerequisites for consciousness.

Phase locking for the system of Josephson junctions

Japanese physicist Yoshiki Kuramato from the University of Kioto has shown that the solutions of the differential equations describing Josephson junctions tend to a state in which there is single collective oscillation frequency. A.T. Winfree from the University of Arizona has shown that a phase transition to single collective oscillation frequency analogous to the freezing of liquid occurs in this kind of system.

The solutions of the differential equations describing Josephson junctions model quantum self-organization and synchronization can be interpreted as an instance of the selection of asymptotic self-organization patterns selected by dissipation and occurring always in quantum self-organization. Of course, the quantum jumps can occur only provided the system of Josephson junction belongs to a system having self so that consciousness is again prerequisite for synchrony rather than vice versa! In any case, the fact that entire brain is hierarchy of space-time sheets such that the space-time sheets at various levels are connected by Josephson junctions makes this result rather encouraging.

Gap junctions and MAPs

As noticed, the formation of the join along bonds is the basic prerequisite for the formation of the macroscopic quantum systems. The so called gap junctions can be regarded as flux tubes between the cell membranes (understood as 3-surfaces in TGD picture) of the neighboring cells. They could have a key role in synchronous firing of neuron groups. Gap junctions could also force the vacuum quantum numbers of the neighboring cell membranes to be identical as well as provide the bridges for the propagation of the Maxwell type fields between neighboring cells. It is known that the coherently firing neuron groups in brain possibly responsible for the generation of sensory experience are gap junction connected. It is not however obvious whether gap junctions have anything to do with the synchronizing of the vacuum currents: the difference between the time scales involved is indeed huge. Also Microtubule Associated Proteins could act as join along boundaries bonds/flux tubes guaranteeing quantum coherence between microtubules inside same cell.

4.3.4 Are Nerve Pulse Patterns Coded Into Vacuum Currents And Coherent Light?

It has turned out that TGD based model for memetic code leads to the same interpretation of nerve pulse patterns as suggested by neuroscience. Nerve pulse/no nerve pulse corresponds to true/false Boolean statement or 1/0 value of binary digit. Fundamental coding of nerve pulse patterns is the coding into temporal sequences of cognitive neutrino pairs associated with cell membrane such that the spin of the cognitive antineurino codes for true/false (1/0). Of course, bits could code also for binary digits in the binary expansion and code for the intensity of the primitive sensory experience associated with the neuron. It is natural to ask whether nerve pulse patterns could be also coded to some other representations. Light-like currents are indeed optimal in this respect.

The dependence of the light-like current on the longitudinal coordinate of massless extremal is arbitrary and therefore light-like current provides ideal tool of classical communication of information with light velocity as well as coding of this information to coherent light received by other massless extremals. The first bio-application to come into mind is that the instantaneous nerve pulse patterns propagating along the axon could be coded into the pattern of the vacuum current. The velocity of propagation for the nerve pulse pattern is extremely small as compared to light velocity but this is not a problem if the coding takes place in the region where nerve pulses are generated. What happens is that same temporal pattern of pulses propagates with different velocities. This coding in turn implies coding of nerve pulses to coherent states of photons and in principle the communication of nerve pulse pattern to other neurons.

The relationship between memetic and genetic code is that between two hierarchy levels of a computer program. This suggests that nerve pulse patterns representing memetic codons could serve as transcription factors at gene level. This requires the communication of nerve pulse patterns to nucleus. Even more, communication mechanism must treat different presynaptic inputs as different inputs. Modulation of the vacuum current could make possible communication of the nerve pulse patterns to the cell nucleus along the massless extremals associated with the radial microtubules which in case of neurons have direct contact with the cell membrane. The fact, that some anesthetics seem to affect microtubules and that some brain diseases involve changes of microtubules could also be explained as a breaking of the cell membrane-nucleus communication link. That this kind of communication link might exist is suggested by the fact that ELF em fields have direct efect on genetic expression [J27].

4.4 Masless Extremals And Information Molecules

The notion of information molecule is central for the understanding of biological control. There are however several rarely asked questions related to the notion of information molecule: in particular, the phenomenon of pleiotropy is not easy to understand on basis of pure chemistry [I35]. TGD inspired view about biocontrol and coordination suggests a general answer to these questions and leads to a general model of biological control based on both MEs and information molecules with massless extremals (MEs) serving as actual information carriers and information molecules having a a role analogous to that of computer passwords.

4.4.1 Questions About Information Molecules

Central nervous system (CNS), endocrine system and immune system are three basic systems involved with bio-control and -communication. The work of Candace Pert and other neuroscientists has led to a general notion of information molecule described in popular manner by Candace Pert [J15]. Neural transmitters and modulators associated with CNS are only special cases of information molecules. Also neuropeptides and various hormones are involved. It has become clear that emotions are closely related with the activity of information molecules and that both brain, endocrine system and immune system communicate intensively with each other. One could regard even brain as a big gland. Of course, one could also consider various glands and organs as mini-brains.

The interactions of the information molecules involve the formation of receptor-information molecule complex either at cell surface or in the cell plasma inside cell. Receptor-information molecule complex inside cell can move to genome and induce gene transcription. In case that the complex is formed at the surface of cell, second messenger action is involved. One can also speak about N: th messenger action. There are many poorly understood aspects related to the mechanisms of information molecule action [I35].

1. There are only few second messenger pathways and relatively few receptors but large number of different functions. This phenomenon is known as pleiotropy or multi-functionality. For instance, given second messenger causes different effects depending on the hormone that activated it (the phenomenon is somewhat analogous to the phenomenon in which message can be understood in several ways depending on the state of receiver). At purely chemical level the problem is how second messenger knows what hormone activated it? In steroid action the complex formed by information molecule and receptor in turn activates some gene. Now the question is: How the activated RNA polymerase knows which gene has to be activated? Pleiotropy appears also at level of hormones. Same hormone can have multiple effects and the border between hormone, neuropeptide or even neurotransmitter is unclear. For instance, hormone which by definition transmits long distance communications, can have effects in nearby cells and thus acts like a neuropeptide. How hormone knows what function it must perform? Also drugs and treatments can have different effects and side effects.

2. There is also functional redundancy: the same function is performed by several second messenger molecules. For instance, glucagon, growth hormone, adrenaline and corticosteroids elevate glucose levels. This suggests that there is deeper level of communication involved and that second messenger molecules are more like computer passwords than subprogram calls. Now the question is: What these subprogram calls do correspond physically?

3. Biological functions can be initiated also in non-chemical manner. The phenomena of healing by touch and the effects of meditation and biofeedback are examples of biological self-organization processes are initiated in non-chemical manner. Even other treatments like massage, acupuncture or meditation can

decrease or inhibit pain. These observations suggest that chemical level is not the deepest level involved with biological functions and the question is: What is this deeper control level?

Simple lock and key mechanism cannot provide answer to the questions raised above. Rather, computer password might provide better metaphor for the second messenger action whereas receptor-information molecule complex would effectively generate subprogram call perhaps carried by the second messenger molecule or possibly broadcasted. It seems that information molecules act more like signs or symbols rather than being purely chemical agents. These symbols are interpreted by cell level intelligences and the interpretation depends on context.

4.4.2 A Model Of Biological Self-Organization Based On Quantum Antenna Hypothesis

The view that self hierarchy is present already at molecular level and realized in terms of MEs provides rather straightforward interpretation of pleiotropy and redundancy. The phenomenon of pleiotropy suggests there is non-chemical communication between receptor-peptide complex and cell nucleus. The most natural TGD inspired candidate for the communication is wake-up of genome sub-self by general wake-up mechanism in which classical em field associated with ME induces quantum jumps leading to quantum phase transition which could correspond to the transcription process. The almost-determinism of the transcription process would be due to the Darwinian selection caused by dissipative effects.

These considerations suggest that information molecule-receptor complex could generate ME carrying classical gauge fields and vacuum current. Vacuum current is excellent candidate for coding the information and can lead to a generation of coherent light.

1. The first possibility is broadcasting. The ME associated with information molecule receptor-complex acts as active quantum antenna and activated structure, say genome, serves as a passive quantum antenna receiving the coherent light. Classical fields and/or coherent light would induce quantum jumps serving as seeds of quantum phase transitions leading to a wake-up of conscious and self-organizing sub-self inside receiver.

2. Alternatively, second messenger molecule could carry the information carrying ME with itself as a genuine message inducing the self-organization process in, say, genome.

A natural hypothesis is that the states of the exotic Super Virasoro representations define the macroscopic quantum phases in question: the reason is that these representations are present in all length scales. The information molecule-receptor pair corresponds to a definite frequency, or more generally, combination of frequencies, coding the corresponding function. For instance, genes might be coded to harmonics of Super Virasoro frequencies associated with various p-adic length scales. All information molecule-receptor combinations initiate some function determined by these frequencies and pleiotropy emerges as a basic prediction of the model. Second messenger pathway is like a password to computer, universal key, together with the frequency or even entire ME specifying the function in question: this initiates the desired self-organization process waking-up proper sub-self.

These ideas suggest the following general framework for understanding biological self-organization.

1. Biological programs consist of self-organization patterns generated by classical gauge fields associated with MEs at specific resonance frequencies inducing quantum jumps leading to quantum phase transitions. These resonance frequencies serve as names of the genetic subprograms. Messenger molecules in turn serve in the role of computer passwords.

2. Self-organization processes are associated with MEs and generated by special frequencies, which could be harmonics of the fundamental frequencies associated with various exotic Super Virasoro representations. For instance, combinations of harmonics of various Super Virasoro transition frequencies could define "name of gene". The fact that these frequencies are constants of Nature means that the model is immediately testable. Of course, also other transition frequencies, in particular, magnetic and Z^0 magnetic transition frequencies, could be important.

3. The ability of a biological system to act effectively like a deterministic computer is due to the Darwinian selection of the asymptotic patterns of self-organization caused by dissipation in systems which are fed by energy.

4. The four-dimensionality of this self-organization process is also important element. The frequency of ME defines time scale $T = 1/f$ which defines the duration of biological chronon. With this interval of geometric time entire 4-dimensional space-time surface changes in self-organization process.

4.5 Evidence For Quantum Antenna Hypothesis

In the following some evidence for quantum MEs and quantum antenna hypothesis is discussed. It must be emphasized that there is also other evidence discussed in other chapters of the book (for instance, see the chapters [K16, K41, K43].

4.5.1 TGD Inspired Model For Sonoluminescence

Sonoluminescence [D27] is a peculiar phenomenon, which might provide an application for the hydrodynamical hierarchy. The radiation pressure of a resonant sound field in a liquid can trap a small gas bubble at a velocity node. At a sufficiently high sound intensity the pulsations of the bubble are large enough to prevent its contents from dissolving in the surrounding liquid. For an air bubble in water, a still further increase in intensity causes the phenomenon of sonoluminecence above certain threshold for the sound intensity. What happens is that the minimum and maximum radii of the bubble decrease at the threshold and picosecond flash of broad band light extending well into ultraviolet is emitted. Rather remarkably, the emitted frequencies are emitted simultaneously during very short time shorter than 50 picoseconds, which suggests that the mechanism involves formation of coherent states of photons. The transition is very sensitive to external parameters such as temperature and sound field amplitude. In the following only the rough hydrodynamical characteristics of the phenomenon are considered from the point of view of p-adic length scale hypothesis. Also an attempt to understand the mechanism behind quantum coherence in terms of light-like vacuum currents associated with massless extremals is made.

Sonoluminescence and hydrodynamic hierarchy

A plausible explanation for the sonoluminescence is in terms of the heating caused by shock waves launched from the boundary of the adiabatically contracting bubble [D27]. The temperature jump across a strong shock is proportional to the square of Mach number and increases with decreasing bubble radius. After the reflection from the mimimum radius $R_s(min)$ the outgoing shock moves into the gas previously heated by the incoming shock and the increase of the temperature after focusing is approximately given by $T/T_0 = M^4$, where M is Mach number at focusing and $T_0 \sim 300\ K$ is the temperature of the ambient liquid. The observed spectrum of sonoluminescence is explained as a brehmstrahlung radiation emitted by plasma at minimum temperature $T \sim 10^5\ K$.

The model reproduces nicely the time development of the bubble and sonoluminescence spectrum and explains sensitivity to the external parameters [D27]. The problem is to understand how the length scales are generated and explain the jump-wise transition to sonoluminescence and the decrease of the bubble readius at sonoluminescence: ordinary hydrodynamics predicts continuous increase of the bubble radius. The length scales are the ambient radius R_0 (radius of the bubble, when gas is in pressure of 1 atm) and the minimum radius $R_s(min)$ of the shock wave determining the temperature reached in shock wave heating. Zero radius is certainly not reached since since shock front is susceptible to instabilities.

Since p-adic length scale hypothesis introduces a hierarchy of hydrodynamics with each hydrodynamics characterised by a p-adic cutoff length scale there are good hopes of achieving a better understanding of these length scales in TGD. The change in bubble size in turn could be understood as a change in the "primary" condensation level of the bubble.

1. The bubble of air is characterized by its primary condensation level k. The minimum size of the bubble at level k must be larger than the p-adic length scale $L(k)$. This suggests that the transition to photoluminescence corresponds to the change in the primary condensation level of the air bubble. In the absence of photoluminescence the level can be assumed to be $k = 163$ with $L(163) \sim .76\ \mu m$ in accordance with the fact that the minimum bubble radius is above $L(163)$. After the transition the primary condensation level of the air bubble is $k = 157$ with $L(157) \sim .07\ \mu m$. In the transition the minimum radius of the bubble decreases below $L(163)$ but should not decrease below $L(157)$: this hypothesis is consistent with the experimental data [D27].

2. The particles of hydrodynamics at level k have minimum size $L(k_{prev})$. For $k = 163$ one has $k_{prev} = 157$ and for $k = 157$ $k_{prev} = 151$ with $L(151) \sim 11.8\ nm$. It is natural to assume that the minimum size of the particle at level k gives also the minimum radius for the spherical shock wave since hydrodynamic approximation fails below this length scale. This means that the minimum radius of the shock wave decreases from $R_s(min, 163) = L(157)$ to $R_s(min, 157) = L(151)$ in the transition to sonoluminescence. The resulting minimum radius is $11\ nm$ and much smaller than the radius $.1\ \mu\ m$ needed to explain the observed radiation if it is emitted by plasma.

A quantitative estimate goes along lines described in [D27].

1. The radius of the spherical shock is given by

$$R_s = At^{\alpha} \ , \tag{4.5.1}$$

where t is the time to the moment of focusing and α depends on the equation of state (for water one has $\alpha \sim .7$).

2. The collapse rate of the adiabatically compressing bubble obeys

$$\frac{dR}{dt} = c_0(\frac{2}{3\gamma}\frac{\rho_0}{\rho}(\frac{R_m}{R_0})^3)^{1/2} \ , \tag{4.5.2}$$

where c_0 is the sound velocity in gas, γ is the heat capacity ratio and ρ_0/ρ is the ratio of densities of the ambient gas and the liquid.

3. Assuming that the shock is moving with velocity c_0 of sound in gas, when the radius of the bubble is equal to the ambient radius R_0 one obtains from previous equations for the Mach number M and for the radius of the shock wave

$$\begin{aligned} M &= \frac{\frac{dR_s}{dt}}{c_0} = (t_0/t)^{\alpha-1} \ , \\ R_s &= R_0(t/t_0)^{\alpha} \ , \\ t_0 &= \frac{\alpha R_0}{c_0} \ . \end{aligned} \tag{4.5.3}$$

where t_0 is the time that elapses between the moment, when the bubble radius is R_0 and the instant, when the shock would focus to zero radius in the ideal case. For $R_0 = L(167)$ (order of magnitude is this) and for $R_s(min) = L(151)$ one obtains $R_0/R_s(min) = 256$ and $M \simeq 10.8$ at the minimum shock radius.

4. The increase of the temperature immediately after the focusing is approximately given by

$$\frac{T}{T_0} \simeq M^4 = (\frac{R_0}{R_s})^{\frac{4(1-\alpha)}{\alpha}} \simeq 1.3 \cdot 10^4 \ . \tag{4.5.4}$$

For $T_0 = 300\ K$ this gives $T \simeq 4 \cdot 10^6\ K$: the temperature is far below the temperature needed for fusion.

In principle the further increase of the temperature can lead to further transitions. The next transition would correspond to the transition $k = 157 \rightarrow k = 151$ with the minimum size of particle changing as $L(k_{prev}) \rightarrow L(149)$. The next transition corresponds to the transition to $k = 149$ and $L(k_{prev}) \rightarrow L(141)$. The values of the temperatures reached depend on the ratio of the ambient size R_0 of the bubble and the minimum radius of the shock wave. The fact that R_0 is expected to be of the order of $L(k_{next})$ suggests that the temperatures achieved are not sufficiently high for nuclear fusion to take place.

The model of sonoluminescence by Buzzacchi, del Giudice and Preparata

The coherence of the light generated in sonoluminescence looks rather mysterious from the view point of standard physics. There is very interesting paper of Buzzacchi, del Giudice and Preparata about sonoluminescence with title "*Sonoluminescence Unveiled?* " [D27]. The study of this paper revealed that the physical picture behind microtubule as quantum antenna hypothesis leads to a model for sonoluminescence and that sonoluminescence could be interpreted as a direct evidence for light-like vacuum currents generating coherent photons in TGD. Needless to say, vacuum currents are a purely TGD based phenomenon and implied by the induced gauge field concept deriving from the hypothesis that space-time is 4-dimensional surface in certain 8-dimensional space.

The assumptions of the work of Buzzacchi, del Giudice and Preparata [D27] are following.

1. The energy of the coherent radiation created in sonoluminescence results from the latent heat 0.26 eV per molecule for gas to liquid phase transition occurring at the final stage of the bubble collapse. In [D27] the latent heat is used to deduce the width Γ of the energy spectrum of photons.

2. When shock wave is formed during the collapse of bubble (collapse velocity becomes supersonic), a front of layers with distance that between water molecules is formed. The average distance of molecules in tangential direction are much larger but gets smaller during the collapse of bubble. One can say that there is

vapor layer looking like water in radial direction but in transversal directions the layer is much less dense. When the radius of the buble reaches certain critical value (so that density is about $1/3$ of the density of liquid phase), condensation in the transversal directions to liquid occurs. Note that this means that there is preferred direction suggesting cylindrical symmetry for the condensing regions.

3. The phase transition is assumed to occur in coherent regions with size of order $\lambda \simeq 500$ Angstroms, which is not far from the diameter of microtubules. In these regions there is a coherent plane wave electromagnetic field with frequency $\omega = 2\pi/\lambda$ and the decay of this field produces the highly synchronized light flash of duration of less than 10^{-11} seconds.

4. The physical origin of the coherent regions is somewhat mysterious in standard physics but authors propose that QED is enough to explain the mystery. Authors identify the source of coherent light as resulting from the transitions between two different molecular energy states with energy difference $\Delta E \simeq 12$ eV. One could criticize this assumption as ad hoc. In any case, classical current must be defined as expectation value, which vanishes unless the two energy eigen states get mixed by interactions.

TGD inspired model for sonoluminescence

Consider now the TGD based modification of this model based on the same assumptions 1), 2), 3) about the origin of the coherent light as related to the liquid-gas phase transition but with different identification for the mechanism producing the coherent light. The model is based on the idea that bubble collapse might involve the sequential formation of several new space-time sheets with p-adic primes $p \simeq 2^k$, $k = 163, 157, 151, 149$ characterizing their typical sizes. The importance of the many-sheeted space-time concept was realized already in the previous rough model of the phenomenon just suggesting the identification of the basic scales of the problem in terms of the p-adic length scale hypothesis but involved no model for the generation of coherent light.

a) Light like vacuum currents generate coherent light

What is known is that the light flash emitted is *coherent* light. All frequencies are emitted simultaneously. The temporal widths of various frequencies do not depend on the nature of the gas. Thus the spectrum is certainly not genuine black body spectrum and the production mechanism must involve macroscopic quantum coherence. In TGD there indeed exists a unique mechanism leading to the generation of coherent light and is based on so called "massless extremals" carrying light-like *vacuum currents* generating coherent light in a resonant like manner. Clearly, this mechanism predicts no dependence of the spectrum on the chemical nature of the gas in bubble. Of course, the gas can affect the spectrum by absorbing some frequencies and this indeed seems to occur. It is also known that the presence of noble gases is favorable for sonoluminescence: this is perhaps understandable from the fact that presence of noble gases (no absorption) reduces the effect of other gases by reducing their densities. In TGD inspired theory of bio-systems as macroscopic quantum systems massless extremals correspond to almost empty space-time sheets associated with microtubules and possibly also other linear bio-structures and create coherent photons (perhaps bio-photons of Popp [I40]).

b) Vapor-liquid phase transition in regions of microtubular size occurs

Following [D27], it will be assumed shockwave formation leads to the formation of vapor layers with the mutual distance $a \simeq 3.2$ Angstroms equal to the average distance between liquid molecules and that condensation to liquid occurs when the transversal distance between the molecules of the layer becomes smaller than some critical distance $a < a_T < a_0$, where $a_0 \simeq 3.2 \times 10^{-7}$ meters is the transversal distance of the molecules when shockwave is generated. In the model of [D27] $a_T \simeq \sqrt{3}a$ holds true: in TGD based model p-adic argument gives $a_T = 2a$. In TGD framework the formation of liquid phase is assumed to mean the formation of new cylindrical space-time sheets of size of order 500 Angstroms, when the transversal distance between H_20 molecules becomes critical (3 times the distance in liquid phase). At these space-time sheets water molecules are condensed into liquid phase. The length scale 500 Angstroms is suggested by [D27] and in TGD framework the justification for this length scale is that it corresponds to the diameter of microtubules: these cylindrical structures could serve as templates for the formation of microtubules). Rather flat cylinders with radius equal to height are in question: of course, one can consider also cubic geometry.

c) p-Adic length scale hypothesis

p-Adic length scale hypothesis makes this picture more quantitative. Before the phase transition vapor phase is join along boundaries/flux tube condensate of $k = 151$ space-time sheets glued to $k = 157$ sheets. Note that $L(151) \simeq 10^{-8}$ meters corresponds to the thickness of the cell membrane: now however the sheets are larger having size of order 500 Angstroms. Gas-to liquid phase transition is identified as a phase transition changing the value of the p-adic prime p: most naturally $k = 151 \rightarrow k = 149$. This implies $a_T = 2a_0$ rather than $\sqrt{3}a_0$ as in the model of [D27]. Therefore the critical density is $\rho^* = \rho(liquid)/4$ instead of $\rho(liquid)/3$ of [D27]. Using the relationship

$$a_T(t) = a_0 \frac{R(t)}{R_0} \ , \tag{4.5.5}$$

where $R_0 \simeq 4.5\mu m$ is the radius of the bubble when contraction velocity becomes supersonic one obtains for the transversal distance a_T^* at criticality:

$$a_T^* \simeq 2a = a_0 R^*/R_0$$

giving $R^* \simeq .9\ \mu m$ to be compared with $R^* \simeq .8\ \mu m$ of [D27].

One can estimate the thickness of the condensing shell from the requirement that the number of molecules in the shell with inner and outer radii R^* and R_0 at time t_0 is same as the number of molecules in the thin liquid shell at time when condensation to liquid has occurred. This gives for the thickness T of the liquid shell

$$T \simeq \frac{R_0^2}{R^{*2}} \frac{a^3}{a_0^3} (1 - \frac{R^{*3}}{R_0^3}) R_0 \ , \tag{4.5.6}$$

giving $T \simeq 10^{-7}$ meters which is *two* (!) times the size of the coherence domain as suggested by the transversal size of microtubules.

d) Topological details of the phase transition process

Consider next the topological details of the process. The transversal size of $k = 151$ sheets is (most naturally) halved in the phase transition and the flux tubes connecting $k = 151$ sheets to each other are probably split. According to the basic rules of p-adic TGD, space-time sheets with different p-adic prime p can have only wormhole contacts as stable contacts. This means that, for a p-changing phase transition to take place, the bonds connecting $k = 151$ sheets belonging to different sides of the shock front must be split, probably immediately after the formation of the shock wave. The inward flow of the newly formed $k = 149$ sheets slows down whereas the flow of $k = 151$ sheets behind them continues: the molecules condensed on them cannot however follow the flow since they collide with the liquid phase. Therefore these sheets become thus almost vacuum space-time sheets and the $k = 149$ sheets containing liquid phase topologically condense on them. At this stage the vacuum currents are generated on these almost empty $k = 151$ sheets.

e) Generation of coherent light

In the last stage of the process vacuum currents are generated on the almost empty $k = 151$ sheets and they generate the coherent light giving rise to the flash. The experience with microtubules as quantum antennae hypothesis suggests that massless extremals carrying classical light-like vacuum currents flowing in radial direction are in question. The vacuum current, possible *only* in TGD context, generates coherent photons and the flux of coherent photons from the system creates the coherent flash of photons. The frequency spectrum for the current associated with the massless extremals comes in multiples of the basic frequency π/L, L being the length of the cylinder, which is roughly equal to the thickness of H_2O layer condensing to liquid (this length is expected to have some distribution). The dependence of the vacuum current on transversal and longitudinal coordinate, which is not specified by the field equations for the vacuum extremals, in principle determines the energy spectrum. The model for the sonoluminescence should be able to predict the form of the vacuum current but this requires a model for the coupling between the parameters of the vacuum current and ordinary matter.

The model of [D27] suggests that only the lowest frequency $\omega_0 = 2\pi/L$ is effectively present. The spectrum of [D27] is of form

$$\begin{aligned}
\frac{1}{V}\frac{dE}{d\omega} &= \frac{3\omega_0^3}{16\pi^3}|c_1|^2|F(\omega)|^2\frac{\omega^2}{(\omega-\omega_0)^2+\Gamma^2/4} \ , \\
|c_1|^2 &\simeq 1.8 \ , \\
F(\omega) &= exp(-1.4\frac{\omega^2}{\omega_0^2}) \ . \qquad (4.5.7)
\end{aligned}$$

It is of considerable interest to verify that a spectrum, which is product of a form factor and resonance factor, results also now. The presence of the form factor $F(\omega)$ reflects the dependence of the vacuum current on transversal coordinate, which for cylindrical geometry is radial coordinate. The dependence on the transversal coordinate is left completely open by the field equations and the unknown coupling of the vacuum current with matter should determine it. The resonance factor has a purely kinematical origin: the energy spectrum for photons has form $1/(\omega-\omega_0)^2$ resulting from the fact that matrix element for photon emission involves the overlap integral $\int exp[i(\omega-\omega_0)t]dt$ over a finite time-interval. One must take dissipation into account so that the real spectrum is proportional to $1/\left[(\omega-\omega_0)^2+\Gamma^2/4\right]$. The resonance width is of order $\Gamma \simeq 18$ eV and in [D27] it is determined by the requirement that total energy output equal to the latent heat $.28$ eV per molecule.

The order of magnitude for the duration of the flash can be estimated from the radial contraction velocity $dR/dt(t_0) \simeq 1.5 \times 10^3 m/s = 10^{-5}c/2$ of the bubble at the moment t_0 when the phase transition begins (according to [D27]) and from the length $l \leq 500$ Angstroms, which the empty $k = 151$ sheets must travel before $k = 149$ sheets can condense on them. This gives the estimate $t(flash) \simeq 3 \times 10^{-11}$ seconds which is less than the experimental upper bound $t(flash) < 5 \times 10^{-11}$ seconds,

To summarize: sonoluminescence could provide a direct verification for the concept of massless extremal and light-like vacuum currents. Gas-liquid phase transitions could quite generally involve the formation of massless extremals. Perhaps massless extremals of microtubular size are always present in liquid phase but carry very weak vacuum currents and bio-systems are perhaps able to amplify them. One could perhaps understand all phase transitions as formation of new space-time sheets involving p-changing phase transition.

4.5.2 Stirred And Shaken

Japanese chemist Kazamuri Dozen and his colleagues have observed mysterious splitting of water into hydrogen and oxygen at room temperature using a simple catalyst (copper oxide in powder form) and by stirring the liquid [I37, I37]. The quicker the container is stirred the more hydrogen and oxygen are produced. Usually the dissociation occurs at temperature of about 3000 C and is driven by light: the photon density of thermal radiation has maximum at $E \sim 4T$ giving the estimate $E \sim 1.32$ eV: which gives an estimate for the energy of O–H bond possibly lowered by the presence of a catalyst. Notice that the photons in question correspond to visible light. Domen believes that direct transformation of the kinetic energy of the liquid motion to chemical energy must take place: standard wisdom allows only the transformation *kinetic energy → thermal energy → chemical energy*. There is no idea about the underlying mechanism. According to [I37, I37] already 1980 analogous direct transformation of acoustic energy to chemical energy was discovered and gave rise to the field of sonochemistry. An attractive possibility is that liquid motion somehow generates coherent light which in turn drives the reaction. Similar mechanism might be at work in sonochemistry. Since sonoluminescence involves the transformation of mechanical energy into coherent light, quantum antenna hypothesis is an obvious guide line in the attempt to identify the mechanism.

The simplest TGD based mechanism explaining the anomalous splitting of hydrogen is following.

1. Stirring creates linear cylindrical vortex like structures, which are accompanied by space-time sheets carrying light like vacuum currents. The splitting to oxygen and hydrogen is driven by the coherent light emitted by the vacuum currents associated with cylindrical structures of length L. The energies for the photons of the coherent light come as multiples of $E_0 = \pi/L$ (or of $E_1 = 2\pi/L$ if periodic boundary conditions are assumed). For $E = E_0 \sim 1.32$ eV this gives the estimate $L \sim .47 \cdot 10^{-6}$ meters. This length scale is not too far from the p-adic length scale $L(163) \sim .64 \cdot 10^{-6}$ meters assuming that $L(151)$ corresponds to cell membrane thickness $L(151) \simeq 10^{-8}$ meters.

2. The rotational motion creates classical Z^0 magnetic fields realized as Z^0 magnetic flux tubes and a natural expectation is that these flux tubes are accompanied by cylindrical space-time sheets carrying light like vacuum currents. Since quarks feed their Z^0 gauge fluxes to the space-time sheets having typically twice the cell size, the naïve expectation for the length of the cylindrical structures in question would be of order $L(169) \sim 5 \cdot 10^{-6}$ meters, which is however almost by one order of magnitude too large. This of course does not exclude the possibility that Z^0 magnetic flux tubes are in question. The generation of Z^0 magnetic flux tubes was suggested already many years ago to explain the observed loss of the super fluidity at much smaller critical rotational velocity than predicted by standard physics [K85].

3. A possible function of the catalyst powder is to lower the O–H bonding energy, so that it is nearer to the energy of the photons of the coherent light.

What is interesting from the point of view of consciousness theorizing is that in gel-phase vigorous streaming of intracellular liquid occurs. Furthermore, the coherent photons causing dissociation would correspond to visible light. Therefore one can wonder whether the generation of light-like vacuum current emitting coherent bio-photons [I40] could be one function of the streaming. A possible test for this hypothesis is to look for an additional sink of metabolic energy inside cell.

4.5.3 Evidence For Quantum Antenna Hypothesis In Living Systems

It is known that some monocellulars possess elementary vision based on the microtubules [I28]. The emergence of the multicellulars during the Cambrian explosion was preceded by the appearance of the microtubules. If the emergence of the microtubules meant the emergence of the visual consciousness in the length scale of the cell, then the formation of the multicellulars as cell societies can be understood as a natural consequence. The length distribution of the microtubules in the rods and cones of the eye is concentrated in the region of the visible wavelengths. The coherent light in question could be identifiable as bio-photons of Popp [I40].

A further piece of evidence comes from the work of Callahan about the sense of smell of insects [I42]. Many insects, such as moths and ants, are known to be attracted by light, say candles and electric lamps and Callahan took as his challenge to understand what is involved. Callahan discovered that insect's olfaction is not based on chemistry but to a maser like emission of infrared light generated by various molecules such as pheromones, scent molecules and many other biomolecules. Thus insects would see rather than chemically perceive the sources of the infrared light. The sensillae of the insects serve as receiving antennas and amplify the incoming infrared radiation. Callahan also observed that the oscillation of insect antennae induce maser like emission from scent/etc. molecules by creating an oscillating emf. Thus sensory experiencing seems to involve active participation from the part of insect. The results of Callahan suggest that coherent light could be important also in our neuronal sensory experiencing.

Quite remarkably, pheromones are known to mediate sexual and social signals also in case of many mammals. For instance, certain chemical messages from female mouse can make male mouse to mate immediately while certain chemical messages from other males make him aggressive. Many mammals, for instance rodents, are known to possess vomeronasal organs, small cigar like sacks containing neurons and having length of order few millimeters [J1], giving rise to an accessory olfactory system, which is known to have much more primitive structure and to work in different way than the ordinary olfactory system. It is also known that this systems bypasses cerebral cortex in rodents. There is evidence that even humans have the ability to sniff certain chemicals mediating social and sexual signals without being aware of it and there is already now an entire perfume industry based on this evidence. The chemicals giving rise to sexual attraction are probably pheromones. The fact that pheromones mediate sexual signals in case of both insects and mammals, is hardly an accident and suggests that the sensory mechanism must be the same and be based on the infrared emissions by pheromones. If the response is at neuronal level and if the cortex is not involved, one could understand why these messages are not experienced consciously. One could test this hypothesis by finding whether coherent infrared radiation at frequencies emitted by pheromones can affect the behavior of higher mammals including humans.

There is a further peculiar co-incidence: the cascade of transduction events occurring in the absorption of photon in retina is repeated in a remarkably similar way in olfactory receptor cells, which respond to odors whereas the receptor cells that respond to sound use a very different system [J1]. Could this mean that also the experience of odor primarily involves the detection of (also) infrared light so that humans would not basically differ from insects or that olfactory system has evolved from the receptor neurons originally sensing infrared light? This would conform with the idea that the Kähler field generated in ear corresponds to classical Z^0 field, which does not generate coherent photons but couples with neutrinos. One must however notice that the resemblances between visual and linguistic imagery suggest that some part of ear generates cognitive representation based on coherent light and experienced by the secondary sensory organs in the thalamus.

In CASYS'2000 conference Peter Marcer reviewed the work done by him in collaboration with Russian group [I19] providing experimental evidence for the hypothesis that DNA acts as receiving and sending quantum antenna. What was observed that irradiation of DNA with visible laser light induced emission of coherent light with both visible and radio frequencies. The emitted radiation was also modulated in time scale of about $.01$ seconds. The modulation could be due to propagation of soliton sequences propagating along Josephson junction formed by the strands of DNA or due to non-propagating spatially constant Josephson current: both cases are mathematically equivalent with gravitational pendulum

4.5.4 Biefeld-Brown Effect

Biefeld-Brown effect was invented as early as 1926 and is one of the oldest poorly understood electromagnetic anomalies [H4, H10, H16]. The basic experiments are following.

1. Capacitor is balanced on beam balance and then charged. If the positive pole of the capacitor points upwards, the condenser moves up. If it points down the condenser moves down.

2. Capacitor is placed in free suspension such that the normal orthogonal to the plane of capacitor plates is horizontal and then charged. Capacitor is found to exhibit a horizontal thrust in the direction of the positive plate.

   Thus it seems that when capacitor is provided with large charge, a force acting on capacitor in direction normal to the plane of the capacitor is observed. The motion takes place to the direction of the positively charged plate. The larger the surface area A of the capacitor, the shorter the distance d between the plates, the larger the mass M between the capacitor plates, the higher the relative dielectric constant ϵ of the dielectric, the larger the voltage V used, the larger is the size the effect. This behavior can be understood if the size of the effect is proportional to the total electric energy $E_e = \epsilon\frac{AV^2}{d}$ between capacitor plates. It is difficult to understand this effect in standard physics framework.

Consider first experiment 1) in which the normal of the capacitor plane is in vertical direction. This experiment could be understood in the general conceptual framework described in the chapter [K51]. Capacitor generates some net gravitational flux. This flux is in general fed to several space-time sheets, although most of it goes to the "standard" sheet at which the gravitational field of Earth resides. One could understand the result of the experiment a) in terms of a redistribution of these gravitational fluxes. When the positive plate points upwards/downwards the flux $\phi_{gr}(Earth)$ fed to the "standard" space-time sheet is reduced/increased. Therefore the effective weight of the capacitor decreases/increases. The dependence of $\phi_{gr}(Earth)$ on the relative orientation of the gravitational field and electric field is not surprising from TGD point of view since classical gravitational and electric fields are very closely related in TGD framework. If classical Z^0 electric force contributes to the effective gravitational force significantly, then similar mechanism in case of Z^0 electric flux could contribute significantly to the change of the effective weight of the capacitor.

It seems that this mechanism cannot explain the result of the second experiment in which capacitor moves to horizontal direction. Rather it seems that two effects must be involved. there must be some mechanism giving for the capacitor momentum in the direction of the electric field. The TGD based general mechanism of energy production relying on the generation of space-time sheets with negative time orientation and carrying negative energies could explain this aspect of Biefeld-Brown effect.

1. Suppose that the charging of capacitor involves generation of space-time sheet with negative time orientation. The energy density associated with classical fields at this space-time sheet is negative. Energy conservation requires that capacitor receives compensating energy which in case of Biefeld-Brown effect is partially realized as kinetic energy associated with center of mass motion.

2. The classical gauge fields associated with the negative energy space-time sheet can carry also momentum and compensating momentum must be developed at the space-time sheet of the capacitor. Therefore condenser is forced to move. The momentum density of em field is proportional to the cross product $E \times B$ of the electric and magnetic fields. This momentum density gives rise to a net field momentum in the direction orthogonal to the plane of condenser plates if E and B are in directions parallel to the plates. This resembles somewhat the situation encountered in the case of Hall effect.

A working hypothesis worth of studying is that the negative energy space-time sheet associated with the capacitor corresponds to a massless extremal with E and B fields propagating from positive to negative plate (field momentum is in this direction).

1. Momentum conservation implies that the space-time sheet of the capacitor generates opposite momentum so that capacitor must move in the direction normal to the plane of the plates. What remains to be understood why the direction of motion is towards the positively charged plate. The light-likeness of 4-momentum gain together with the presence of Fourier components with single direction of wave vector means that momentum gain per energy gain is maximal. Therefore generation of negative energy "massless extremals" is optimal mechanism of propulsion. Massless extremals can have also net angular momentum since polarized Fourier components carry spin. Therefore capacitor can gain internal angular momentum in some form.

2. Assuming that the entire momentum of the classical field on negative energy space-time sheet is compensated by the momentum gain of capacitor, one obtains for the total energy gain

$$E_t = M\beta \ ,$$

where M is total mass of the capacitor and β is its velocity (the units $\hbar = 1$, $c = 1$ are used). This means quite large energy gain. For instance, for $M = .01$ kg and $\beta = 10^{-12}$, one has $E_t \sim 10^2$ Joule. The energy ΔE, which is not realized as kinetic energy, is given by

$$\Delta E = M\beta(1 - \frac{\beta}{2}) \ .$$

Obviously, only a small fraction of the energy is realized as kinetic energy of the capacitor.

The ratio of the energy to thermal energy is given by

$$\frac{E_t}{E_{th}} \sim A\frac{m_p\beta}{T} \ ,$$

where A denotes atomic number. This ratio is much smaller than one for $\beta \ll T/Am_p$. In room temperature this gives $\beta \ll 10^{-11}/A$. An estimate for the magnitude of the electric field is obtained from $E_t = P$. Expressing everything in terms of integrals of energy and momentum densities, one obtains $EB \sim \rho\beta$. Since $E = B$ holds true for massless extremals, one has $B \sim \sqrt{\rho\beta}$. In condensed matter densities one has $\rho \sim Am_p/a^3$, where a is Bohr radius. This gives $B \sim \sqrt{10^5 A\beta}/a^2$. B is roughly about one $\sqrt{A}$ Tesla for $\beta \sim 10^{-12}$. Very strong electric and magnetic fields are clearly involved.

The proposed mechanism might also make possible to understand how living systems are able to generate coherent motions.

1. The ability of bio-systems (70 per cent of water!) to generate coherent motions is complete mystery from the point of view of standard physics describing bio-system as a soup of randomly moving atoms and molecules. The generation of massless extremals provides an optimal mechanism for coherent motion. Negative energies are not absolutely essential for generating coherent motions. However, if massless extremals have positive energies, the efficiency of energy usage is however very low, approximately $\beta/2$, where β is the velocity generated: something like 10^{-8} if velocity is of order one meter per second. It could quite well be that massless extremal is created only for the period of time that motion lasts: this in accordance with the idea that classical counterparts of virtual

particles are in question. Since the surplus energy generated on the material space-time sheet is partially dissipated during this time interval, this mechanism requires that metabolism feeds energy to the system to compensate this loss. Thus there is no contradiction with the general wisdom about the necessity of metabolic energy feed.

2. Brown observed that capacitors had definite effects on plants and animals. This is not surprising if TGD picture about bio-systems is correct. Coherent light is generated and this coherent light can affect the communications of neuronal society.

3. If bio-systems can generate negative energy massless extremals, a very efficient generation of metabolic energy from vacuum becomes possible. There is a lot of anecdotal evidence about the ability of yogis and mystics to survive without eating [J36]. The explanation often proposed by yogis themselves [J36] is that the energy of light replaces the usual sources of the metabolic energy. Standard science sceptics of course "know" and ridicule all this but, against the background of new physics predicted by TGD, I cannot avoid asking myself whether there might be some seed of truth behind these claims.

4.6 Appendix: A Model For The Topological Condensation Of Coherent Vapor Phase Photons

In ordinary QED classical gauge fields can have only ordinary charged particles as their sources. In TGD genuine vacuum currents are possible. The coupling of the quantum field to the classical em field with a non-vanishing vacuum source implies the generation of a coherent state of photons such that each Fourier component present in the classical gauge current gives rise to an eigen state of the corresponding photonic annihilation operator. In case of light-like vacuum currents allowed by TGD, the coherent state is generated in resonant-like manner so that light-like vacuum current acts as an ideal quantum antenna.

If one introduces a second space-time sheet, which contains BE condensate of photons for some modes of the photon field, a stimulated topological condensation of both coherent vapor phase photons and transfer of coherent condensed photons from other space-time sheets to this space-time sheet occurs. This effect makes possible the action of the second space-time sheet as an optimal receiving antenna. In the following calculation the consideration is restricted to the stimulated condensation of vapor phase photons.

In biological context microtubules could server both as senders and receivers of coherent photons. According to the proposed identification of coherent photons as the quantum correlate of vision, the microtubules contain BE condensate of photons in some some modes would have the ability to see in some primitive manner.

4.6.1 The Action

The simplest model for the situation is based on Maxwell action for electromagnetic field regarded as an induced field obtained from superposition of the classical emf in CP_2 degrees of freedom and second quantized free emf in $M^4_+ \times CP_2$ having only M^4 components and depending on M^4_+ coordinates only and having decomposition into vapor phase and condensate parts ($\hbar = 1$ and $c = 1$ will defined the units used in the following).

$$\begin{aligned}
F_{\mu\nu} &= F_{\mu\nu}(cl) + F_{\mu\nu}(qu) \ , \\
F_{\mu\nu}(cl) &= F_{kl}(cl)\partial_\mu s^k \partial_\nu s^l \ , \\
F_{\mu\nu}(qu) &= F_{kl}(qu)\partial_\mu m^k \partial_\nu m^l \ , \\
F_{kl}(qu) &= \partial_l A_k(qu) - \partial_k A_l(qu) \ , \\
A_k(qu) &= A_k(qu,v) + A_k(qu,c) \ .
\end{aligned} \tag{4.6.1}$$

$F_{kl}(qu)$ satisfies empty space Maxwell equations. m^k and s^k refer to M^4_+ and CP_2 coordinates and v and c refer to vapor phase and condensate.

Maxwell action density can be transformed to a sum of a total divergence reducing to mere boundary term, to be neglected, plus free part and two interaction terms in the following manner:

$$\begin{aligned}
\frac{L}{\sqrt{g}} &= \sum_i L(free,i) + L_1(int) + L_2(int) \ , \\
L(free,i) &= \frac{1}{4} F_{\mu\nu}(qu,i)F^{\mu\nu}(qu,i) \ , \ i = c,v \ . \\
L_1(int) &= \frac{1}{2} j^\mu(cl) \sum_i A_\mu(qu,i) \ , \\
L_2(int) &= \frac{1}{2} \sum_i J^\mu(qu,i) A_{mu}(cl) \ , \\
J^\mu(qu,i) &= F^\mu_k(i) M^{k\nu}_\nu + F_k{}^\nu(i) M^{k\mu}_\nu \ , \ i = c,v \\
M^k_{\alpha\beta} &= D_\beta \partial_\alpha m^k \ .
\end{aligned} \tag{4.6.2}$$

$L(free,i)$ denotes the free action for the classical emf and vapor phase and condensed quantum emfs and defines photon propagators. Standard propagator is obtained, when Minkowski coordinates are used for space-time surface.

$L_1(int)$ corresponds to the action of the vapor phase and condensed quantum emf with the vacuum current and leads to generation of coherent state of photons both in vapor phase and condensate.

$L_2(int)$ is non-vanishing only, when the M^4_+ part of the second fundamental form $M^k_{\alpha\beta}$ for 4-surface is non-vanishing: in this case the em current associated with $A_{mu}(qu)$ is non-vanishing despite the fact that it vanishes for $A_k(qu)$! This term describes the external curvature of the 4-surface as opposed to the internal curvature described by the curvature tensor. In general case, the external curvature can be large even when the gravitational field vanishes. It must be however emphasized that this term is proportional to the metric of CP_2 and, in case of the massless extremals, this term is significant only if the dependence of CP_2 coordinates on the transversal coordinates of M^4_+ is strong: this in turn requires huge value for the light-like Einstein tensor. This term will be neglected in the sequel.

The representation

$$\begin{aligned}
&A_+(k,\lambda) = \sqrt{\tfrac{2\pi}{\omega_k}} a^\dagger(k,\lambda) \ , \\
&\left[a(k_1,\lambda_1), a^\dagger(k_2,\lambda_2)\right] = \delta^3(k_1 - k_2)\delta_{\lambda_1,\lambda_2} \ ,
\end{aligned} \tag{4.6.3}$$

for which the density of states factor for photon states is $dN = d^3k$, will be used in the sequel.

4.6.2 Coherent State Is Generated In Resonant-Like Manner For Light-Like Vacuum Currents

The presence of the vacuum current leads to the generation of coherent state of photons both in vapor phase and condensate. Coherent states states are eigen states of the photonic annihilation operators and in the estimates for the rate of topological condensation, one in a good approximation one can replace $A_\mu(qu,i)$, $i = cond, vap$, with the classical photon field $A_\mu(coh,i)$ having classical vacuum current as its source and serving as order parameters for the coherent state. The Fourier component of a vector potential describing the eigenvalue of the annihilation operator part of the photon field is for given momentum k and polarization direction λ given by

$$
\begin{aligned}
A^\mu(coh,v|\lambda,k) &= \sum_n c(k,k_n)\frac{\lambda_\mu J^\mu(k_n)\lambda^\mu}{k_n^2} \ , \\
exp(-ik\cdot m) &= \sum_n c(k,k_n)exp(-ik_n\cdot m) \ .
\end{aligned}
\tag{4.6.4}
$$

$c(k,k_n)$ is the Fourier component of the plane wave $exp(-ik\cdot m)$ expressed using discrete plane wave basis for the space-time sheet containing the vacuum current. m denotes Minkowski coordinates.

If the classical vacuum current is associated with a "massless extremal", em current is light-like and this implies resonance for those frequencies for which photon wave vector corresponds to the wave vectors appearing in the vacuum current. The resonance is smoothed out by the finite spatial size of the space-time sheet containing the light-like vacuum current. At the limit of an infinitely large spatial size for the space-time sheet, one obtains infinitely large amplitude since one has $k_n^2 = k^2 = 0$ at this limit.

4.6.3 Stimulated Topological Condensation

The presence of the coherent state of photons implies the possibility of the topological condensation of photons. If the device contains $N(k,\lambda)$ photons in the state (k,λ), stimulated topological condensation, completely analogous to the stimulated emission, occurs and the condensation rate is proportional to $(N(k,\lambda)+1)^2$.

Assume that there exists a coherent state generated by quantum antenna of possibly astrophysical dimension and associate label "1" with this space-time sheet. Assume also a second space-time sheet and associate with it label "2". In the lowest order the matrix element for the topological condensation of single photon can be obtained as the matrix element of the creation operator part of the interaction term of the action

$$
\begin{aligned}
&iS_+ = \frac{i}{2}\int_{V_2} dV_2 j^\mu_\perp(coh,1)A_{\mu,+}(cond,2) \\
&= \frac{i}{2}\sum_{\lambda_2}\int d^3k_2 X(k_2,\lambda_2)a^\dagger(k_2,\lambda_2) \ , \\
&X(k_2,\lambda_2) = \sqrt{\frac{2\pi}{\omega_{k_2}}}\sum_{\lambda_1}\int d^3k_1 Y(k_1,\lambda_1,k_2,\lambda_2) \ , \\
&Y(k_1,\lambda_1,k_2,\lambda_2) = j(coh,1|k_1,\lambda_1)c(k_1,k_2)e_{\lambda_1}\cdot e_{\lambda_2} \ , \\
&c(k_1,k_2) = \int_{V_2} dV_2 exp\left[i(k_1-k_2)\cdot m\right] \ ,
\end{aligned}
\tag{4.6.5}
$$

between the initial and final states. $j^\mu(coh,1)$ is just the transversal part of the classical vacuum current creating the coherent state. The latter expression is obtained by using Fourier expansions for j and A_+ (, which denotes the creation operator part of the free photon field projected to the space-time surface representing the device: Minkowski coordinates are used for both source regions and device).

In case that the region V_1 is box of length L in the direction of the vacuum current, the explicit calculation, writing the light-like vacuum current as $j^\mu = Jp^\mu$, $p^0 = p^z = 1$, leads to the following expression for the Fourier component $j(coh,1|k_1,\lambda_1)$:

$$
\begin{array}{l}
j(coh,1|k,\omega_k,\lambda) = j^{\mu}(coh,1|k,\omega_k)e^{\lambda}_{\mu} \ , \\
= \sum_n \frac{exp(ik_zL)-1}{ik_z} J(\omega_n,k_T)p\cdot e^{\lambda}\delta(k^0-\omega_n) \ , \\
\omega_n = \frac{n\pi}{L} \ .
\end{array}
\tag{4.6.6}
$$

Delta-function expresses the fact that only discrete frequencies are allowed for the vacuum current and one can write the condensation amplitude as a sum $iS_+ = i\sum_n iS_{+,n}$ over the allowed frequencies ω_n. k_T refers to the transversal part of the wave vector orthogonal to the light-like vacuum current.

From this expression one can deduce the probability for the topological condensation of photon (k,λ) to a state containing $N(k,\lambda)$ photons as

$$
|S(k,\lambda)|^2 \ = \ |\sum_n S_{+,n}|^2(N(k,\lambda)+1)^2 \ , \tag{4.6.7}
$$

Clearly, $(N(k,\lambda)+1)^2$ factor corresponds to the induced condensation. By a standard trick one can eliminate the square of the delta-function by replacing the condensation probability with condensation rate $R(k,\lambda)$ obtained by dividing condensation probability with $T\rightarrow\infty$ eliminating one delta function. Furthermore, one can calculate the transition rate to a set of final states by multiplying the expression thus obtained with the density of states factor $dN = d^3k$, which after the elimination of the second delta function effectively reduces to $\omega_n^2 d\Omega$. In this manner one obtains for the differential condensation rate a a rather neat expression in terms of the vacuum current

$$
\begin{array}{l}
\frac{dR(k,\lambda,n)}{d\Omega} = \frac{\pi}{2}\omega_n L^2|M(k,\lambda|^2(N(k,\lambda)+1)^2 \ , \\
M(k,\lambda) = i\sum_{\lambda_1}\int d^3k_1 J(\omega_n,k_T^1)c(k^1,k)X(k_1,\lambda_1) \ , \\
X(k_1,\lambda_1) = \frac{exp(ik_z^1L)-1}{ik_z^1L} p\cdot e_{\lambda_1}e_{\lambda_1}\cdot e_{\lambda} \ .
\end{array}
\tag{4.6.8}
$$

From this expression it is clear that resonance indeed occurs and at the limit $L\rightarrow\infty$ the rate for condensation diverges as L^2. In this expression the overlap integral $c(k_1,k_2)$ carries information about the geometry of the space-time sheet associated with the "device" whereas $J(\omega_n,k_T)$ characterizes the vacuum current and the remaining factor X is a purely "kinematic" factor.

Chapter 5

Wormhole Magnetic Fields

5.1 Introduction

Topological field quantization has turned out to be fundamental for the understanding of quantum TGD and TGD inspired theory of consciousness. What makes topological field quantization so important is that it provides very precise classical representation for the quantum aspects of the theory. Even virtual particles have geometric counterparts. In TGD the sign of the classical energy correlates with the time orientation of the space-time sheet and this makes possible pairs of space-time sheets of finite duration having vanishing total energy. This suggest an astonishingly simple mechanism for the formation of cognitive representations: direct mimicry in which classical fields in some region of the material space-time sheet are realized at the two mind-like space-time sheets of opposite time orientation! This realization would make physicist's universe analogous to the computer scientist's universe filled with computers emulating each other. Concerning the understanding of how intelligent consciousness is realized, the implications would be highly nontrivial.

The fact that em fields oscillating with multiples of the cyclotron frequencies of various charged particles in Earth's magnetic fields have effects on living matter [J17] could indeed mean that biomatter mimics Earth's magnetic field by forming double sheeted structures, wormhole magnetic fields, with magnetic field strength equal to that of Earth's magnetic field. This observation could serve as a good motivation for the modelling of wormhole magnetic fields. This was not the original motivation for studying wormhole magnetic fields. Rather, it was the modelling of homeopathy in terms mind-like space-time sheets, which led to the discovery of the astonishing possibility of a direct mimicry performed by mind-like space-time sheets. Note that also more abstract cognitive representations are possible. In particular, various oscillation frequencies of material space-time sheets could be transferred to mind-like space-time sheets and the counterparts of FM and AM modulation would provide obvious cognitive representations.

Topological field quantization originates from the fact that given classical gauge field configuration does not allow global representation as an induced gauge field but space-time splits into separate regions, topological field quanta. Typically, magnetic field reduces to a bundle of disjoint *flux tubes* flowing along field lines of classical field, which in TGD context are cylindrical regions of 3-space with outer boundaries. There is no doubt about the fundamental importance of topological field quanta for biosystems if TGD is correct and the natural working hypothesis is that topologically quantized classical gauge field configurations belong to the basic tools of biocontrol and that the vacuum quantum numbers characterizing topological field quanta (for the definition of vacuum quantum numbers see the Appendix) carry bio-information.

It has also become clear, that the closely related concepts of *many-sheeted space-time* and *charged wormhole* play crucial role in biosystems. Wormholes feed gauge fluxes from a smaller sheet of 3-space to a larger one and are located near the boundary

of the smaller 3-space sheet and have size of order CP_2 length of order 10^4 Planck lengths as do also ordinary elementary particles. Not only electromagnetic but also Z^0 wormholes are possible in TGD since long range classical Z^0 fields are unavoidable in TGD context. Wormhole throat can have also magnetic charge. Furthermore, the topology of the wormhole throat, being characterized by the genus of the 2-surface in question, gives rise to a degeneracy analogous to the family replication of elementary fermions.

Wormhole concept leads naturally to the concept of *wormhole flux tube*, which by assumption contains no ordinary matter inside it and is forced by Maxwell equations to be a *hollow cylinder*. Maxwell's equations require rotating charge carrier densities with opposite total charges on the inner and outer boundaries of this cylinder. Since ordinary charges are excluded, the only possibility is that these charge carries are charged wormholes. Since the wormhole behaves like a gauge charge $\pm Q$ on the two space-time sheets respectively, there is return flux on the second space-time sheet. Wormhole flux tubes need not be closed unlike ordinary flux tubes: at the end point magnetic flux just flows from "upper" space-time sheet to the "lower" space-time sheet via magnetic wormhole behaving as magnetic charge $\pm Q_m$ on the two space-time sheets respectively. Charged wormhole flux tubes can form arbitrary complicated net like structures. Since wormholes form *BE condensate* and behave as super conductor, the classical field is transformed in TGD context to a macroscopic quantum system, *wormhole magnetic field*. It has become clear that electronic and neutrino superconductivity might play fundamental role in biosystems: it might be even possible to identify the quantum correlates of sensory qualia as coherent photons and gravitons, wormhole BE condensate and BE condensates of electronic and neutrino Cooper pairs. What is important is that wormhole magnetic fields seem to provide a topological representation for the defects of fermionic super conductors.

Quantum antenna hypothesis states that the light-like vacuum currents associated with microtubules, and possibly also other linear structures, serve as sources of quantum coherent photon fields [K34] , in particular of bio-photons. The phenomenon of sonoluminescence has an explanation in terms of light-like vacuum currents underlying the quantum antenna hypothesis and that microtubular diameter provides a natural intrinsic length scale of hydrodynamics of water. One of the many challenges is to understand how wormholes and coherent photons interact. In this chapter a model for this interaction is proposed. The model leads to possible explanations of *Comorosan effect* [I44, I10] and *phantom DNA effect* [I20, I50]. Also the effect of homeopathy could reduce to that of mind-like space-time sheets associated with the drug if these mind-like space-time sheets mimic directly the classical gauge field structure of the drug.

The first version of this chapter was written for almost two decades ago and some interpretations have changed since then. It was argued that two purely TGD based concepts: topological field quantization and wormhole BE condensate are fundamental for the understanding of biosystems. There is not reason to modify this claim. The ideas about the physical interpretation of wormhole contacts have however developed since then dramatically: in the recent formulation of the theory wormhole contacts define basic building bricks of elementary particles. Hierarchy of Planck constants assigned with dark matter is second new notion and this might allow to see wormhole BE-condensates as BE-condensates of dark variants of ordinary particles.

The concept of wormhole magnetic field is proposed as a possible explanation for claimed psychokinetic effects (PK). Topologically quantized wormhole magnetic field, being a macroscopic quantum system, can give rise to PK effect via *magnetic levitation*, if external object is wormhole super conductor and if the density of charged wormholes on its boundary is sufficiently high to generate Meissner effect. This same structure could enlarge DNA and other basic structures to macroscopic quantum systems with size much larger than the basic object consisting of ordinary matter. One could even imagine that the structure of DNA sequences could be coded into the structure of the topologically quantized magnetic field created by it.

An alternative model of psychokinesis is based on the possibility of space-time

sheets having negative time orientation and carrying therefore negative classical energy. It is not clear whether the space-time sheets associated with the wormhole magnetic fields could have opposite time orientations. This kind of mechanism of energy production might explain claimed poltergeist type effects involving spontaneous gain of kinetic energy. Many-sheeted space-time concept makes possible also psychokinesis based on levitation: what is needed that subsystem is able to topologically condense to a sufficiently large space-time sheet carrying very weak gravitational fields.

This chapter describes the view about wormhole contacts as it was for more than decade ago. The recent identification of wormhole contacts is as bosons with positive and negative energy fermion and anti-fermion at the opposite light-like throats of the contact. This allows to identify also virtual gauge bosons as pairs of on mass shell fermions. Virtual fermions could correspond to wormhole contacts with second contact identifiable as Fock vacuum. Also super-symmetric partners of these states obtained by applying fermionic oscillator operator algebra correspond to particle like states. Therefore wormhole contacts might not represent completely new physics and be identifiable as gauge boson like or Higgs like states. If the wormhole throat carries magnetic flux it could define a dyonlike partner of ordinary gauge boson or Higgs.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L5].

5.2 Basic Conceptual Framework

The notions of topological condensate and p-adic length scale hierarchy are in a central role in TGD and for a long time it seemed that the physical interpretation of these notions is relatively straightforward. The evolution of number theoretical ideas however forced to suspect that the implications for physics might be much deeper and involve not only a solution to the mysteries of dark matter but also force to bring basic notions of TGD inspired theory of consciousness. At this moment the proper interpretation of the mathematical structures involving typically infinite hierarchies generalizing considerably the mathematical framework of standard physics is far from established so that it is better to represent just questions with some plausible looking answers.

5.2.1 Basic Concepts

It is good to discuss the basic notions before discussing the definition of gauge charges and gauge fluxes.

CP_2 type vacuum extremals

CP_2 type extremals behave like elementary particles (in particular, light-likeness of M^4 projection gives rise to Virasoro conditions). CP_2 type vacuum extremals have however vanishing four-momentum although they carry classical color charges. This raises the question how they can gain elementary particle quantum numbers.

In topological condensation of CP_2 type vacuum extremal a light-like causal horizon is created. Number theoretical considerations strongly suggest that the horizon carries elementary particle numbers and can be identified as a parton. The quantum numbers or parton would serve as sources of the classical gauge fields created by the causal horizon.

In topological evaporation CP_2 type vacuum extremal carrying only classical color charges is created. This would suggest that the scattering of CP_2 type vacuum extremals defines a topological quantum field theory resulting as a limit of quantum gravitation (CP_2 is gravitational instanton) and that CP_2 type extremals define the counterparts of vacuum lines appearing in the formulation of generalized Feynman diagrams.

Wormhole contacts as parton pairs

The earlier view about wormhole (#) contacts (see Fig. http://tgdtheory.fi/appfigures/wormholecontact.jpg or Fig. ?? in the appendix of this book) as passive mediators of classical gauge and gravitational fluxes is not quite correct. The basic modification is due to the fact that one can assign parton or parton pair to the # contact so that it becomes a particle like entity. This means that an entire p-adic hierarchy of new physics is predicted.

1. Formally # contact can be constructed by drilling small spherical holes S^2 in the 3-surfaces involved and connecting the spherical boundaries by a tube $S^2 \times D^1$. For instance, CP_2 type extremal can be glued to space-time sheet with Minkowskian signature or space-time sheets with Minkowskian signature can be connected by # contact having Euclidian signature of the induced metric. Also more general contacts are possible since S^2 can be replaced with a 2-surface of arbitrary genus and family replication phenomenon can be interpreted in terms of the genus.

   The # contact connecting two space-time sheets with Minkowskian signature of metric is accompanied by two "elementary particle horizons", which are light-like 3-surfaces at which the induced 4-metric becomes degenerate. Since these surfaces are causal horizons, it is not clear whether # contacts can mediate classical gauge interactions. If there is an electric gauge flux associated with elementary particle horizon it tends to be either infinite by the degeneracy of the induced metric. It is not clear whether boundary conditions allow to have finite gauge fluxes of electric type. A similar difficulty is encountered when one tries to assign gravitational flux to the # contact: in this case even the existence of flux in non-singular case is far from obvious. Hence the naïve extrapolation of Newtonian picture might not be quite correct.

2. Number theoretical considerations suggests that the two light-like horizons associated with # contacts connecting space-time sheets act as dynamical units analogous to shock waves or light fronts carrying quantum numbers so that the identification as partons is natural. Quantum holography would suggest itself in the sense that the quantum numbers associated with causal horizons would determine the long range fields inside space-time sheets involved.

3. # contacts can be modelled in terms of CP_2 type extremals topologically condensed simultaneously to the two space-time sheets involved. The topological condensation of CP_2 type extremal creates only single parton and this encourages the interpretation as elementary particle. The gauge currents for CP_2 type vacuum extremals have a vanishing covariant divergence so that there are no conserved charges besides Kähler charge. Hence electro-weak gauge charges are not conserved classically in the region between causal horizons whereas color gauge charges are. This could explain the vacuum screening of electro-weak charges at space-time level. This is required since for the known solutions of field equations other than CP_2 type extremals vacuum screening does not occur.

4. In the special case space-time sheets have opposite time orientations and the causal horizons carry opposite quantum numbers (with four-momentum included) the # contact would serve the passive role of flux mediator and one could assign to the contact generalized gauge fluxes as quantum numbers associated with the causal horizons. This is the case if the contact is created from vacuum in topological condensation so that the quantum numbers associated with the horizons define naturally generalized gauge fluxes. Kind of generalized quantum dipoles living in two space-times simultaneously would be in question. # contacts in the ground state for space-time sheets with opposite time orientation can be also

seen as zero energy parton-antiparton pairs bound together by a piece of CP_2 type extremal.

5. When space-time sheets have same time orientation, the two-parton state associated with the $\#$ contact has non-vanishing energy and it is not clear whether it can be stable.

$\#_B$ contacts as bound parton pairs

Besides $\#$ contacts also flux tubes (JABs, $\#_B$ contacts) are possible. They can connect outer boundaries of space-time sheets or the boundaries of small holes associated with the interiors of two space-time sheets which can have Minkowskian signature of metric and can mediate classical gauge fluxes and are excellent candidates for mediators of gauge interactions between space-time sheet glued to a larger space-time sheet by topological sum contacts and join along boundaries contacts. The size scale of the causal horizons associated with parton pairs can be arbitrary whereas the size scale of $\#$ contacts is given by CP_2 radius.

Consider first the original vision about JABs. The original belief was that the existence of the holes for real space-time surfaces is a natural consequence of the induced gauge field concept: for sufficiently strong gauge fields the imbeddability of gauge field as an induced gauge field fails and hole in space-time appears as a consequence. The holes connected by $\#_B$ contacts obey field equations, and a good guess is that they are light-like 3-surfaces and carry parton quantum numbers. This would mean that both $\#$ and $\#_B$ contacts allow a fundamental description in terms of pair of partons.

Magnetic flux tubes provide a representative example of $\#_B$ contact. Instead of $\#_B$ contact also more descriptive terms such as join along boundaries bond (JAB), color bond, and magnetic flux tube are used. $\#_B$ contacts serve also as a space-time correlate for bound state formation and one can even consider the possibility that entanglement might have braiding of bonds defined by $\#$ contacts as a space-time correlate [K67].

It seems difficult to exclude flux tubes between between holes associated with the two space-time sheets at different levels of p-adic hierarchy. If these contacts are possible, a transfer of conserved gauge fluxes would be possible between the two space-time sheets and one could speak about interaction in conventional sense.

The most recent TGD view about JABs is different. The recent belief is that boundaries- and jus JABs- are not allowed by the boundary conditions: space-time sheets with boundary are replaced with their double covers. Furthermore, elementary particles and also larger systems correspond to space-time regions which as lines of generalized Feynman diagrams have Euclidian signature of the induced metric. This suggests that magnetic flux tubes as deformations of cosmic strings have Euclidian signature of metric too. This is quite possible and in the simplest situation would require that string world sheet has Euclidian signature of the induced metric. JABs in this sense would serve as correlates of quantum entanglement between system that they connect together.

Double cover property means that JABs identified as Kähler magnetic flux tubes have cross section, which are closed surfaces, and thus can carry quantized Kähler magnetic flux. These flux tubes would provide correlates for the magnetic fields known to exist in cosmological scales but no possible in standard cosmology due to the fact that needed currents should be coherent in long scales. For monopole fluxes no currents are needed.

Wormhole contacts as bosons and their super partners

The original interpretation of wormhole contacts (see Fig. `http://tgdtheory.fi/appfigures/wormholecontact.jpg` or Fig. ?? in the appendix of this book) was as genuinely new kind of particle like objects. With the emergence of zero energy ontology it gradually became clear that ordinary gauge bosons and Higgs particle and their super partners can be identified as wormhole contacts. Free fermions and their super-partners would be identified as CP_2 type vacuum extremals glued to a space-time sheet with a Minkowskian signature of the induced metric and thus possessing only single wormhole throat identificed as a light-like 3-surface.

This identification has far reaching implications. For instance, off mass shall particles can be interpreted as pairs of on mass shell positive and negative energy states at the opposite throats of the wormhole contact. This representation of virtual particles is crucial for the generalization of twistor formalism to TGD framework [K100].

A possible interpretation of wormhole contacts in living matter is as scaled up variants of bosons having much smaller mass and massless below confinement scale and appropriate p-adic length scale. This would mean the existence of scaled up copies of QCD type physics and electro-weak physics. These phases could be dark and characterized by a large value of Planck constant.

Topological condensation and evaporation

Topological condensation corresponds to a formation of $\#$ or $\#_B$ contacts between space-time sheets. Topological evaporation means the splitting of $\#$ or $\#_B$ contacts. In the case of elementary particles the process changes almost nothing since the causal horizon carrying parton quantum numbers does not disappear. The evaporated CP_2 type vacuum extremal having interpretation as a gravitational instanton can carry only color quantum numbers.

As $\#$ contact splits partons are created at the two space-time sheets involved. This process can obviously generate from vacuum space-time sheets carrying particles with opposite signs of energies and other quantum numbers. Positive energy matter and negative energy anti-matter could be thus created by the formation of $\#$ contacts with zero net quantum numbers which then split to produce pair of positive and negative energy particles at different space-time sheets having opposite time orientations. This mechanism would allow a creation of positive energy matter and negative energy antimatter with an automatic separation of matter and antimatter at space-time sheets having different time orientation. This might resolve elegantly the puzzle posed by matter-antimatter asymmetry.

The creation of $\#$ contact leads to an appearance of radial gauge field in condensate and this seems to be impossible at the limit of infinitely large space-time sheet since it involves a radical instantaneous change in field line topology. The finite size of the space-time sheet can however resolve the difficulty.

If all quantum numbers of elementary particle are expressible as gauge fluxes, the quantum numbers of topologically evaporated particles should vanish. In the case of color quantum numbers and Poincare quantum numbers there is no obvious reason why this should be the case. Despite this the cancellation of the interior quantum numbers by those at boundaries or light-like causal determinants could occur and would conform with the effective 2-dimensionality stating that quantum states are characterized by partonic boundary states associated with causal determinants. This could be also seen as a holographic duality of interior and boundary degrees of freedom [K93].

5.2.2 Gauge Charges And Gauge Fluxes

The concepts of mass and gauge charge in TGD has been a source of a chronic headache. There are several questions waiting for a definite answer. How to define gauge charge? What is the microscopic physics behind the gauge charges necessarily accompanying long range gravitational fields? Are these gauge charges quantized in elementary particle level? Can one associate to elementary particles classical electro-weak gauge charges equal to its quantized value or are all electro-weak charges screened at intermediate boson length scale? Is the generation of the vacuum gauge charges, allowed in principle by the induced gauge field concept, possible in macroscopic length scales? What happens to the gauge charges in topological evaporation? Should Equivalence Principle be modified in order to understand the fact that Robertson-Walker metrics are inertial but not gravitational vacua. Or is there some other way to solve the problem.

How to define the notion of gauge charge?

In TGD gauge fields are not primary dynamical variables but induced from the spinor connection of CP_2. There are two ways to define gauge charges.

1. In purely group theoretical approach one can associate non-vanishing gauge charge to a 3-surface of finite size and quantization of the gauge charge follows automatically. This definition should work at Planck length scales, when particles are described as 3-surfaces of CP_2 size and classical space-time mediating long range interactions make no sense. Gauge interactions are mediated by gauge boson exchange, which in TGD has topological description in terms of CP_2 type extremals [K102].

2. Second definition of gauge charge is as a gauge flux over a closed surface. In this case quantization is not obvious nor perhaps even possible at classical level except perhaps for Abelian charges. For a closed 3-surface gauge charge vanishes and one might well argue that this is the case for finite 3-surface with boundary since the boundary conditions might well generate gauge charge near the boundary cancelling the gauge charge created by particles condensed on 3-surface. This would mean that at low energies (photon wavelength large than size of the 3-surfaces) the 3-surfaces in vapor phase look like neutral particles. Only at high energies the evaporated particles would behave as ordinary elementary particles. Furthermore, particle leaves in topological evaporation its gauge charge in the condensate.

   The alternative possibility that the long range $\frac{1}{r^2}$ gauge field associated with particle disappears in the evaporation, looks topologically impossible at the limit when larger space-time sheet has infinite size: only the simultaneous evaporation of opposite gauge charges might be possible in this manner at this limit. Topological evaporation provides a possible mechanism for the generation of vacuum gauge charges, which is one basic difference between TGD and standard gauge theories.

There is a strong temptation to draw a definite conclusion but it is better to be satisfied with a simplifying working hypothesis that gauge charges are in long length scales definable as gauge fluxes and vanish for macroscopic 3-surfaces of finite size in vapor phase. This would mean that the topological evaporation of say electron as an electromagnetically charged particle would not be possible except at CP_2 length scale: in the evaporation from secondary condensation level electron would leave its gauge charges in the condensate. Vapor phase particle still looks electromagnetically charged in length scales smaller than the size of the particle surface if the neutralizing charge density is near (or at) the boundary of the surface and gauge and gravitational interactions are mediated by the exchange of CP_2 type extremals.

In what sense could # contacts feed gauge fluxes?

One can associate with the # throats magnetic gauge charges $\pm Q_i$ defined as gauge flux running to or from the throat. The magnetic charges are of opposite sign and equal magnitude on the two space-time sheets involved. For Kähler form the value of magnetic flux is quantized and non-vanishing only if the $t = constant$ section of causal horizon corresponds to a non-trivial homology equivalence class in CP_2 so that # contact can be regarded as a homological magnetic monopole. In this case # contacts can be regarded as extremely small magnetic dipoles formed by tightly bound

throats possessing opposite magnetic gauge charges. # contacts couple to the difference of the classical gauge fields associated with the two space-time sheets and matter-# contact and # contact-# contact interaction energies are in general non-vanishing.

Electric gauge fluxes through # throat evaluated at the light-like elementary particle horizon X_l^3 tend to be either zero or infinite. The reason is that without appropriate boundary conditions the normal component of electric $F^{tn}\sqrt(g_4)/g^2$ either diverges or is infinite since g^{tt} diverges by the effective three-dimensionality of the induced metric at X_l^3. In the gravitational case an additional difficulty is caused by the fact that it is not at all clear whether the notion of gravitational flux is well defined. It is however possible to assign gravitational mass to a given space-time sheets as will be found in the section about space-time description of charge renormalization.

The simplest conclusion would be that the notions of gauge and gravitational fluxes through # contacts do not make sense and that # contacts mediate interactions in a more subtle manner. For instance, for a space-time sheet topologically condensed at a larger space-time sheet the larger space-time sheet would characterize the basic coupling constants appearing in the S-matrix associated with the topologically condensed space-time sheets. In particular, the value of $\hbar$ would characterize the relation between the two space-time sheets. A stronger hypothesis would be that the value of $\hbar$ is coded partially by the Jones inclusion between the state spaces involved. The larger space-time sheet would correspond to dark matter from the point of view of smaller space-time sheet [K106, K80].

One can however try to find loopholes in the argument.

1. It might be possible to pose the finiteness of $F^{tn}\sqrt{g_4}/g^2$ as a boundary condition. The variation principle determining space-time surfaces implies that space-time surfaces are analogous to Bohr orbits so that there are also hopes that gauge fluxes are quantized.

2. Another way out of this difficulty could be based on the basic idea behind renormalization in TGD framework. Gauge coupling strengths are allowed to depend on space-time point so that the gauge currents are conserved. Gauge coupling strengths $g^2/4\pi$ could become infinite at causal horizon. The infinite values of gauge couplings at causal horizons might be a TGD counterpart for the infinite values of bare gauge couplings in quantum field theories. There are however several objections against this idea. The values of coupling constants should depend on space-time sheet only so that the situation is not improved by this trick in CP_2 length scale. Dependence of g^2 on space-time point means also that in the general case the definition of gauge charge as gauge flux is lost so that gauge charges do not reduce to fluxes.

It seems that the notion of a finite electric gauge flux through the causal horizon need not make sense as such. Same applies to the notion of gravitational gauge flux. The notion of gauge flux seems however to have a natural quantal generalization. The creation of a # contact between two space-time sheets creates two causal horizons identifiable as partons and carrying conserved charges assignable with the states created using the fermionic oscillator operators associated with the second quantized induced spinor field. These charges must be of opposite sign so that electric gauge fluxes through causal horizons are replaced by quantal gauge charges. For opposite time orientations also four-momenta cancel each other. The particle states can of course transform by interactions with matter at the two-space-time sheets so that the resulting contact is not a zero energy state always.

This suggests that for gauge fluxes at the horizon are identifiable as opposite quantized gauge charges of the partons involved. If the net gauge charges of # contact do not vanish, it can be said to possess net gauge charge and does not serve as a passive flux mediator anymore. The possibly screened classical gauge fields in the region faraway from the contact define the classical correlates for gauge fluxes. A similar treatment applies to gravitational flux in the case that the time orientations are opposite and gravitational flux is identifiable as gravitational mass at the causal horizon.

Internal consistency would mildly suggest that # contacts are possible only between space-time sheets of opposite time orientation so that gauge fluxes between space-time sheets of same time orientation would flow along $\#_B$ bonds.

Are the gauge fluxes through # and $\#_B$ contacts quantized?

There are good reasons (the fact that the extremals are critical in the sense that they allow an infinite number of deformations with a vanishing second variation of Kähler action plus maximization of the Kähler function) to expect that the gauge fluxes through # (if well-defined) and $\#_B$ contacts are quantized.

The expectation is that the number of critical deformations defining the symmetries is infinite and conformal symmetries are in question. The conformal algebras would form an infinite hierarchy of sub-algebras with generators labelled by integers proportional to an integer $n = 1, 2....$ One would have n conformal equivalence classes of space-time surfaces connecting given 3-surfaces at the boundaries of CD and n would define Planck constant $h_{eff} = n \times h$ labelling the hierarchy of dark matters (see Fig. http://tgdtheory.fi/appfigures/planckhierarchy.jpg or Fig. ?? in the appendix of this book).

The most natural guess would be that the unit of electric electromagnetic flux for $\#_B$ contact is $1/3$ since this makes it possible for the electromagnetic gauge flux of quarks to flow to larger space-time sheets. Anyons could however mean more general quantization rules [K67]. The quantization of electromagnetic gauge flux could serve as a unique experimental signature for # and $\#_B$ contacts and their currents. The contacts can carry also magnetic fluxes. In the case of $\#_B$ contacts the flux quantization would be dynamical and analogous to that appearing in super conductors.

Hierarchy of gauge and gravitational interactions

The observed elementary particles are identified as CP_2 type extremals topologically condensed at space-time sheets with Minkowski signature of induced metric with elementary particle horizon being responsible for the parton aspect. This suggests that at CP_2 length scale gauge and gravitational interactions correspond to the exchanges of CP_2 type extremals with light-like M^4 projection with branching of CP_2 type extremal serving as the basic vertex as discussed in [K102]. The gravitational and gauge interactions between the partons assignable to the two causal horizons associated with # contact would be mediated by the # contact, which can be regarded as a gravitational instanton and the interaction with other particles at space-time sheets via classical gravitational fields.

Gauge fluxes flowing through the $\#_B$ contacts would mediate higher level gauge and interactions between space-time sheets rather than directly between CP_2 type extremals. The hierarchy of flux tubes defining string like objects strongly suggests a p-adic hierarchy of "strong gravities" with gravitational constant of order $G \sim L_p^2$, and these strong gravities might correspond to gravitational fluxes mediated by the flux tubes.

5.2.3 The Relationship Between Inertial And Gravitational Masses

The understanding of the relationship between TGD and GRT and quantum and classical variants of Equivalence Principle (EP) in TGD have develope rather slowly but the recent picture is rather feasible.

1. The recent view is that EP at quantum level reduces to Quantum Classical Correpondence (QCC) in the sense that Cartan algebra Noether charges assignable to 3-surface in case of Kähler action (inertial charges) are identical with eigenvalues of the quantal variants of Noether charges for Kähler-Dirac action (gravitational

charges). The well-definedness of the latter charges is due to the conformal invariance assignable to 2-D surfaces (string world sheets and possibly partonic 2-surfaces) at which the spinor modes are localized in generic case. This localization follows from the condition that em charge has well defined value for the spinor modes. The localization is possibly only for the Kähler-Dirac action and key role is played by the modification of gamma matrices to Kähler-Dirac gamma matrices. The gravitational four-momentum is thus completely analogous to stringy four-momentum.

2. At classical level EP follows from the interpretation of GRT space-time as effective space-time obtained by replacing many-sheeted space-time with Minkowski space with effective metric determined as a sum of Minkowski metric and sum over the deviations of the induced metrices of space-time sheets from Minkowski metric. Poincare invariance suggests strongly classical EP for the GRT limit in long length scales at least (see Fig. http://tgdtheory.fi/appfigures/manysheeted.jpg or Fig. 9 in the appendix of this book).

ZEO and non-conservation of Poincare charges in Poincare invariant theory of gravitation

In positive energy ontology the Poincare invarance of TGD is in sharpt contrast with the fact that GRT based cosmology predicts non-conservation of Poincare charges (as a matter fact, the definition of Poincare charges is very questionable for general solutions of field equations).

In zero energy ontology (ZEO) all conserved (that is Noether-) charges of the Universe vanish identically and their densities should vanish in scales below the scale defining the scale for observations and assignable to causal diamond (CD). This observation allows to imagine a ways out of what seems to be a conflict of Poincare invariance with cosmological facts.

ZEO would explain the local non-conservation of average energies and other conserved quantum numbers in terms of the contributions of sub-CDs analogous to quantum fluctuations. Classical gravitation should have a thermodynamical description if this interpretation is correct. The average values of the quantum numbers assignable to a space-time sheet would depend on the size of CD and possibly also its location in M^4. If the temporal distance between the tips of CD is interpreted as a quantized variant of cosmic time, the non-conservation of energy-momentum defined in this manner follows. One can say that conservation laws hold only true in given scale defined by the largest CD involved.

Equivalence Principle at quantum level

The interpretation of EP at quantum level has developed slowly and the recent view is that it reduces to quantum classical correspondence meaning that the classical charges of Kähler action can be identified with eigen values of quantal charges associated with Kähler-Dirac action.

1. At quantum level I have proposed coset representations for the pair of super-symplectic algebras assignable to the light-like boundaries of CD and the Super Kac-Moody algebra assignable to the light-like 3-surfaces defining the orbits of partonic 2-surfaces as realization of EP. For coset representation the differences of super-conformal generators would annihilate the physical states so that one can argue that the corresponding four-momenta are identical. One could even say that one obtains coset representation for the "vibrational" parts of the super-conformal algebras in question. It is now clear that this idea does not work. Note however that coset representations occur naturally for the subalgebras of symplectic algebra and Super Kac-Moody algebra and are naturally induced by finite measurement resolution.

2. The most recent view (2014) about understanding how EP emerges in TGD is described in [K103] and relies heavily on superconformal invariance and a detailed realisation of ZEO at quantum level. In this approach EP corresponds to quantum classical correspondence (QCC): four-momentum identified as classical conserved Noether charge for space-time sheets associated with Käbler action is identical with quantal four-momentum assignable to the representations of super-symplectic and super Kac-Moody algebras as in string models and having a realisation in ZEO in terms of wave functions in the space of causal diamonds (CDs).

3. The latest realization is that the eigenvalues of quantal four-momentum can be identified as eigenvalues of the four-momentum operator assignable to the Kähler-Dirac equation. This realisation seems to be consistent with the p-adic mass calculations requiring that the super-conformal algebra acts in the tensor product of 5 tensor factors.

Equivalence Principle at classical level

How Einstein's equations and General Relativity in long length scales emerges from TGD has been a long-standing interpretational problem of TGD.

The first proposal making sense even when one does not assume ZEO is that vacuum extremals are only approximate representations of the physical situation and that small fluctuations around them give rise to an inertial four-momentum identifiable as gravitational four-momentum identifiable in terms of Einstein tensor. EP would hold true in the sense that the average gravitational four-momentum would be determined by the Einstein tensor assignable to the vacuum extremal. This interpretation does not however take into account the many-sheeted character of TGD spacetime and is therefore questionable.

The resolution of the problem came from the realization that GRT is only an effective theory obtained by endowing M^4 with effective metric.

1. The replacement of superposition of fields with superposition of their effects means replacing superposition of fields with the set-theoretic union of space-time surfaces. Particle experiences sum of the effects caused by the classical fields at the space-time sheets (see Fig. `http://tgdtheory.fi/appfigures/fieldsuperpose.jpg` or Fig. ?? in the appendix of this book).

2. This is true also for the classical gravitational field defined by the deviation from flat Minkowski metric instandard M^4 coordinates for the space-time sheets. One can define effective metric as sum of M^4 metric and deviations. This effective metric would correspond to that of General Relativity. This resolves long standing issues relating to the interpretation of TGD.

3. Einstein's equations could hold true for the effective metric. They are motivated by the underlying Poincare invariance which cannot be realized as global conservation laws for the effective metric. The conjecture vanishing of divergence of Kähler energy momentum tensor can be seen as the microscopic justification for the claim that Einstein's equations hold true for the effective space-time.

4. The breaking of Poincare invariance could have interpretation as effective breaking in zero energy ontology (ZEO), in which various conserved charges are length dependent and defined separately for each causal diamond (CD).

One can of course consider the possibility that Einstein's equations generalize for preferred extremals of Kähbler action. This would actually represent at space-time level the notion of QCC rather than realise QCC interpreted as EP. The condition that the energy momentum tensor for Kähler action has vanishing covariant divergence would be satisfied in GRT if Einstein's equations with cosmological term hold true. This is the case also now but one can consider also more general solutions in which one has two cosmological constants which are not genuine constants anymore: it however seems that this option is not promising.

An interesting question is whether inertial-gravitational duality generalizes to the case of color gauge charges so that color gauge fluxes would correspond to "gravitational" color charges and the charges defined by the conserved currents associated with color isometries would define "inertial" color charges. Since the induced color fields are proportional to color Hamiltonians multiplied by Kähler form they vanish identically for vacuum extremals in accordance with "gravitational" color confinement.

Gravitational mass is necessarily accompanied by non-vanishing gauge charges

The experience from the study of the extremals of the Kähler action [K70] suggests that for non-vacuum extremals at astrophysical scales Kähler charge doesn't depend on the properties of the condensate and is apart from numerical constant equal to the gravitational mass of the system using Planck mass as unit:

$$Q_K = \epsilon_1 \frac{M_{gr}}{m_{proton}} \ . \tag{5.2.1}$$

The condition $\frac{\epsilon_1}{\sqrt{\alpha_K}} < 10^{-19}$ must hold true in astrophysical length scales since the long range gauge force implied by the Kähler charge must be weaker than gravitational interaction at astrophysical length scales. It is not clear whether the "anomalous" Kähler charge can correspond to a mere Z^0 gauge or em charge or more general combination of weak charges.

Also for the embedding of Schwartschild and Reissner-Nordström metrics as vacuum extremals non-vanishing gravitational mass implies that some electro-weak gauge charges are non-vanishing [K70]. For vacuum extremals with $sin^2(\theta_W) = 0$ em field indeed vanishes whereas Z^0 gauge field is non-vanishing.

If one assumes that the weak charges are screened completely in electro-weak length scale, the anomalous charge can be only electromagnetic if it corresponds to ordinary elementary particles. This however need not be consistent with field equations. Perhaps the most natural interpretation for the "anomalous" gauge charges is due to the elementary charges associated with dark matter. Since weak charges are expected to be screened in the p-adic length scale characterizing weak boson mass scale, the implication is that scaled down copies of weak bosons with arbitrarily small mass scales and arbitrarily long range of interaction are predicted. Also long ranged classical color gauge fields are unavoidable which forces to conclude that also a hierarchy of scaled down copies of gluons exists.

One can hope that photon and perhaps also Z^0 and color gauge charges in Cartan algebra could be quantized classically at elementary particle length scale ($p \leq M_{127}$, say) and electromagnetic gauge charge in all length scales apart from small renormalization effects. One of the reasons is that classical electromagnetic fields make an essential part in the description of, say, hydrogen atom.

The study of the extremals of Kähler action and of the embeddings of spherically symmetric metrics [K70, K103] shows that the embeddings are characterized by frequency type vacuum quantum numbers, which allow to fix these charges to pre-determined values. The minimization of Kähler action for a space-time surface containing a given 3-surface leads to the quantization of the vacuum parameters and hopefully to charge quantization. This motivates the hypothesis that the electromagnetic charges associated with the classical gauge fields of topologically condensed elementary particles are equal to their quantized counterparts. The discussion of dark matter leads to the conclusion that electro-weak and color gauge charges of dark matter can be non-vanishing [K80, K79].

5.2.4 Can One Regard # *Resp.* $\#_B$ Contacts As Particles*Resp.* String Like Objects?

#-contacts have obvious particle like aspects identifiable as either partons or parton pairs. $\#_B$ contacts in turn behave like string like objects. Using the terminology of M-theory, $\#_B$ contacts connecting the boundaries of space-time sheets could be also seen as string like objects connecting two branes. Again the ends holes at the ends of $\#_B$ contacts carry well defined gauge charges.

contacts as particles and $\#_B$ contacts as string like objects?

The fact that # contacts correspond to parton pairs raises the hope that it is possible to apply p-adic thermodynamics to calculate the masses of # contact and perhaps even the masses of the partons. If this the case, one has an order of magnitude estimate for the first order contribution to the mass of the parton as $m \sim 1/L(p_i)$, $i = 1, 2$. It can of course happen that the first order contribution vanishes: in this case an additional factor $1/\sqrt{p_i}$ appears in the estimate and makes the mass extremely small.

For # contacts connecting space-time sheets with opposite time orientations the vanishing of the net four-momentum requires $p_1 = p_2$. According to the number theoretic considerations below it is possible to assign several p-adic primes to a given space-time sheet and the largest among them, call it p_{max}, determines the p-adic mass scale. The milder condition is that p_{max} is same for the two space-time sheets.

There are some motivations for the working hypothesis that # contacts and the ends of $\#_B$ contacts feeding the gauge fluxes to the lower condensate levels or vice versa tend to be located near the boundaries of space-time sheets. For gauge charges which are not screened by vacuum charges (em and color charges) the embedding of the gauge fields created by the interior gauge charges becomes impossible near the boundaries and the only possible manner to satisfy boundary conditions is that gauge fluxes flow to the larger space-time sheet and space-time surface becomes a vacuum extremal of the Kähler action near the boundary.

For gauge bosons the density of boundary $\#_B$ contacts should be very small in length scales, where matter is essentially neutral. For gravitational $\#_B$ contacts the situation is different. One might well argue that there is some upper bound for the gravitational flux associated with single # or $\#_B$ contact (or equivalently the gravitational mass associated with causal horizon) given by Planck mass or CP_2 mass so that the number of gravitational contacts is proportional to the mass of the system.

The TGD based explanation for Podkletnov effect [H18] is based on the assumption that magnetically charged # contacts are carries of gravitational flux equal to Planck mass and predicts effect with correct order of magnitude. The model generalizes also to the case of $\#_B$ contacts. The lower bound for the gravitational flux quantum must be rather small: the mass $1/L(p)$ determined by the p-adic prime associated with the larger space-time sheet is a first guess for the unit of flux.

Could # and $\#_B$ contacts form Bose-Einstein condensates?

The description as # contact as a parton pair suggests that it is possible to assign to # contacts inertial mass, say of order $1/L(p)$, they should be describable using d'Alembert type equation for a scalar field. # contacts couple dynamically to the geometry of the space-time since the induced metric defines the d'Alembertian. There is a mass gap and hence # contacts could form a Bose-Einstein (BE) condensate to the ground state. If # contacts are located near the boundary of the space-time surface, the d'Alembert equation would be 3-dimensional. One can also ask whether # contacts define a particular form of dark matter having only gravitational interactions with the ordinary matter.

Also the probability amplitudes for the positions of the ends of $\#_B$ contacts located at the boundary of the space-time sheet could be described using an order parameter satisfying d'Alembert equation with some mass parameter and whether the notion of Bose-Einstein condensate makes sense also now. The model for atomic nucleus assigns to the ends of the $\#_B$ contact realized as a color magnetic flux tube quark and anti-quark with mass scale given by $k = 127$ (MeV scale) [K94].

This inspires the question whether # and $\#_B$ contacts could be essential for understanding bio-systems as macroscopic quantum systems [K11]. The BE condensate associated with the # contacts behaves in many respects like super conductor: for instance, the concept of Josephson junction generalizes. As a matter fact, it seems that $\#_B$ contacts, join along boundaries (JABs), or magnetic flux tubes could indeed be a key element of not only living matter but even nuclear matter and condensed matter in TGD Universe. Whether boundaries (and thus JABs) are allowed depends on whether boundary conditions for Kähler action allow space-like or light-like boundaries and in the simplest situation they do not seem to be allowed.

Decades after writing these lines it has become clear that Kähler action need not allow boundaries in the usual sense. They would be replaced with boundaries between space-time regions with Minkowskian and Euclidian signature and magnetic flux tubes carrying possibly monopole flux would replace join along boundaries contacts.

5.2.5 TGD Based Description Of External Fields

The description of a system in external field provides a nontrivial challenge for TGD since the system corresponds now to a p-adic space-time sheet k_1 condensed on background 3-surface $k_2 > k_1$. The problem is to understand how external fields penetrate into the smaller space-time sheet and also how the gauge fluxes inside the smaller space-time sheet flow to the external space-time sheet. One should also understand how the penetrating magnetic or electric field manages to preserve its value (if it does so). A good example is provided by the description of system, such as atom or nucleus, in external magnetic or electric field. There are several mechanisms of field penetration:

Induction mechanism

In the case of induction fields are mediated from level k_1 to levels $k_2 \neq k_1$. The external field at given level k_1 acts on # and $\#_B$ throats (both accompanied by a pair of partons) connecting levels k_2 and k_1. The motion of # and $\#_B$ contacts, induced by the gauge and gravitational couplings of partons involved to classical gauge and gravitational fields, creates gauge currents serving as sources of classical gauge field at the space-time sheets involved. This mechanism involves "dark" partons not predicted by standard model.

A good example is provided by the rotation of charged # throats induced by a constant magnetic field, which in turn creates constant magnetic field inside a cylindrical condensate space-time sheet. A second example is the polarization of the charge density associated with the # throats in the external electric field, which in turn creates a constant electric field inside the smaller space-time sheet.

One can in principle formulate general field equations governing the penetration of a classical gauge field from a given condensate level to other levels. The simplified description is based on the introduction of series of fields associated with various condensate levels as analogs of H and B and D and E fields in the ordinary description of the external fields. The simplest assumption is that the fields are linearly related. A general conclusion is that due to the delicacies of the induced field concept, the fields on higher levels appear in the form of flux quanta and typically the field strengths at the higher condensate levels are stronger so that the penetration of field from lower levels to the higher ones means a decomposition into separate flux tubes.

The description of magnetization in terms of the effective field theory of Weiss introduces effective field H, which is un-physically strong: a possible explanation as a field consisting of flux quanta at higher condensate levels. A general order of magnitude estimate for field strength of magnetic flux quantum at condensate level k is as $1/L^2(k)$.

Penetration of magnetic fluxes via # contacts

At least magnetic gauge flux can flow from level p_1 to level p_2 via # contacts. These surfaces are of the form $X^2 \times D^1$, where X^2 is a closed 2-surface. The simplest topology for X^2 is that of sphere S^2. This leads to the first nontrivial result. If a nontrivial magnetic flux flows through the contact, it is quantized. The reason is that magnetic flux is necessarily over a closed surface.

The concept of induced gauge field implies that magnetic flux is nontrivial only if the surface X^2 is homologically nontrivial: CP_2 indeed allows homologically nontrivial sphere. Ordinary magnetic field can be decomposed into co-homologically trivial term plus a term proportional to Kähler form and the flux of ordinary magnetic field comes only from the part of the magnetic field proportional to the Kähler form and the magnetic flux is an integer multiple of some basic flux.

The proposed mechanism predicts that magnetic flux can change only in multiples of basic flux quantum. In super conductors this kind of behavior has been observed. Dipole magnetic fields can be transported via several # contacts: the minimum is one for ingoing and one for return flux so that magnetic dipoles are actual finite sized dipoles on the condensed surface. Also the transfer of magnetic dipole field of, say neutron inside nucleus, to lower condensate level leads to similar magnetic dipole structure on condensate level. For this mechanism the topological condensation of elementary particle, say charged lepton space-time sheet, would involve at least two # contacts and the magnetic moment is proportional to the distance between these contacts. The requirement that the magnetic dipole formed by the # contacts gives the magnetic moment of the particle gives an estimate for the distance d between # throats: by flux quantization the general order of magnitude is given by $d \sim \frac{\alpha_{em} 2\pi}{m}$.

Penetration of electric gauge fluxes via # contacts

For # contact for the opposite gauge charges of partons define the value of generalized gauge electric flux between the two space-time sheets. In this case it is also possible to interpret the partons as sources of the fields at the two space-time sheets. If the # contacts are near the boundary of the smaller space-time sheet the interpretation as a flow of gauge flux to a larger space-time sheet is perfectly sensible. The partons near the boundary can be also seen as generators of a gauge field compensating the gauge fluxes from interior.

The distance between partons can be much larger than p-adic cutoff length $L(k)$ and a proper spatial distribution guarantees homogeneity of the magnetic or electric field in the interior. The distances of the magnetic monopoles are however large in this kind of situation and it is an open problem whether this kind of mechanism is consistent with experimental facts.

An estimate for the electric gauge flux Q_{em} flowing through the # contact is obtained as $n \sim \frac{E}{QL(k)}$: $Q \sim EL^2(k)$, which is of same order of magnitude as electric gauge flux over surface of are $L^2(k)$. In magnetic case the estimate gives $Q_M \sim BL^2(k)$: the quantization of Q_M is consistent with homogeneity requirement only provided the condition $B > \frac{\Phi_0}{L^2(k)}$, where Φ_0 is elementary flux quantum, holds true. This means that flux quantization effects cannot be avoided in weak magnetic fields. The second consequence is that too weak magnetic field cannot penetrate at all to the condensed surface: this is certainly the case if the total magnetic flux is smaller than elementary flux quantum. A good example is provided by the penetration of magnetic field into cylindrical super conductor through the end of the cylinder. Unless the field is strong enough the penetrating magnetic field decomposes into vortex like flux tubes or does not penetrate at all.

The penetration of flux via dipoles formed by # contacts from level to a second level in the interior of condensed surface implies phenomena analogous to the generation of polarization (magnetization) in dielectric (magnetic) materials. The conventional description in terms of fields H, B, M and D, E, P has nice topological interpretation (which does not mean that the mechanism is actually at work in condensed matter length scales). Magnetization M (polarization P) can be regarded as the density of fictitious magnetic (electric) dipoles in the conventional theory: the proposed topological picture suggests that these quantities essentially as densities for # contact pairs. The densities of M and P are of opposite sign on the condensed surface and condensate. $B = H - M$ corresponds to the magnetic field at condensing surface level reduced by the density $-M$ of # contact dipoles in the interior. H denotes the external field at condensate level outside the condensing surface, M $(-M)$ is the magnetic field created by the # contact dipoles at condensate (condensed) level. Similar interpretation can be given for D, E, P fields. The penetrating field is homogenous only above length scales larger than the distance between # throats of dipoles: p-adic cutoff scale $L(k)$ gives natural upper bound for this distance: if this is the case and the density of the contacts is at least of order $n \sim \frac{1}{L^3(k)}$ the penetrating field can be said to be constant also inside the condensed surface.

In condensed matter systems the generation of ordinary polarization and magnetization fields might be related to the permanent # contacts of atomic surfaces with, say, $k = 139$ level. The field created by the neutral atom contains only dipole and higher multipoles components and therefore at least two # contacts per atom is necessary in gas phase, where flux tubes between atoms are absent. In the absence of external field these dipoles tend to have random directions. In external field # throats behave like opposite charges and their motion in external field generates dipole field. The expression of the polarization field is proportional to the density of these static dipole pairs in static limit. # contacts make possible the penetration of external field to atom, where it generates atomic transitions and leads to the emission of dipole type radiation field, which gives rise to the frequency dependent part of dielectric constant.

Penetration via $\#_B$ contacts

The field can also through $\#_B$ contacts through the boundary of the condensed surface or through the small holes in its interior. The quantization of electric charge quantization would reduce to the quantization of electric gauge flux in $\#_B$ contacts. If there are partons at the ends of contact they affect the gauge gauge flux.

The penetration via $\#_B$ contacts necessitates the existence of join along boundaries bonds starting from the boundary of the condensed system and ending to the boundary component of a hole in the background surface. The field flux flows simply along the 3-dimensional stripe $X^2 \times D^1$: since X^2 has boundary no flux quantization is necessary. This mechanism guarantees automatically the homogeneity of the penetrating field inside the condensed system.

An important application for the theory of external fields is provided by biosystems in which the penetration of classical electromagnetic fields between different space-time sheets should play central role: what makes the situation so interesting is that the order parameter describing the # and $\#_B$ Bose-Einstein condensates carries also phase information besides the information about the strength of the normal component of the penetrating field.

5.2.6 Number Theoretical Considerations

Number theoretical considerations allow to develop more quantitative vision about the how p-adic length scale hypothesis relates to the ideas just described.

How to define the notion of elementary particle?

p-Adic length scale hierarchy forces to reconsider carefully also the notion of elementary particle. p-Adic mass calculations led to the idea that particle can be characterized uniquely by single p-adic prime characterizing its mass squared. It however turned out that the situation is probably not so simple.

The work with modelling dark matter suggests that particle could be characterized by a collection of p-adic primes to which one can assign weak, color, em, gravitational interactions, and possibly also other interactions. It would also seem that only the space-time sheets containing common primes in this collection can interact. This leads to the notions of relative and partial darkness. An entire hierarchy of weak and color physics such that weak bosons and gluons of given physics are characterized by a given p-adic prime p and also the fermions of this physics contain space-time sheet characterized by same p-adic prime, say M_{89} as in case of weak interactions. In this picture the decay widths of weak bosons do not pose limitations on the number of light particles if weak interactions for them are characterized by p-adic prime $p \neq M_{89}$. Same applies to color interactions.

The p-adic prime characterizing the mass of the particle would perhaps correspond to the largest p-adic prime associated with the particle. Graviton which corresponds to infinitely long ranged interactions, could correspond to the same p-adic prime or collection of them common to all particles. This might apply also to photons. Infinite range might mean that the flux tubes mediating these interactions can be arbitrarily long but their transversal sizes are characterized by the p-adic length scale in question.

The natural question is what this collection of p-adic primes characterizing particle means? The hint about the correct answer comes from the number theoretical vision, which suggests that at fundamental level the branching of boundary components to two or more components, completely analogous to the branching of line in Feynman diagram, defines vertices [K96, K102].

1. If space-time sheets correspond holographically to multi-p p-adic topology such that largest p determines the mass scale, the description of particle reactions in terms of branchings indeed makes sense. This picture allows also to understand the existence of different scaled up copies of QCD and weak physics. Multi-p p-adicity could number theoretically correspond to q-adic topology for $q = m/n$ a rational number consistent with p-adic topologies associated with prime factors of m and n ($1/p$-adic topology is homeomorphic with p-adic topology).

2. One could also imagine that different p-adic primes in the collection correspond to different space-time sheets condensed at a larger space-time sheet or boundary components of a given space-time sheet. If the boundary topologies for gauge bosons are completely mixed, as the model of hadrons forces to conclude, this picture is consistent with the topological explanation of the family replication phenomenon and the fact that only charged weak currents involve mixing of quark families. The problem is how to understand the existence of different copies of say QCD. The second difficult question is why the branching leads always to an emission of gauge boson characterized by a particular p-adic prime, say M_{89}, if this p-adic prime does not somehow characterize also the particle itself.

What effective p-adic topology really means?

The need to characterize elementary particle p-adically leads to the question what p-adic effective topology really means. p-Adic mass calculations leave actually a lot of room concerning the answer to this question.

1. The naïvest option is that each space-time sheet corresponds to single p-adic prime. A more general possibility is that the boundary components of space-time sheet correspond to different p-adic primes. This view is not favored by the view that each particle corresponds to a collection of p-adic primes each characterizing one particular interaction that the particle in question participates.

2. A more abstract possibility is that a given space-time sheet or boundary component can correspond to several p-adic primes. Indeed, a power series in powers

of given integer n gives rise to a well-defined power series with respect to all prime factors of n and effective multi-p-adicity could emerge at the level of field equations in this manner.

One could say that space-time sheet or boundary component corresponds to several p-adic primes through its effective p-adic topology in a hologram like manner. This option is the most flexible one as far as physical interpretation is considered. It is also supported by the number theoretical considerations predicting the value of gravitational coupling constant [K96].

An attractive hypothesis is that only space-time sheets characterized by integers n_i having common prime factors can be connected by join along boundaries bonds and can interact by particle exchanges and that each prime p in the decomposition corresponds to a particular interaction mediated by an elementary boson characterized by this prime.

The physics of quarks and hadrons provides an immediate test for this interpretation. The surprising and poorly understood conclusion from the p-adic mass calculations was that the p-adic primes characterizing light quarks u, d, s satisfy $k_q < 107$, where $k = 107$ characterizes hadronic space-time sheet [K31].

1. The interpretation of $k = 107$ space-time sheet as a hadronic space-time sheet implies that quarks topologically condense at this space-time sheet so that $k = 107$ cannot belong to the collection of primes characterizing quark.

2. Quark space-time sheets must satisfy $k_q < 107$ unless $\hbar$ is large for the hadronic space-time sheet so that one has $k_{eff} = 107 + 22 = 129$. This predicts two kinds of hadrons. Low energy hadrons consists of u, d, and s quarks with $k_q < 107$ so that hadronic space-time sheet must correspond to $k_{eff} = 129$ and large value of $\hbar$. One can speak of confined phase. This allows also $k = 127$ light variants of quarks appearing in the model of atomic nucleus [K94]. The hadrons consisting of c, t, b and the p-adically scaled up variants of u, d, s having $k_q > 107$, $\hbar$ has its ordinary value in accordance with the idea about asymptotic freedom and the view that the states in question correspond to short-lived resonances.

Do infinite primes code for q-adic effective space-time topologies?

Besides the hierarchy of space-time sheets, TGD predicts, or at least suggests, several hierarchies such as the hierarchy of infinite primes [K96], hierarchy of Jones inclusions [K106], hierarchy of dark matters with increasing values of $\hbar$ [K80, K79], the hierarchy of extensions of given p-adic number field, and the hierarchy of selves and quantum jumps with increasing duration with respect to geometric time. There are good reasons to expect that these hierarchies are closely related.

1. Some facts about infinite primes

The hierarchy of infinite primes can be interpreted in terms of an infinite hierarchy of second quantized super-symmetric arithmetic quantum field theories allowing a generalization to quaternionic or perhaps even octonionic context [K96]. Infinite primes, integers, and rationals have decomposition to primes of lower level.

Infinite prime has fermionic and bosonic parts having no common primes. Fermionic part is finite and corresponds to an integer containing and bosonic part is an integer multiplying the product of all primes with fermionic prime divided away. The infinite prime at the first level of hierarchy corresponds in a well defined sense a rational number $q = m/n$ defined by bosonic and fermionic integers m and n having no common prime factors.

2. Do infinite primes code for effective q-adic space-time topologies?

The most obvious question concerns the space-time interpretation of this rational number. Also the question arises about the possible relation with the integers characterizing space-time sheets having interpretation in terms of multi-p-adicity. On can assign to any rational number $q = m/n$ so called q-adic topology. This topology is not consistent with number field property like p-adic topologies. Hence the rational number q assignable to infinite prime could correspond to an effective q-adic topology.

If this interpretation is correct, arithmetic fermion and boson numbers could be coded into effective q-adic topology of the space-time sheets characterizing the non-determinism of Kähler action in the relevant length scale range. For instance, the power series of $q > 1$ in positive powers with integer coefficients in the range $[0, q)$ define q-adically converging series, which also converges with respect to the prime factors of m and can be regarded as a p-adic power series. The power series of q in negative powers define in similar converging series with respect to the prime factors of n.

I have proposed earlier that the integers defining infinite rationals and thus also the integers m and n characterizing finite rational could correspond at space-time level to particles with positive *resp.* negative time orientation with positive *resp.* negative energies. Phase conjugate laser beams would represent one example of negative energy states. With this interpretation super-symmetry exchanging the roles of m and n and thus the role of fermionic and bosonic lower level primes would correspond to a time reversal.

1. The first interpretation is that there is single q-adic space-time sheet and that positive and negative energy states correspond to primes associated with m and n respectively. Positive (negative) energy space-time sheets would thus correspond to p-adicity ($1/p$-adicity) for the field modes describing the states.

2. Second interpretation is that particle (in extremely general sense that entire universe can be regarded as a particle) corresponds to a pair of positive and negative energy space-time sheets labelled by m and n characterizing the p-adic topologies consistent with $m-$ and n-adicities. This looks natural since Universe has necessary vanishing net quantum numbers. Unless one allows the non-uniqueness due to $m/n = mr/nr$, positive and negative energy space-time sheets can be connected only by # contacts so that positive and negative energy space-time sheets cannot interact via the formation of $\#_B$ contacts and would be therefore dark matter with respect to each other.

   Positive energy particles and negative energy antiparticles would also have different mass scales. If the rate for the creation of # contacts and their CP conjugates are slightly different, say due to the presence of electric components of gauge fields, matter antimatter asymmetry could be generated primordially.

These interpretations generalize to higher levels of the hierarchy. There is a homomorphism from infinite rationals to finite rationals. One can assign to a product of infinite primes the product of the corresponding rationals at the lower level and to a sum of products of infinite primes the sum of the corresponding rationals at the lower level and continue the process until one ends up with a finite rational. Same applies to infinite rationals. The resulting rational $q = m/n$ is finite and defines q-adic effective topology, which is consistent with all the effective p-adic topologies corresponding to the primes appearing in factorizations of m and n. This homomorphism is of course not 1-1.

If this picture is correct, effective p-adic topologies would appear at all levels but would be dictated by the infinite-p p-adic topology which itself could refine infinite-P p-adic topology [K96] coding information too subtle to be caught by ordinary physical measurements.

Obviously, one could assign to each elementary particle infinite prime, integer, or even rational to this a rational number $q = m/n$. q would associate with the particle q-adic topology consistent with a collection of p-adic topologies corresponding to the prime factors of m and n and characterizing the interactions that the particle can participate directly. In a very precise sense particles would represent both infinite and finite numbers.

Under what conditions space-time sheets can be connected by $\#_B$ contact?

Assume that particles are characterized by a p-adic prime determining it mass scale plus p-adic primes characterizing the gauge bosons to which they couple and assume that $\#_B$ contacts mediate gauge interactions. The question is what kind of space-time sheets can be connected by $\#_B$ contacts.

1. **The first working hypothesis that comes in mind is that the p-adic primes associated with the two space-time sheets connected by $\#_B$ contact must be identical. This would require that particle is many-sheeted structure with no other than gravitational interactions between various sheets. The problem of the multi-sheeted option is that the characterization of events like electron-positron annihilation to a weak boson looks rather clumsy.**

2. **If the notion of multi-p p-adicity is accepted, space-time sheets are characterized by integers and the largest prime dividing the integer might characterize the mass of the particle. In this case a common prime factor p for the integers characterizing the two space-time sheets could be enough for the possibility of $\#_B$ contact and this contact would be characterized by this prime. If no common prime factors exist, only $\#$ contacts could connect the space-time sheets. This option conforms with the number theoretical vision. This option would predict that the transition to large $\hbar$ phase occurs simultaneously for all interactions.**

5.3 Model For Topologically Quantized Magnetic Field

5.3.1 Topological Field Quantization

Topological field quantization [K85] implies that various notions of quantum field theory have rather precise classical analogies. Topological field quantization provides the correspondence between the abstract Fock space description of elementary particles and the description of the elementary particles as concrete geometric objects detected in the laboratory. In standard quantum field theory this kind of correspondence is lacking since classical fields are regarded as a phenomenological concept only. Topological field quanta define regions of coherence for the classical fields and classical coherence is the prerequisite of the quantum coherence.

The energies and other classical charges of the topological field quanta are quantized by the criticality of the preferred extremals making classical space-time surfaces the counterparts of the Bohr orbits. Feynman diagrams become classical space-time surfaces with lines thickened to 4-manifolds. For instance, "massless extremals" representing topologically quantized classical radiation fields are the classical counterparts of gravitinos and photons. Topologically quantized non-radiative nearby fields give rise to various geometric structures such as magnetic and electric flux tubes.

The virtual particles of quantum field theory have also classical counterparts. In particular, the virtual particles of quantum field theory can have negative energies: this is true also for the TGD counterparts of the virtual particles. The fundamental difference between TGD and GRT is that in TGD the sign of energy depends on the time orientation of the space-time sheet: this is due to the fact that in TGD energy current is vector field rather than part of tensor field. Therefore space-time sheets with negative energies are possible. This could have quite dramatic technological consequences: consider only the possibility of generating energy from vacuum and classical signalling backwards in time along negative energy space-time sheets [K34, K53]. Also bio-systems might have invented negative energy space-time sheets: in fact, so called "massless extremals" provide an ideal manner to generate coherent motions as recoil effects caused by the creation of negative energy massless extremals [K36, K35]. An interesting possibility is that quantum entanglement has the formation of the join along boundaries bonds/flux tubes as its geometric correlate.

The crucial question is of course "How to make this idea quantitative?". An attractive possibility is that topological field quanta identified as material or mind-like space-time sheets could be regarded as counterparts of oscillator operators of free fields in quantum field theory. This would mean that one could make order of magnitude estimates for the probabilities for the presence of various numbers of both material and mind-like space-time sheets using quantum field theoretical intuition. The coefficient of a particular state in the expansion of the creation operators of the outgoing interacting quantum fields in terms of the creation and annihilation operators of free quantum fields could provide an estimate for the probability that a particular configuration containing topological field quanta with positive and negative energies results in quantum jump between quantum histories. Since mind-like space-time sheets are correlates for virtual particles, this would also mean a deep connection between quantum field theory and cognition.

Topological field quanta could serve as templates for the formation of the bio-structures. Thus topologically quantized classical electromagnetic fields could be equally important for the functioning of the living systems as the structures formed by the visible bio-matter and the visible part of bio-system might represent only a dip of an ice berg.

Topological field quantization of magnetic field (see Fig. 5.1) means that given classical magnetic field is replaced with a bundle of flux tubes flowing along the field lines of classical magnetic field.

In TGD context magnetic flux tubes are really what they look, that is cylindrical 3-surfaces with *boundary* if one assumes that they do not carry monopole flux which is also possible by the topology of CP_2. Boundary can be present only if one adds to the Kähler action Chern-Simons term as boundary term. The boundary of the flux tube must by Maxwell equations contain rotating em or Z^0 charges creating the magnetic field in the interior (just like an induction coil creates an axial magnetic field inside it). The concept of topological field quantum generalizes also to the case of classical fields generated by wormholes.

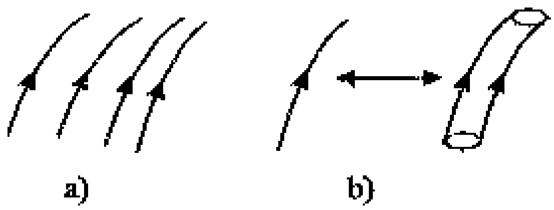

Figure 5.1: Topological field quantization for magnetic field replaces flux lines with flux tubes having outer boundary as 3-surfaces.

In case of wormhole super conductivity "charge carriers" are wormholes. Wormhole looking like charge $+Q$ on the "upper" sheet looks like charge $-Q$ on the "lower"

sheet; when looked from the wider perspective (embedding space), wormhole behaves as a dipole with extremely small dipole strength. The currents associated with wormholes are of opposite sign on the two space-time sheets and magnetic flux tube consists of two fluxes: the flux on the "upper" space-time sheet and return flux on the "lower" space-time sheet (see **Fig. 5.2**). Closed wormhole flux tube can be visualized as two circles above each other and having Planck distance; the circles carry opposite magnetic fluxes. This visualization turns out to be useful later.

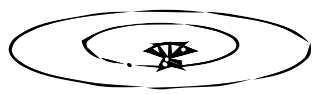

Figure 5.2: Artistic visualization of wormhole

5.3.2 Mind Like Space-Time Sheets

The original formulation of quantum TGD led to the conclusion that there are two kinds of space-time sheets: material space-time sheets and mind-like space-time sheets so that one can say that Matter Mind duality is realized in geometrical sense: of course, Mind is understood in the sense of cognitive representations only. What one means with mind like space sheets is however not at all obvious.

1. The original proposal was that mind like space-time sheets have by definition a finite temporal extension. In zero energy ontology this holds true for all space-time sheets so that all space-time sheets would be mind-like. This could make perfect sense. For instance, the fermionic part of zero energy state can be regarded as a logical rule $A \rightarrow B$ with the instances of A and B represented as positive and negative energy fermion states in Fock basis: the Fock basis for many-fermion states indeed defines a representation of Boolean logic.

2. Mind like space-time sheets could be also interpreted as p-adic space-time sheets responsible for cognition whereas real space-time sheets would be matter like in the sense that they define the space-time correlates of sensory experience. The intersection of p-adic and real worlds is along rational and common algebraic points of the embedding space and is discrete (note that this statement assumes the identification of preferred embedding space coordinates). p-Adic space-time sheets could serve as natural correlates of cognition and intentionality and their interaction with real space-time sheets could give rise to effective p-adic topology crucial for the interpretation of p-adic mass calculations. p-Adic space-time sheets have infinite size in real topology so that cognition and intentionality could not be localized in brain. Only the cognitive representations defined by the intersections of real and p-adic space-time sheets allow this localization.

3. p-Adic space-time sheets can be mapped to real space-time sheets via a generalization of the canonical identification map which is continuous and maps rationals m/n, $m, n < p^k$, $k > 0$.

to rationals. The explicit form of the map is $m/n \rightarrow I_k(m)/I_k(n)$, with $I_k(m)$ defined as

$$x = \sum x_n p^{nk} \rightarrow \sum x_n p^{-nk} \quad .$$

This map could define the effective p-adic topology for real space-time sheets in finite measurement resolution reducing to discretized real topology above distances defined by the p-adic length scale corresponding to p^k. Below the resolution length scale the impossibility to well-order p-adic numbers would correspond to the impossibility to order space-time points by physical measurements. What makes this map attractive is that it commutes with the discrete counterparts of various space-time symmetries in the resolution defined by p^k and is also continuous.

4. In zero energy ontology two scales emerges naturally. The scale of causal diamond comes as an octave of CP_2 scale and corresponds to secondary p-adic length scale. The primary p-adic length scale characterizing elementary particles is essentially square root of this scale. In case of electron the latter scale is of order electron Compton length and the first one equals to.1 seconds defining the fundamental bio-rhythm. This suggests that MEs and magnetic flux tubes corresponding to secondary p-adic scale and having size of order CD size could be interpreted as mind-like space-time sheets. This interpretation will be adopted in the sequel.

5.3.3 Do Mind-Like Space-Time Sheets Perform Simple Mimicry?

Mind-like space-time sheets serve as quantum correlates of selves and are made possible by the classical non-determinism of the Kähler action and their defining property is finite temporal extension. mind-like space-time sheets are absolutely crucial for TGD inspired theory of consciousness since their presence is what makes possible conscious experiences with contents localized in a finite time interval, which characterized by the duration of the mind-like space-time sheet: without mind-like space-time sheets the contents of conscious experiences would not be temporally localized. Topological field quantization suggests the identification of the mind-like space-time sheets as classical counterparts of virtual particles, in particular, virtual photons. This suggests that some (not all) mind-like space-time sheets could be topological correlates of the internal (photon) lines of Feynman diagram and thus have naturally finite time duration.

Rather remarkably, TGD based notion of energy correlates the sign of energy with time orientation and allows mind-like space-time sheets to have also negative energy. Also wormhole-magnetic fields could be analogous to virtual particle pairs with vanishing total energy if the space-time sheets associated with the wormhole magnetic field have opposite time orientation. Mind-like space-time sheets provide cognitive representations and the simplest representation is direct mimicry. Hence one cannot exclude the possibility that wormhole magnetic fields form cognitive representations of the surrounding world in an extremely concrete manner: the magnetic field strength is the same as the field strength of the "real" magnetic field. This could hold true quite generally: pairs of space-time sheets with opposite time orientation could form cognitive representations of the external world such that the field strengths are same as those of the external world.

A concrete manner to achieve this mimicry is to glue mind-like space-time sheet pairs on the boundaries of the material space-time sheets by connecting the material space-time sheet by join along boundaries bond to the mind-like space-time sheet with a positive time orientation. This would mean that universe would be mimicking itself at classical level and in very concrete manner: note that this mimicry would resemble the emulation of Turing machines performed by Turing machines. In particular, the effect of em radiation on living matter at cyclotron frequencies of ions in Earth's magnetic field (or modulated by these frequencies) [J17] could be due to the fact that some ions "drop" (or rather, flow along join along boundaries bonds/flux tubes) to the space-time sheets of wormhole magnetic fields providing cognitive representation for Earth's magnetic field.

An interesting possibility is that cell membranes correspond to Z^0 wormhole magnetic fields glued to the boundaries of the cellular space-time sheets, or rather, are between and glued to the boundaries of cellular and extracellular space-time sheets characterized by same p-adic prime. The model for hearing and cognition is consistent with but does not require this assumption [K16, K18, K40].

This view reflects my thinking for more than decade ago. In particular, the notion of mind-like space-time sheet is based on the observation that determinism in its standard form fails and the idea that one can save determinism by allowing 3-surfaces consisting of union of disjoint space-time sheets with time-like separations. In zero energy ontology providing a more rigorous formulation for the generalized notion of classical determinism causal diamonds (CDs) defined as intersections of future and past directed light-cones play a key role. Space-time sheets connect the two light-like boundaries of CDs carrying opposite net quantum numbers. Mind-like space-time sheets could be identified as to space-time sheets associated with sub-CDs and would be analogous to radiative corrections in quantum field theory picture. One can of course argue that all space-time sheets are mind-like in this framework. For instance, the fermionic oscillator operators at the ends of space-time sheet provide a representation of Boolean algebra and zero energy states could be interpreted as Boolean statements of type A implies B.

One should not confuse mind-like space-time sheets with cognitive space-time sheets identified as p-adic counterparts of space-time sheets and having literally infinite size in real sense and a discrete intersection with real space-time sheets consisting of rational points and points in some algebraic extension of rationals.

5.3.4 Model For Wormhole Flux Tube As A Hollow Cylinder

In the absence of ordinary matter the electric part of gauge field is sourceless in the interior of the flux tube and one must assume the geometry of a *hollow cylinder* for the flux tube to avoid singularities. The wormhole charge densities on the inner and outer boundaries of the cylinder are of opposite sign and sourceless radial electric field is created in the interior of the cylinder. Rotational motion of the wormholes creates axial magnetic fluxes of opposite sign on the two space-time sheets. Clearly, the magnetic flux runs along the cylinder; goes to "lower" space-time sheet via magnetic wormhole, and returns along the "lower" space-time sheet. It is perhaps needless to add that hollow cylindrical structures are very frequent in bio-systems: representative examples are provided by microtubules and axons.

5.3.5 Wormhole Flux Tubes Need Not Be Closed In Ordinary Sense

The wormhole flux tube can apparently have an end unlike ordinary magnetic flux tube. At the end point the magnetic flux from the "upper" sheet flows to the "lower" sheet through *magnetic* wormhole, which looks like a magnetic monopole, when viewed from either sheet of 3-space. From embedding space perspective, one has extremely weak magnetic dipole, with monopoles located at Planck distance. Note that magnetic flux lines are closed as they should be.

The simplest expectation is that also wormhole flux tubes run along the closed field lines of the average classical magnetic field associated with the wormhole flux tube configuration. Wormhole flux tube structures can however form topologically much more complicated structures since one can construct also branched flux tubes by gluing two flux tubes together such that contact point contains magnetic wormhole.

5.3.6 Wormhole Flux Tubes Form A Macroscopic Quantum System

Since wormholes populate the boundaries of the flux tubes and since they form BE condensate, the entire exotic magnetic field configuration can be regarded as a macroscopic quantum system. Thus, according to TGD inspired theory of consciousness, flux tube configurations should be indeed controllable by quantum jumps and quantum mechanical free will becomes possible in the entire region covered by the exotic magnetic field configuration. One might even say, that wormhole condensate makes classical field a potential conscious being. This suggests that wormhole magnetic fields are crucial for the understanding the behavior of bio-systems as systems possessing free will.

The simplest possibility is that only the fluxes of the magnetic fluxes inside flux tubes are controlled by free will. As a consequence, psychokinetic effects on objects, which are wormhole super conductors, are in principle possible via a voluntary control of Meissner force (levitation). As found in [K85], magnetic fluxes associated with flux tubes are in general quantized so that control occurs in discrete steps.

5.3.7 The Interaction Of Coherent Light With Wormhole Flux Tubes

To understand Comorosan effect and phantom DNA effect to be considered in next section, one must construct a model for the interaction of wormholes with laser light. Needless to say, this interaction is fundamental for the TGD based description of bio-systems as macroscopic quantum systems.

1. Wormholes have coupling to the *difference* ΔA of the quantized gauge potentials describing photons (Planck size 3-surfaces) of topologically condensed coherent light on the two space-time sheets of the wormhole flux tube. This is due to the fact that wormhole behaves as a pair of two opposite charges on the two parallel space-time sheets connected by it.

2. The absorption of laser light can induce topology change for a closed wormhole flux tube. It is useful to visualize wormhole flux tubes as two one-dimensional closed circles above each other (within distance of Planck length). Clearly, the circles span in the initial situation *annulus*. The absorption of laser light can induce a pinching process in which the two circles are deformed so that they touch each other momentarily. At the moment of touching the circles are cut and the ends can recombine in two different ways to form a single circle. Either the upper and lower ends of circle on the same side recombine to give single circle which spans *annulus with cut*. Or the upper and lower ends belonging to different sides recombine to form a circle with a twist of π, which spans a *twisted annulus*, known as Möbius strip, which is non-orientable, single-sided surface. The model for Comorosan and phantom DNA effects relies on the process *annulus* $\rightarrow$ *twisted annulus*.

5.3.8 Quantum Antenna Hypothesis And Wormholes

Quantum antenna hypothesis states that microtubules create a coherent state of photons (in particular bio-photons) and possibly also of gravitons. If the proposed model for the interaction between wormholes and coherent light is correct, then the presence of quantum coherent light in bio-system is necessary for the generation of currents in wormhole flux tube structures associated with DNA.

These currents correspond to phase gradients and the integer valued quantum numbers characterizing the phase increments around closed loops have been proposed to provide a coding of biological information and a model of memory [K11]. Although the model was constructed assuming that bio-system is ordinary super conductor, it works also for wormhole super conductor option. Note also, that the previous model fixes also the interaction between coherent photons and wormholes associated with the lipid layers of cell membrane, which is only one example of hollow cylinder like configurations frequent in bio-systems. An interesting possibility is that bio-system uses the twisted and untwisted configurations of closed flux tubes to store binary data.

Combining these ideas with the suggested identification for the quantum correlates of the sensory qualia, a definite picture of bio-system as a macroscopic quantum in which both wormholes and wormhole magnetic fields, coherent light electronic and neutrino Cooper pairs have essential roles, seems to emerge. [To be honest, this is actually quite an old discovery: the basic concepts of Hindu yoga are prana channels (wormhole flux tubes) and light (coherent photons)!].

5.3.9 Phantom DNA Effect, Comorosan Effect, DNA As A Conductor, ORMEs: Four Peculiar Effects With A Common Explanation

The concept of closed wormhole flux tube provides explanation for Comorosan effect and phantom DNA effect as also the conductivity of DNA [D28] described in [K9, K10]. The irradiation of bio-matter using visible laser light with certain preferred frequencies is crucial for *all* these effects. The interpretation is that irradiation transfers electron from one space-time sheet to another one (and creates automatically wormhole) and since the energy of electron is quantized, the preferred frequencies correspond to energy differences of electron on the two space-time sheets associated with the wormhole flux tube. This in turn provides support for the exotic atom concept providing explanation for the properties of ORMEs [H7].

5.4 Comorosan Effect, Phantom DNA Effect And Homeopathy

5.4.1 Comorosan Effect

The first model for Comorosan effect was based on super conductivity and the formation of Josephson junctions between interacting organic molecules assumed to contain closed super conducting current loops. The model reproduced the basic formula of Comorosan effect but *not all* aspects related to the interaction of laser light with organic molecule were understood. Wormhole super conductivity leads to much more precise model for this interaction and wormhole super conductivity is strongly favored over ordinary the super conductivity as an explanation of the effect.

The effect

Comorosan effect [I44, I10] demonstrates rather peculiar looking facts about the interaction of organic molecules with visible laser light at wavelength $\lambda = 546\ nm$. As a result of irradiation molecules seem to undergo a transition $S \rightarrow S^*$. S^* state has anomalously long lifetime and stability in solution. $S \rightarrow S^*$ transition has been detected through the interaction of S^* molecules with different biological macromolecules, like enzymes and cellular receptors.

The typical result in the enzyme-substrate interaction is represented by the enhancement of the enzymic rate, when the respective enzyme substrate is previously irradiated for certain sharply defined times. These *efficient (irradiation) times* are enzyme dependent and can also depend on the biological origin of the enzyme. They are always of the following type $t_i = i * 5$ sec, where i is certain integer. The general formula for the effective times is $t_k = t_m + (k-1)\tau_n$, $k = 1, 2, .., 6$, where t_m is the minimum radiation time inducing the first effect and τ_n is the period between two consecutive effects [I44, I10]. $t_m = m_E t_1$ and $\tau_n = n_E t_1$ are multiples of the basic time scale $t_1 = 5\ sec$: $t_k = (m_E + (k-1)n_E)t_1$. The integers m_E and n_E can be regarded as enzyme characteristics, depending however on the biological origin of the enzyme.

Consider the specific enzymic interaction $E+S \leftrightarrow ES \leftrightarrow E+P$, where E stands for enzyme, S for substrate and P interaction product. Assume that substrate S is subject to a sequence of distinct irradiations lasting for times $t_a, t_b, ...$. The following rules are found to hold true.
1) The irradiations of the substrate performed after an irradiation with efficient time have no effect on the enzyme-substrate interaction.
2) Any arbitrary irradiation of the substrate with irradiation time less than sixth efficient time t_6 performed prior to any other efficient time, is irrelevant for the enzyme-substrate interaction.
3) Any arbitrary irradiation of the substrate lasting more than the sixth efficient time t_6 and performed prior to an efficient time precludes all other subsequent effects in enzyme-substrate interaction.

The work of Comorosan demonstrates that all irradiation times have nontrivial effect on organic molecules but that for effective times something very special must occur. One must understand what this "very special" is, derive Comorosan formula from a physical model and find physical interpretation for the integers m_E and n_E appearing in the formula as well as explain the special role of $t > t_6$ irradiation times.

Model for the interaction of laser light with organic molecule

The model reproduces the basic formula of Comorosan effect but there were also some not so well understood aspects.

1. Effect occurs for *preferred frequencies* only. This can be understood if the process the interaction of laser light with wormhole flux tube involves transfer of electron from one condensate level to another one and thus a change of energy level. The transfer of electron leads to a creation of a wormhole.

2. The *intensity of laser light does not matter*. What is needed is that the intensity is above certain threshold. The original explanation in terms of saturation of effect (for large intensities of laser light the effect of laser light on organic molecules does not depend on the intensity)

has turned to be unsatisfactory. It seems that laser light just initiates some process which itself does not depend on the laser light.

3. The assumption that laser light stimulates the increase of a phase angle increment type variable defined over a loop, which is effectively cut in process, explains the preferred radiation times. What happens is that the phase increment increases linearly with time and for preferred radiation times the increase of phase angle is multiple of 2π so that the loop can close back again. The experience with super conductivity suggests the identification of the phase angle gradient as quantized momentum: the problem is to identify the carrier of this momentum.

An elegant explanation for these aspects of Comorosan effect results if one assumes that wormhole super conductivity is in question and that laser light induces a transformation of a closed wormhole tube spanning an *annulus* to that spanning a *twisted annulus*. Since the characteristic time scale is defined by the frequency of laser light, the process in question occurs very rapidly as compared to the time scale of order 5 seconds of the laser irradiaton. What is important is that the reverse process in which a twisted annulus transforms to an untwisted annulus cannot occur if the wormholes possess momentum k which is not multiple of $2\pi/L$ (by the quantization of momentum propagating in closed loop) and the wave length of laser length is large compared to the size of the loop.

The twisted annulus configuration leads to the acceleration of the wormholes and generation of longitudinal wormholes currents. If the initial, annulus type configuration of the flux tube contains constant wormhole charge density, then for the twisted annulus the charge density is of constant magnitude and of opposite sign on the different sides of each kink since the twist interchanges the "upper" and "lower" space-time sheets. Half of the structure corresponds to positive, and half of the structure to negative wormhole charge density (see **Fig. ??**).

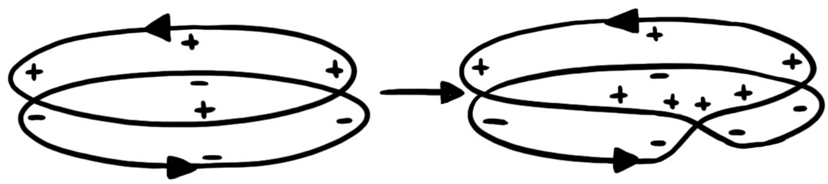

Figure 5.3: The interaction with laser light is assumed to induce the transformation of annulus configuration of wormhole flux tube to twisted annulus and creation of at least one wormhole pair with opposite charges. The members of wormhole pair go to separate kinks and create small longitudinal electric field.

One must assume that both kinks contain *additional wormhole charges of opposite sign* generated from vacuum, when the twisted annulus configuration is created in the interaction with the laser light. The creation of a twisted annulus is necessary in order to get a pair of opposite charges with large distance along the flux tube. These wormhole charges serve as sources of additional electric fields. Most of the electric flux flows in the radial direction of the flux tube but a small fraction $E_L = \epsilon E_{max}$ of the maximal flux $E_{max} = e/2S$, where S is the transverse area of the tube, is assumed to flow along the flux tube surface. E_L has constant magnitude and is of opposite sign on the "upper" and "lower" space-time sheets.

E_L accelerates the wormholes. The acceleration is of opposite sign at the opposite sides of the kinks and leads to the flow of the wormholes to the kink, where they must annihilate topologically. Newton's equation for the wormhole in external field gives wormhole momentum $k(t)$ as a function of time

$$\begin{aligned} \frac{dk}{dt} &= \epsilon 2eE \ , \\ E &= \frac{e}{2S} sign(x) \ . \\ sign(x) &= \left\{ \begin{array}{ll} -1, & x < 0 \\ +1, & x > 0 \end{array} \right. , \end{aligned} \tag{5.4.1}$$

Here $|x|$ measures the distance from the twist. The factor 2 in Coulomb force comes from the identical contributions of the two space-time sheets to the Coulomb force. The momentum of wormhole as function of time can also be obtained from the quantization condition

$$k - 2eA_L = 0 \ , \tag{5.4.2}$$

stating that wormhole order parameter is covariantly constant in the longitudinal direction. Since $A_L = E_L t$ holds true, one obtains same result as from Newton's equation.

Wormhole momentum increases linearly as a function of time since constant force is in question apart from the effect caused by the gradually decreasing density of wormholes caused by wormhole pair annihilation in kinks; this effect is however completely negligible since the time scale is so slow. In an excellent approximation the momentum gained by the wormholes in time t is

$$\begin{aligned} k(t) &= \epsilon \frac{e^2}{S} t = \frac{2\pi}{L} \frac{t}{t_0} \ , \\ t_0 &= \frac{1}{\alpha} \frac{1}{2\epsilon} \frac{S}{L} \ , \\ \alpha &= \frac{e^2}{4\pi} \ . \end{aligned} \tag{5.4.3}$$

Here t_0 is the time during which k achieves a value allowing the transitions back to the untwisted flux tube configuration. In agreement with the experimental data, the time scale t_0 is does not depend on the intensity of irradiation; t_0 should be of the order of 5 seconds. L should be considerably smaller than the wavelength of the visible light in case of Comorosan effect. For $\sqrt{S}$ and L of order 10^{-9} and 10^{-8} meters respectively one obtains the estimate $\epsilon \sim 10^{-16}$ so that the longitudinal fraction of electric gauge flux is extremely small.

For $t = t_n = nt_0$ wormholes have gained momentum $k = n2\pi/L$, for which the return to the ordinary closed untwisted flux tube configuration is possible. Laser light stimulates automatically transitions to the untwisted configuration. If laser light stimulation is not continued after t_n, a certain fraction of molecules is left to the closed untwisted loop state with wormhole momentum $k = n2\pi/L$. It is the presence of these loops carrying wormhole super current, which explains the change in the interactions of with organic molecules if interaction involves the formation of Josephson junctions between interacting molecules. If the stimulation is continued, also the closed untwisted loops suffer a re-transition to the twisted state and the momentum k continues to increase and the effect remains small. If stimulation ceases at such moment of time that k fails badly to satisfy the quantization condition the loops remain in twisted configuration and transitions to untwisted configuration are rare.

The explanation for Comorosan formula

It is assumed that organic molecules are wormhole super conductors containing closed wormhole flux tubes. The explanation as such does not differentiate between ordinary and wormhole super conductors.

If wormhole order parameter is proportional to a spatially non-constant phase factor then the flux tubes of the wormhole magnetic field carry longitudinal wormhole supra currents proportional to the gradient of the phase factor. The increment of the phase factor around any closed loop is $n2\pi$, n integer, and the momentum associated with the wormhole is proportional to n. These supra currents are created with the interaction of the wormhole flux tubes with laser light by a mechanism already considered.

Assume that enzyme contains a loop carrying wormhole supra current characterized by an enzyme specific integer m_E and created by the previously described interaction with the laser light. Assume that the substrate contains a similar loop, characterized by integer n_S. Assume further that in the enzyme-substrate interaction n_E Josephson junctions between the identical loops are formed and that the Josephson junctions are evenly spaced in Φ and there are either $n_E = 2s+1$ or $n_E = 2s$ junctions corresponding to ODDandEVEN receptors defined by Comorosan [I10]. Assume that the directions of the wormhole supra currents are same. The phase difference between the ends of the Josephson junction gives phase factor $exp(i(N_E - N_S)\Phi_n)$ to the current flowing through n: th junction and destructive interference in general occurs for the sum of Josephson currents. If the junctions are identical Josephson current is proportional to quantity U defined as a sum of phase factors

$$\begin{aligned} U &= \sum_{k=0,..,n_E} exp((m_E - n_S)\frac{i2\pi}{n_E}) \\ n_E &= 2s+1 \ (ODD\ receptor) \\ n_E &= 2s \ (EVEN\ receptor) \end{aligned} \tag{5.4.4}$$

All phase factors are trivial and constructive interference occurs, when the condition

$$n_S = m_E + (k-1)n_E ,\ k = 1, 2, ... \tag{5.4.5}$$

is satisfied. This is just the condition for for Comorosan effect to occur. Therefore, if the occurrence of constructive interference leads to enhanced enzymatic effect, that is “reading” of the substrate state in terminology of Comorosan, the model reproduces the experimental results of Comorosan for $k \leq 6$ and gives interpretation for m_E as angular momentum like quantum number associated with super current and n_E as the number of Josepshon junctions.

Note that Comorosan defines UP-type receptors as a receptor which read only ODD states with t_k odd multiple of t_1 [I10]. These correspond to odd value of m_E and even value of n_E. DOWN-type receptors read only DOWN-type states with t_k even multiple of t_1: these correspond to even values of m_E and n_E.UP-DOWN receptors correspond to odd values of m_E and n_E.

The model reproduces the basic experimental regularity observed by Comorosan with single exception. Comorosan has observed no effect for $t_{rad} > t_6$: according to the model the effect should be observed for all odd values of k and depend on $k_1 = k\ mod\ n_E$ only so that k and $k + n_E$ ought to lead to same effect. The problem looks difficult since t_6 is enzyme dependent parameter. The only manner to explain this observation seems to be following. Assume that substrate contains several loops L_i, one loop for each enzyme type E_i studied and that each loop is radiation detector in the sense already described. Assume that E_i-loop ceases to respond to irradiation, when the value of $\Delta\Phi$ exceeds the critical limit corresponding to $n_{cr}(E) = m_E + 5n_E$. One explanation for this behavior is that the supra current exceeds critical value and wormhole super conductivity is lost. The shorter the loop the smaller the critical value of $n_{cr}(E)$ is expected to be.

This model suggest that organic molecules are able to store memories into the integer valued vacuum quantum numbers associated with their supra current loops and that the interaction with coherent light, bio-photons perhaps, provides a mechanism of memory storage. The enzyme-substrate interactions in turn code this information to chemical form.

What is the origin of the 5 second time scale?

The time scale $\tau = 5$ seconds associated with the Comorosan effect has remained a teasing mystery for almost a decade. In particular, p-adic length scale hypothesis does not explain the time scale, and it does not correspond to any obvious time scale associated with magnetic transitions.

Only the model for quantum dark matter [K91] inspired by the fascinating findings that planetary orbits obey Bohr rules analogous to those for hydrogen atom but with a huge value of Planck constant equal to $\hbar_{gr} = GMm\hbar/v$, where v/c is a harmonic or sub-harmonic of $v_0/c = 4.8233 \times 10^{-4}$, led to a progress in the understanding of the time scale τ.

The idea about astro-quantal dark matter as a fundamental bio-controller by its gigantic value of Planck constant, inspires the guess that τ could relate to a quantal dark matter structure topologically condensed around a magnetic flux tube around a planetary Bohr orbit of radius R via the correspondence $\tau = R/c$. As observed by [E2], $n = 1$ orbit for $v_0 \to 3v_0$ corresponds in a good approximation to the solar radius $R_1 = AU/(9 \times 25) = R_S$ and thus to a time scale of 2.18 seconds. Since Earth's orbit corresponds to the principal quantum number $n = 5$, $n = 1$ orbit corresponds for $v_0 \to 2v_0$ to Bohr radius $R_1 = AU/4 \times 25 = (9/4)R_S$ and $\tau = AU/(4 \times 25) = 4.992$ seconds ($c = 1$): here $R = AU$ is the astronomical unit equal to the average distance of Earth from Sun. R corresponds approximately to the radius of solar core. The deviation from τ_C is only one per cent and of the same order of magnitude as the variation of the radius for the orbit due to orbital eccentricity $(a - b)/a = .0167$. [E1].

One could argue that $v_0 \to 2v_0$ is artificial trick unless one can assign it to the analog of $n = 1$ Bohr orbit with radius smaller than solar radius. v_0 would give for the orbit of $n = 1$ radius $R = AU/25$ roughly equal to and $\tau = 20$ s. $\tau = 5$ seconds could be interpreted in terms of 4:th harmonic in this case

An alternative explanation emerged with the discovery of dark matter hierarchy based on the scaled up values of M^4 and CP_2 Planck constants given as $\hbar(M^4) = n_a\hbar_0$ and $\hbar(CP_2) = n_a\hbar_0$, $n_i > 2$ [K81]. Typical quantum times and lengths, say Compton length and time, scale as n_a. The integers n_i have number theoretically preferred values which correspond to n-polygons constructible using only ruler and compass. These integers are given as $n = 2^k \prod_s F_s$, where each Fermat prime F_s can appear only once in the product. F_s has the form $F_s = 2^{2^s} + 1$. The known Fermat primes are $3, 5, 17, 257$, and $2^{16} + 1$. If one scales the fundamental biological time scale $T_2(127 = .1$ s by $n_F = 3 \times 17$ one obtains the time scale $T = 5.1$ s.

5.4.2 Phantom DNA Effect

The phenomenon of phantom DNA [I20, I50] suggests that physical vacuum can have some additional structure with no obvious identification in the standard physics context. What is studied, is the scattering of the laser light on chamber, which is either empty or contains DNA. The autocorrelation function for scattered laser light is measured. This means in practise a linear array of detectors, which measure the number of scattered photons during certain time interval. There are three subsequent stages in the experiment.

1. Scattering chamber is empty. In this case autocorrelation function is random. The numbers of photons detected by various detectors are essentially random.

2. One adds the DNA in the chamber and finds that autocorrelation function is decaying exponential, which oscillates. This is due to the scattering of laser light on DNA.

3. One removes the DNA and instead of random autocorrelation finds that autocorrelation function exhibits exponential decay and oscillations also now! The numbers of photons detected are many orders of magnitude smaller but it is clear that something in the structure of vacuum, call it *phantom DNA*, serves as an effective scatterer of the laser light. For phantom DNA effect to occur it is essential that DNA in chamber is illuminated with laser light before its removal. The effect is long lasting, phantom DNA is detected even after period of months!

Is the mechanism explaining Comorosan effect behind phantom DNA effect?

The mechanism explaining Comorosan effect could explain also phantom DNA effect. Assume that the presence of DNA creates wormhole magnetic field, that is a net of wormhole flux tubes. This configuration is indeed vacuum configuration from the point of view of standard physics since the only "particles" are wormholes on the boundaries of the flux tubes. Laser light transforms closed untwisted flux tubes to twisted ones and accelerates wormholes so that they get net momentum.

When DNA is removed from the chamber, part of the wormhole magnetic field remains in chamber. If the chamber is now irradiated with laser light, the *wormhole supra currents* created in the irradiation of DNA interact with the laser light. Before the irradiation these currents vanish so that there is no effect. More quantitative argument goes as follows. Coupling is just the standard coupling of charged scalar field to the difference of topologically condensed coherent photon fields so that the interaction term is of the general form $\bar{\Psi}\Delta A\nabla\Psi$. In Fourier basis the couplings are of the form $e(k_i + k_f)A(k_i - k_f)$. If A is slowly varying, one has in good approximation $k_i = k_f$ for the allowed transitions, and transition matrix element is proportional to k. Thus the value of momentum k and thus coupling is appreciable *only* if DNA is irradiated before its removal.

The transfer of electron between the space-time sheets must be *crucial* for the process acceleration process. Otherwise, the irradiation of mere wormhole flux tube structure, "phantom DNA", would accelerate the wormholes creating supra currents and would eventually lead to stimulated emission.

Other explanations

With the development of the model for the bio-system as a macroscopic quantum system are also other possible explanations of the phantom DNA effect have emerged.

1. Perhaps the simplest explanation would be that a small fraction of DNA molecules drops to the magnetic flux tubes of Earth's magnetic field and scatters the coherent light.

2. The hypothesis that liquid crystal water blobs can mimic the electromagnetic body of the DNA molecule in the sense that some parts of the electromagnetic spectrum represented by MEs are more or less identical with that of DNA, could explain the phantom DNA effect in terms of the liquid crystal blobs remaining when DNA is removed. The explanation would be same as for the effect of the homeopathic remedies. The explanation requires that LC water blobs are able to mimic the electromagnetic spectrum of DNA at visible frequencies. This is not at all obvious since water is transparent for visible light and thus does not have intense spectral lines in the visible frequency range.

5.4.3 Mind-Like Space-Time Sheets, Mimicry And Homeopathy

Homeopathy resembles phantom DNA effect in the sense that the repeated dilution of some drugs seems to give rise to a concentration of a "phantom drug" affecting the patient in some non-chemical manner. Standard science refuses to take homeopathy seriously. As often is the case with the paranormal phenomena, the refusal is based on very simple argument: standard science does not allow this kind of effect. TGD however framework allows room for homeopathy and homeopathy provides evidence for the notion of mind-like space-time sheet absolutely crucial for TGD based theory of consciousness as also for the general hypothesis that magnetic and Z^0 transition frequencies are quantum correlates of consciousness.

In TGD inspired theory of consciousness mind-like space-time sheets, which by definition have finite time duration, are geometric correlates of selves. TGD inspired theory of consciousness predicts that self hierarchy starts already from the elementary particle level and that the typical duration of self is given by the p-adic time scale $T_p = l \times L_p/c$, $l \simeq 10^4$ Planck lengths. For elementary particle selves the duration of wake-up time is of order Compton time and extremely short in human standards but extremely long when using the average duration of single quantum jump of order l/c as standard: elementary particle performs roughly $\sqrt{p}$ quantum jumps during its wake-up period and the values of p-adic prime are huge (electron has $p = 2^{127} - 1$).

If this scenario is correct, mind-like space-time sheets should accompany all forms of matter. Against this background it would not be too surprising that given drug would be characterized, not only by its chemistry, but also by the mind-like space-time sheets associated with its sub-selves. When the drug is dissolved into water, it can happen that mind-like space-time sheets associated with the drug lose their original owner and become (potential) sub-selves of the solvent. If this really happens, a concentration of mind-like space-time sheets associated with the "drug selves", remains into the solution, even when the drug is diluted to practically zero concentration. Water need not be a mere passive receiver of the mind-like space-time sheets of the drug but can also generate new mind-like space-time sheets mimicking the mind-like space-time sheets of drug. The effect of the drug on living organism involves self-organization and therefore also consciousness at some level. Thus is would not be surprising if "drug selves" were the effective component of some drugs and that the chemistry would only determine what "drug selves" and their effects are.

This is indeed expected, since mind-like space-time sheets provide cognitive representations for the properties of the material space-time sheets associated with the drug.

One can imagine several options for how mind-like space-time sheets represent the relevant properties of drug. If cognitive space-time sheets perform direct mimicry of the material space-time sheets this scenario becomes even more plausible since mind-like space-time sheet and drug space-time sheets would not differ much in their electromagnetic properties. For instance, disease could involve the inability of some sub-selves of the organism to stay awake and self-organize: brisk new drug selves could simply replace these sleepish sub-selves and initiate the self-organization processes again! Note that direct mimicry might be involved also with the phantom DNA effect. The wormhole magnetic fields (or massless extremals) associated with DNA could mimic the classical fields associated with DNA molecule. TGD based concept of space-time allows in principle non-vanishing vacuum currents so that also the smoothed out charge distribution of DNA might be mimicked. If this indeed occurs, the interaction of the coherent light with DNA could resemble to some degree to its interaction with real DNA.

"Direct mimicry" understood as a generation of a copy about classical fields associated with the material space-time sheet (note that the sheet is 4-dimensional!) might be too strong a requirement. A more abstract mimicry is restricted on regeneration of dominating frequencies associated with the classical fields: this could be enough since it is resonance frequencies rather than amplitudes which are crucial for quantum control and coordination. The effects of ELF modulated em fields on living matter [J17] suggest that also amplitude modulation could be involved with the formation of the cognitive representations. mind-like space-time sheets associated with water could simply mimic the drug in frequency domain by reproducing the frequencies generated by the drug molecules or corresponding mind-like space-time sheets. That this might be the case is supported by the following arguments.

1. There are well documented effects related to the ability of water to absorb and transmit frequencies [J28] . The ability of water to absorb and transmit frequencies could rely on the generation of mind-like space-time sheets oscillating with the same frequency as stimulus. Water would form cognitive representation for the stimulus, mimic it.

2. The hypothesis that magnetic and Z^0 magnetic transitions frequencies are basic correlates of consciousness [K16] suggests that the effects of at least some drugs are quantum control effects and basically frequency mediated and that chemical effects are only secondary. If the effect of a drug indeed relies on its ability to generate an oscillation (say ELF em field) with some frequency and if this oscillation is generated by mind-like space-time sheets associated with water, then the mechanism of homeopathy could be understood.

Rather interestingly, subject persons allergic to a particular substance exposed to the substance and frequency at the same time develop after a short association period an allergic response to the frequency alone [J28]. A patient who has developed allergic response to certain frequency has also allergic response to water treated by the same frequency. Thus the water in human body together with central nervous system seems to have cognitive abilities, in particular ability to form associations. This suggests the possibility of associative medicine: the effect of drug is conditioned with frequency: in this manner the undesired side effects of the chemical drug could be circumvented.

5.4.4 Clustering of RNA polymerase molecules and Comorosan effect

Once again I had good luck: I received a link (see `http://tinyurl.com/y7bego83`) to a highly interesting popular article telling about the work by Ibrahim Cisse at MIT and his colleagues [I17] (see `http://tinyurl.com/y9wzt5yl`) about the clustering of RNA polymerase proteins in the transcription of RNA. Similar clustering has been observed already earlier and interpreted as a phase separation giving rise to protein droplets [L25]. Now this interpretation is not proposed by experiments but they say that it is quite possible but they cannot prove it.

I have already earlier discussed the coalescence of proteins into droplets as this kind of process in TGD framework [K75] [L25]. The basic TGD based ideas is that proteins - and biomolecules in general - are connected by flux tubes characterized by the value of Planck constant $h_{eff} = n \times h_0$ for the dark particles at the flux tube. The higher the value of n is the larger the energy of given state. For instance, the binding energies of atoms decrease like $1/n^2$. Therefore the formation of the molecular cluster liberates energy usable as metabolic energy.

Remark: h_0 is the minimal value of h_{eff}. The best guess is that ordinary Planck constant equals to $h = 6h_0$ [L13, L21] (see `http://tinyurl.com/goruuzm` and `http://tinyurl.com/y9jxyjns`.

TGD view about the findings

Gene control switches - such as RNA II polymerases in DNA transcription to RNA - are found to form clusters called super-enhancers. Also so called Mediator proteins form clusters. In both cases the number of members is in the range 200-400. The clusters are stable but individual molecules spend very brief time in them. Clusters have average lifetime of $5.1 \pm .4$ seconds.

Why the clustering should take place? Why large number of these proteins are present although single one would be enough in the standard picture. In TGD framework one can imagine several explanations. One can imagine at least following reasons.

1. If the initiation of transcription is quantum process involving state function reduction, clustering could allow to make this process process deterministic at the level of single gene in spite of the non-determinism of state function reduction. Suppose that the initiation of transcription is one particular outcome of state function reduction. If there is only single RNA II polymerase able to make only single trial, the changes to initiate the transcription are low. This could be the case if the protein provides metabolic energy to initiate the process and becomes too "tired" to try again immediately. In nerve pulse transmission there is analogous situation: after the passing of the nerve pulse generation the neuron has dead time period. As a matter of fact, it turns out that the analogy could be much deeper.

   How to achieve the initiation with certainty in this kind of situation? Suppose that the other outcomes do not affect the situation appreciably. If one particular RNA polymerase fails to initiate it, the others can try. If the number of RNA transcriptase molecule is large enough, the transcription is bound to begin eventually! This is much like in fairy tales about princess and suitors trying to kill the dragon to get the hand of princess. Eventually comes the penniless swineherd.

2. If the initiation of transcription requires large amount of metabolic energy then only some minimal number of N of RNA II polymerase molecules might be able to provide it collectively. The collective formed by N molecules could correspond to a formation of magnetic body (MB) with a large value of $h_{eff} = n \times h_0$ and controlling the molecules and inducing its coherent behavior. The molecules would be connected by magnetic flux tubes.

3. If the rate for occurrence is determined by an amplitude which is superposition of amplitudes assignable to individual proteins the rate is proportional to N^2, N the number of RNA II polymerase molecules. The process for the cluster is reported to be surprisingly fast as compared to the expectations - something like 20 seconds. The earlier studies have suggests that single RNA polymerase stays at the DNA for minutes to hours.

   Clustering could allow to speed up bio-catalysis besides the mechanism allowing to find molecules to find by a reduction of $h_{eff}/h = n$ for the bonds connecting the reactants and the associated liberation of metabolic energy allowing to kick the reactants over the potential wall hindering the reaction.

Concerning the process of clustering there are two alternative options both relying on the model of liquid phase explaining Maxwell's rule assuming the presence of flux tube bonds in liquid and of water explaining its numerous anomalies in terms of flux tubes which can be also dark (see `http://tinyurl.com/ydhknc2c`).

1. **Option I**: Molecules could form in the initial situation a phase analogous to vapour phase and there would be very few flux tube bonds between them. The phase transition would create liquid phase as flux tube loops assignable to molecules would reconnect form flux tube pairs connecting the molecules to a tensor network giving rise to quantum liquid phase. The larger then value of n, the longer the bonds between molecules would be. This kind of

model [?] (see `http://tinyurl.com/yassnhzb`) is used to explain the strange findings that a system consisting of plastic balls seems to show primitive features of life such as metabolism.

2. **Option II**: The molecules are in the initial state connected by flux tubes and form a kind of liquid phase and the clustering reduces the value of $h_{eff}/h = n$ and therefore the lengths of flux tubes. This would liberate dark energy as metabolic energy going to the initiation of the transcription. One could indeed argue that connectedness in the initial state with large enough value of n is necessary since the protein cluster must have high enough "IQ" to perform intelligent intentional actions.

Protein blobs are said to be drawn together by the "floppy" bits (pieces) of intrinsically disordered proteins. What could this mean in the proposed picture? Disorder would mean absence of correlations between building bricks of floppy parts of the proteins in translational degrees of freedom.

1. Could floppiness correspond to low string tension assignable to long flux loops with large n assignable to the building bricks of "floppy" pieces of protein? Could reconnection for these loops give rise to pairs of flux tubes connecting the proteins in the transition to liquid phase (Option I)? Floppiness would also make possible to scan the environment by flux loops to get in touch with the flux loops of other molecules and in the case of hit (cyclotron resonance) induce reconnection.

2. In spite of floppiness in this sense, one could have quantum correlations between the internal quantum numbers of the building bricks of the floppy pieces. This would also increase the value of n serving as molecular IQ and provide molecule with higher metabolic energy liberated in the catalysis.

About Comorosan effect and clustering of RNA II polymerase proteins

What about the interpretation of the time scales τ equal 5, 10, and 20 seconds appearing in the clustering of RNA II polymerase proteins and Mediator proteins? What is intriguing that so called Comorosan effect [I45, I10] involves time scale of 5 seconds and its multiples claimed by Comorosan long time ago to be universal time scales in biology. The origin of these time scales has remained more or less a mystery although I have considered several TGD inspired explanations for this time scale is based on the notion of gravitational Planck constant [K55] (see `http://tinyurl.com/yb8fw3kq`).

One can consider several starting point ideas, which need not be mutually exclusive.

1. The time scales τ associated with RNA II polymerase and perhaps more general bio-catalytic systems as Comorosan's claims suggest could correspond to the durations of processes ending with "big" state function reduction. In zero energy ontology (ZEO) there are two kinds of state function reductions [L19]. "Small" state function reductions - analogs of weak measurements - leave the passive boundary of causal diamond (CD) unaffected and thus give rise to self as generalized Zeno effect. The states at the active boundary change by a sequence of unitary time evolutions followed by measurements inducing also time localization of the active boundary of CD but not affecting passive boundary. The size of CD increases and gives rise to flow of time defined as the temporal distance between the tips of CD. Large reductions change the roles of the passive and active boundaries and mean death of self. The process with duration of τ could correspond to a life-time of self assignable to CD.

   Remark: It is not quite clear whether CD can disappear and generated from vacuum. In principle this is possible and the generation of mental images as sub-selves and sub-CDs could correspond to this kind of process.

2. In [K55] I proposed that Josephson junctions are formed between reacting molecules in bio-catalysis. These could correspond to the shortened flux tubes. The difference $E_J = ZeV$ of Coulomb energy of Cooper pair over flux tube defining Josephson junction between molecules would correspond to Josephson frequency $f_J = 2eV/h_{eff}$. If this frequency corresponds to $\tau_J = 5$ seconds, h_{eff} should be rather large since E_J is expected to be above thermal energy at physiological temperature.

Could Josephson radiation serve as a kind of of synchronizing clock for the state function reductions so that its role would be analogous to that of EEG in case of brain? A more plausible option is that Josephson radiation is a reaction to the presence of cyclotron radiation generated at MB and performing control actions at the biological body (BB) defined in very general sense. In the case of brain dark cyclotron radiation would generate EEG rhythms responsible for control via genome and dark generalized Josephson radiation modulated by nerve pulse patterns would mediate sensory input to the MB at EEG frequencies.

A good guess motivated by the proposed universality of the Comorosan periods is that the energy in question does not depend on the catalytic system and corresponds to Josephson energy for protein through cell membrane acting as Josephson junction and giving to ionic channel or pump. The flux tubes themselves have universal properties.

3. The hypothesis $\hbar_{eff} = \hbar_{gr} = GMm/\beta_0 c$ of Nottale [E2] for the value of gravitational Planck constant [K91, K87, K88, K75] gives large $\hbar$. Here $v_0 = \beta_0 c$ has dimensions of velocity. For dark cyclotron photons this gives large energy $E_c \propto \hbar_{gr}$ and for dark Josephson photons small frequency $f_J \propto 1/h_{gr}$. Josephson time scale τ_f would be proportional to the mass m of the charged particle and therefore to mass number A of ion involved: $f_J \propto A$ possibly explaining the appearance of multiples of 5 second time scale. Cyclotron time scale does not depend on the mass of the charged particle at all and now sub-harmonics of τ_c are natural.

The time scales assignable to CD or the lifetime-time of self in question could correspond to either cyclotron of Josephson time scale τ.

1. If one requires that the multiplies of the time scale 5 seconds are possible, Josephson radiation is favoured since the Josephson time scale proportional to $h_{gr} \propto m \propto A$, A mass number of ion.

   The problem is that the values $A = 2, 3, 4, 5$ are not plausible for ordinary nuclei in living matter. Dark nuclei at magnetic flux tubes consisting of dark proton sequences could however have arbitrary number of dark protons and if dark nuclei appear at flux tubes defining Josephson junctions, one would have the desired hierarchy.

2. Although cyclotron frequencies do not have sub-harmonics naturally, MB could adapt to the situation by changing the thickness of its flux tubes and by flux conservation the magnetic field strength to which f_c is proportional to. This would allow MB to produce cyclotron radiation with the same frequency as Josephson radiation and MB and BB would be in resonant coupling.

Consider now the model quantitatively.

1. For $\hbar_{eff} = \hbar_{gr}$ one has

$$r = \frac{\hbar_{gr}}{\hbar} = \frac{GM_D m}{c\beta_0} = 4.5 \times 10^{14} \times \frac{m}{m_p}\frac{y}{\beta_0} \quad .$$

   Here $y = M_D/M_E$ gives the ratio of dark mass M_D to the Earth mass M_E. One can consider 2 favoured values for m corresponding to proton mass m_p and electron mass m_e.

2. $E = h_{eff} f$ gives the concrete relationship $f = (E/eV) \times 2.4 \times 10^{14} \times (h/h_{eff})$ Hz between frequencies and energies. This gives

$$x = \frac{E}{eV} = 0.4 \times r \times \frac{f}{10^{14} Hz} \quad .$$

3. If the cyclotron frequency $f_c = 300$ Hz of proton for $B_{end} = .2$ Gauss corresponds to bio-photon energy of x eV, one obtains the condition

$$r = \frac{GM_D m_p}{\hbar\beta_0} \simeq .83 \times 10^{12} x \quad .$$

Note that the cyclotron energy does not depend on the mass of the charged particle. One obtains for the relation between Josephson energy and Josephson frequency the condition

$$x = \frac{E_J}{eV} = 0.4 \times .83 \times 10^{-2} \times \frac{m}{m_p} \times x\frac{f_J}{Hz} \ \ , \ \ E_J = ZeV \ \ .$$

One should not confuse eV in ZeV with unit of energy. Note also that the value of Josephson energy does not depend on h_{eff} so that there is no actual mass dependence involved.

For proton one would give a hierarchy of time scales as A-multiples of $\tau(p)$ and is therefore more natural so that it is natural to consider this case first.

1. For $f_J = .2$ Hz corresponding to the Comorosan time scale of $\tau = 5$ seconds this would give $ZeV = .66x$ meV. This is above thermal energy $E_{th} = T = 27.5$ meV at $T = 25$ Celsius for $x > 42$. For *ordinary* photon ($h_{eff} = h$) proton cyclotron frequency $f_c(p)$ would correspond for $x > 42$ to EUV energy $E > 42$ eV and to wavelength of $\lambda < 31$ nm.

   The energy scale of Josephson junctions formed by proteins through cell membrane of thickness $L(151) = 10$ nm is slightly above thermal energy, which suggests $x \simeq 120$ allowing to identify $L(151) = 10$ nm as the length scale of the flux tube portion connecting the reactants. This would give $E \simeq 120$ eV - the upper bound of EUV range. For $x = 120$ one would have $GM_Em_py/v_0 \simeq 10^{14}$ requiring $\beta_0/y \simeq 2.2$. The earlier estimates [K75] for the mass M_D give $y \sim 2 \times 10^{-4}$ giving $\beta_0 \sim 4.4 \times 10^{-4}$. This is rather near to $\beta_0 = 2^{-11} \sim m_e/m_p$ obtained also in the model for the orbits of the 4 inner planets as Bohr orbits.

   For ion with mass number A this would predict $\tau_A = A \times \tau_p = A \times 5$ seconds so that also multiples of the 5 second time scale would appear. These multiples were indeed found by Comoran and appear also in the case of RNA II polymerase.

2. For proton one would thus have 2 biological extremes - EUV energy scale associated with cyclotron radiation and thermal energy scale assignable to Josephson radiation. Both would be assignable to dark photons with $h_{eff} = h_{gr}$ with very long wavelength. Dark and ordinary photons of both kind would be able to transform to each other meaning a coupling between very long lengths scales assignable to MB and short wavelengths/time scales assignable to BB.

   The energy scale of dark Josephson photons would be that assignable with Josephson junctions of length 10 nm with long wavelengths and energies slightly above E_{th} at physiological temperature. The EUV energy scale would be 120 eV for dark cyclotron photons of highest energy would be fixed by flux tube length of 10 nm.

   For lower cyclotron energies forced by the presence of bio-photons in the range containing visible [K61, K71] and UV and obtained for B_{end} below .2 Gauss, the Josephson photons would have energies below E_{th}. That the possible values of B_{end} are below the nominal value $B_{end} = .2$ Gauss deduced from the experiments of Blackman [J16] does not conform with the earlier ad hoc assumption that B_{end} represents lower bound. This does not change the earlier conclusions.

   Could the 120 eV energy scale have some physical meaning in TGD framework? The corresponding wavelength for ordinary photons corresponds to the scale $L(151) = 10$ nm which correspond to the thickness of DNA double strand. Dark DNA having dark proton triplets as codons could correspond to either $k = 149$ or $k = 151$. The energetics of Pollack effect suggests that $k = 149$ is realized in water even during prebiotic period [L20] (see `http://tinyurl.com/yalny39x`). In the effect discovered by Blackman the ELF photons would transform dark cyclotron photons having $h_{eff} = h_{gr}$ and energy about .12 keV. They would induce cyclotron transitions at flux tubes of B_{end} with thickness of order cell size scale. These states would decay back to previous states and the dark photons transformed to ordinary photons absorbed by ordinary DNA with coil structure with thickness of 10 nm. Kind of standing waves would be formed. These waves could transform to acoustic waves and induce the observed effects. Quite generally, dark cyclotron photons would control the dynamics of ordinary DNA by this mechanism.

It is natural to assume that $B_{end} = .2$ Gauss corresponds to the upper bound for B_{end} since magnetic fields are expected to weaken farther from the Earth's surface: weakening could correspond to thickening of flux tubes reducing the field intensity by flux conservation. The model for hearing [K40] requires cyclotron frequencies considerably above proton's cyclotron frequency in $B_{end} = .2$ Gauss. This requires that audible frequencies are mapped to electron's cyclotron frequency having upper bound $f_c(e) = (m_p/m_e)f_c(p) \simeq 6\times 10^5$ Hz. This frequency is indeed above the range of audible frequencies even for bats.

For electron one has $h_{gr}(e) = (m_e/mp)\times h_{gr}(p) \simeq 5.3\times 10^{-4} h_{gr}(p)$, $\hbar_{gr}(p)/\hbar = 4.5\times 10^{14}/\beta_0$. Since Josephson energy remains invariant, the Josephson time scales up from $\tau(p) = 5$ seconds to $\tau(e) = (m_e/m_p)\tau(p) \simeq 2.5$ milliseconds, which is the time scale assignable to nerve pulses [K41, K15].

To sum up, the model suggests that the idealization of flux tubes as kind of universal Josephson junctions. The model is consistent with bio-photon hypothesis. The constraints on $h_{gr} = GM_D m/v_0$ are consistent with the earlier views and allows to assign Comorosan time scale 5 seconds to proton and nerve pulse time scale to electron as Josephson time scales. This inspires the question whether the dynamics of bio-catalysis and nerve pulse generation be seen as scaled variants of each other at quantum level? This would not be surprising if MB controls the dynamics. The earlier assumption that $B_{end} = 0.2$ Gauss is minimal value for B_{end} must be replaced with the assumption that it is maximal value of B_{end}.

5.5 Subcellular Control And Wormhole Flux Tubes

5.5.1 Intracellular Bio-Control And Memory

Wormhole magnetic fields could provide a tool of quantum bio-control below cell length scales. For instance, cell nucleus could control from distance the motion of cell organelles using magnetic and Z^0 magnetic fields generated by wormholes. In [K11] it is suggested that the winding numbers associated with closed wormhole flux tubes, which actually correspond to quantized momenta for wormhole supra currents, might provide a memory, which is very stable against perturbations. It must be however emphasized that the TGD based model of long term memory does not require any memory storage since memories are essentially re-experienced episodes of geometric past. Wormhole supra currents, and the entire zoo of various supra-currents predicted by quantum TGD, might however form cognitive representations and an important brain function would be the construction of this kind of representations as caricatures of the conscious experience.

5.5.2 Coding Of Genetic Information To Topologically Quantized Fields?

The mechanisms behind ontogeny leading from single cell do an adult individual are poorly known. The wormhole flux tubes represent spatial extension of bio-system to a larger quantum system via magnetic fields so that long distance control via topologically quantized magnetic field becomes possible. As suggested in [K9, K10], either the flux tubes of ordinary or wormhole magnetic field could serve as templates of bio-structures: more specifically, wormhole flux tubes could provide topological representation for defects of various bio-super conductors.

Various bio-structures are expected to be surrounded by a characteristic flux tube network extending over a spatial region considerably larger than structure itself and bio-structure could control the fluxes inside the individual flux tubes. The field configuration would somehow control the ontogeny. By the previous considerations also the coherent photons created by microtubules and possibly other linear structures, could control the state of magnetic flux tubes. Note that also ordinary super conductivity with topologically quantized wormhole flux tubes representing defects might be involved. In this case the wormhole magnetic field cancels the penetrating field in the larger space-time sheet and recreates it in the smaller space-time sheet.

One can wonder how the genetic information is coded into extended spatial structures and to what extend wormholes flux tubes and various related structures represent something genuinely new. The p-adic hierarchy of space-time sheets certainly breaks naïve reductionistic philosophy so that the dynamics wormhole flux tubes and related structures is probably not completely determined by the genetic code. The idea about the flux tubes of magnetic field as templates for bio-structures does not support (or at least, does not require it) the idea about the coding of the magnetic structure to DNA and flux tube structure could be a result of self-organization process and topological field quantization. For instance, in case of DNA the structure of the topologically quantized wormhole magnetic field surrounding DNA (with quantized magnetic flux) can depend only on the general properties of the DNA sequence since only few topological quantum numbers are involved and it indeed seems that these quantum numbers are determined by the dynamics at larger length scales in accordance with Slaving Principle. On the other hand, the structure of the wormhole magnetic fields in length scales shorter than DNA could be determined completely by the structure of DNA sequence.

5.5.3 Are Magnetic And Wormhole Magnetic Fields Involved With The Control Of Gene Expression?

The development of organism is a complicated self-organization process during which gene expression is controlled by the feedback from long length scales. The mechanism of this “biofeedback” is poorly understood. It is not even known whether it is really chemical. In fact, it is known that besides the chemical transcription factors (proteins) controlling gene expression, there are non-chemical transcription factors called silencers and enhancers, whose action mechanism is not known [K25] , [I7]. Magnetic and wormhole magnetic fields could indeed be involved with the control of gene expression performed by growing organism using Josephson currents.

1. As suggested in [K36, K35], magnetic and perhaps also wormhole magnetic fields could be involved with the gene expression via Josephson currents and make possible biological alarm clocks “waking-up” gene self and initiating gene expression. Complicated circuits, involving pattern recognizers, comparison circuits and novelty detectors could serve as building bricks of logical circuits conditioning the gene expression to begin only when certain conditions are satisfied.

2. The realization of the alarm clock would be following. Ions and electrons form in the magnetic fields or wormhole magnetic fields bound states characterized by cyclotron frequencies. When the potential difference between the space-time sheets representing two weakly couple super conductors connected by the join boundaries bonds representing Josephson junctions equals to a magnetic transition frequency of a charge carrier in either superconductor, quantum jumps occur and “wakes-up” the “clock self” and initiate thus self-organization process.

3. One can imagine that the genetic alarm clock is formed by Josephson junction formed by one of the many space-time sheets associated with the many-sheeted DNA and the space-time sheet of the growing organ [K25]. The size of the space-time sheet correlates with the vacuum frequency ω_1 of the space-time sheet (there are two frequency type vacuum quantum numbers denoted by ω_1 and ω_2 [L1] and a natural assumption is that the difference of the frequencies ω_1 associated with the gene space-time sheet and organ’s space-time sheet corresponds to the electromagnetic potential difference over Josephson junction: $\Delta\omega_1 = ZeV$. When this difference equals to the energy difference for the states localized in either super conductor, the superconductor “wake up”. Thus a precise timing for the wake-up results and the initiation of the gene expression correlates in a precise manner with the size of the organ. This is something highly nontrivial: chemical transcription factors are concentrations and it is very difficult to imagine how concentrations, which carry purely local information, could code precise information about the size of the organ and even use it to control purposes.

4. If the states are cyclotron states confined in (wormhole) magnetic fields, the energy difference is in general case difference for multiples of the corresponding cyclotron frequencies. This flow of charge would eventually lead to the “wake-up” of the gene and initiate the self-organization process leading to gene expression.

5.5.4 Wormhole Flux Tubes As Templates Of Bio-Structures

One aspect of control of ontogeny is that part of a flux tube structure could serve as a template in the sense that bio-matter gathers around flux tubes during ontogeny. According the considerations of [K9, K10], magnetic or wormhole magnetic fields could provide general representation for the defects of super conductors. Microtubules, axons and very many other basic bio-structures are indeed *hollow* cylinders identifiable as defects of super conductors of type II (electronic super conductors). It is also known that macroscopic cylindrical bio-structures such as legs are characterized by winding numbers (for rather peculiar consequences, see [A5]): this suggests that wormhole condensates associated with the boundaries of bio-sub-structures of all sizes play important role in bio-control. The stripe like structures (cell membranes, epithelial sheets, larger bi-layered structures of brain) could in turn correspond to defects of super conductors of type I (neutrino super conductors).

Ordinary atom could topologically condense on the interior of the flux tubes and topological condensation could become stable if one or more valence electrons is dropped on the "lower" space-time sheet of the flux tube. The resulting atom would be "exotic atom" with chemical properties those of atom having Z smaller by one unit (electronic alchemy!). As a matter of fact, the potential importance of the wormhole concept became clear from the attempt to explain the peculiar properties of so called ORMEs [H7] in terms of the concept of exotic atom [K9, K10].

The formation of exotic atoms might have been the basic step from the ordinary chemical evolution to bio-evolution. The process would be amplified by the presence of wormholes on the magnetic flux tube just like the formation of BE condensate is catalyzed by the presence of already existing seed of BE condensate (condensation probability is proportional to N^2, where N is the number of bosons in ground state). The possibility that Na, K, Ca ions in cell could be really exotic atoms with s wave valence electron(s) dropped on the lower space-time sheet, is not excluded.

5.6 TGD Inspired Models For Psychokinesis

The reality of psychokinesis (PK) as of also other psi phenomena is subject of a continuous debate and it seems that opinions are not always based on rational arguments. I am personally neither believer nor non-believer of psi phenomena but regard it as important (and also entertaining) to try to find rational testable models for psi rather than ridiculing or mystifying it. Indeed, in the following a TGD inspired model of psychokinesis is considered.

The basic philosophy of the model is following. PK is not just some isolated exotic phenomenon but only a special case of the voluntary control of bodily motions, which we all routinely perform. The only difference is that the range of voluntary control extends over the boundaries of the body in case of PK. This leads to an important conclusion: PK phenomena must involve classical long range fields, which give for bio-systems spatial extension larger than what is visible (that is hands with which to grasp on external object!). According to TGD inspired theory of consciousness, cell and even DNA can be conscious and perform choices. Thus the model should also provide understanding about small scale bio-control such as the (voluntary!) control of the motion of cell organelles performed by cell nucleus. A related problem is how genetic code is transformed into spatial structures during ontogeny, and the idea that each DNA sequence corresponds to a characteristic classical field configuration, is attractive. Thus the model in question is not meant to be an ad hoc solution of a particular problem called PK but a general solution of several basic problems in biology.

5.6.1 Wormhole Magnetic Fields And Psychokinesis

The model for psychokinesis is fixed to rather high degree by the following arguments.

PK as a special case of voluntary action

Our subjective experience tells that our bodily motions are controlled by our free will. Only the fact, that we are so familiar with this PK in the scale of our own body, makes us believe that nothing peculiar is involved. This suggests that PK-able persons differ from ordinary people in that they can perform PK also in length scales larger than their own body. PK is probably possible and probably occurs also below cell length scales, say in the control of motions of cellular organelles by nucleus. Also DNA and microtubules could perform PK. The only logical conclusion is that PK, as well as voluntary control of motion, involves long range classical fields effectively giving for PK-able system hands with which to grasp on the external object.

Quantum entanglement and PK

Quantum entanglement plays basic role in TGD inspired theory of consciousness and this is especially so for TGD inspired model of psi phenomena such as telepathy [K42]. Therefore it is assumed that PK mechanism involves quantum entanglement of some part of brain B with some part S of body such that S has ability to generate some classical field, which affects the material object. The field depends sensitively on quantum state of S so that the control becomes possible via B-S entanglement and quantum jumps reducing the entanglement. The most promising classical fields are magnetic fields (ordinary or Z^0-).

p-Adic considerations might exclude the possibility of PK in many cases. Suppose that, as strongly suggested by QFT limit of TGD, the space-time sheets indeed have effective p-adic topology characterized by p-adic prime. The tensor product for p-adic state spaces with different p-adic primes p_1 and p_2 gives rise to R_p valued state space, where p is the p-adic prime associated with the entire system. There are some reasons to believe that $p_1 \neq p_2$ quantum entanglement is rare phenomenon: if true this implies the decomposition of the space-time into separate space-time sheets labelled by primes and behaving more or less classically with respect to each other: this is certainly in accordance with the everyday intuition. An immediate consequence is that subsystems of brain can get quantum entangled mostly with subsystems having same p. Furthermore, the space-time sheet for the object of PK should be such that magnetic field created by PK is on the space-time sheet at which it the object has suffered topological condensation.

Bio-systems and classical Z^0 fields

Bio-matter must be in special position as far as PK is considered and thus cell length scale should be somehow in special role in the possible explanation of PK. Indeed, TGD predicts that the prime $p \simeq 2^{169}$ corresponds to the primary condensation level of neutrinos (on basis of data from latest neutrino mass experiments [K26]. The corresponding p-adic length scale corresponds to cell size. This p-adic condensation level is also the p-adic condensation level at which nuclei must feed their Z^0 charges, where they in turn are screened by neutrinos (this requirement is necessitated by the stability of condensed matter against *classical* long range Z^0 force). In this manner one also avoids the large parity breaking effects caused by classical Z^0 fields, if present in atomic length scales.

Thus *neutrinos* and *classical* Z^0 force correspond to the new TGD-based physics emerging at cell length scale. TGD neutrinos are predicted to be super-conducting and classical Z^0 magnetic fields break the super conductivity: an attractive possibility is that cell membranes and endoplasma membranes correspond to the defects in the resulting superconductor of type I. The explanation of chirality selection [K80] in terms of Z^0 magnetic fields and neutrinos and of tritium beta decay anomaly [K94] provide strong support for this picture. The additional important piece of new physics important for bio-systems is related to *wormhole contacts*. For instance, wormhole contacts are created when electrons of ordinary atom drops from atomic space-time sheet to a larger space-time sheet parallel to it. This process leads to so called exotic atom [K9, K10] explaining the peculiar properties of so called ORMEs [H7]. In fact, the dropping of electron on larger space-time sheet might have been a (perhaps even the!) crucial step in transforming chemical evolution to bio-evolution. Also the penetration of classical electric and magnetic fields from a space-time sheet to another one requires the presence of charged wormholes and classical em fields are known to be very important in bio-systems.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

Magnetic levitation as a basic mechanism of PK

The simplest possibility is PK effect is based on magnetic levitation. Both classical magnetic and Z^0 magnetic fields can give rise to the effect. This requires that all objects which can be moved by PK, must be diamagnetic and repel from their interior external magnetic fields by generating currents on their boundaries. If they behave like superconductors (in some sense) this is indeed the case.

Wormholes feed the gauge flux from a smaller p-adic space time sheet to a larger one and the throats of the wormhole look like classical charges of opposite sign coupling to the difference of classical fields associated with the two space-time sheets. When looked from embedding space context, they can be regarded as extremely weak dipoles and their coupling to vapor phase photons is extremely weak, which explains why they have not been observed via radiation. Wormhole Bose-Einstein condensates are a purely TGD-based phenomenon. Z^0 wormholes have classical $Z0$ interaction with atomic nuclei screened by neutrinos and this in turn couples them to phonons and electromagnetic interactions indirectly. If Z^0 are in thermal equilibrium with ordinary matter then wormhole Bose-Einstein condensates are possible in the length scales below $L = 1/T$ (T is temperature, in room temperature L is about $10^{-5} - 10^{-4}$ meters).

Wormhole BE-condensate behaves in many respects like super conductor. Thus wormhole superconductivity is a possible candidate for a mechanism behind PK. What is required is that the density of wormholes on the boundary of the object is high enough so that surface currents can cancel external magnetic field and magnetic levitation becomes possible. Charged wormholes provide also a mechanism of electronic bio-super conductivity and also this might be involved in PK as it possibly appears in bio-control.

Topological field quantization could make possible precise quantum control of magnetic fields

Bio-system must has an ability to create and control in precise manner magnetic fields. The only manner to achieve this is to construct magnetic field from magnetic flux tubes with *quantized magnetic fluxes*. Actually, the decomposition into flux tubes with quantized magnetic fluxes occurs *automatically* for any magnetic field in TGD [K85]. This is due to the induced gauge field concept: the embedding of classical gauge field as induced gauge field in general fails outside some region and 3-surface with boundary is generated (in [K85] these regions were christened as topological field quanta). Since wormholes form a Bose-Einstein condensate on the boundaries of flux tubes, topological field quantization actually makes the classical magnetic field quantum object and potential conscious being if TGD inspired theory of consciousness is correct! Control of the magnetic field occurs via the control of the order parameter describing the state of the wormhole condensate.

PK mechanism could be at work below cell length scale for ordinary magnetic fields and it is tempting to speculate that this kind of PK is one of the basic mechanisms of intracellular control. For instance, cell nucleus could control from distance the motion of cell organelles using magnetic and Z^0 magnetic fields generated by wormholes. Also microtubules and perhaps even DNA could apply PK mechanism for control purposes. In longer length scales, much above the cell length scale, Z^0 type wormhole magnetic fields might be important.

Order of magnitude estimates

One can imagine several mechanisms for the penetration of the magnetic and wormhole magnetic fields. If the size of the object is small as compared to the thickness of the flux tube, the wormhole magnetic field at either sheet can penetrate (or try to penetrate in present case!) to the space-time sheet of an object topologically condensed at the space-time sheet of the flux tube. When the size of the object is larger than the thickness of the magnetic flux tube, situation is more complicated: a similar microscopic mechanism could however be at work also in this case since the object contains hierarchy of smaller space-time sheets topologically condensed on it. The following discussion neglects these complications and treats the (wormhole) magnetic field as ordinary classical fields: intuitively the idealization of the flux tube structure with ordinary classical magnetic field seems natural.

The energy for creating and changing magnetic or wormhole magnetic fields must come from the metabolism. Dissipation effects are expected to be small since wormholes behave as a super conductor. Super conductivity (perfect diagmagnetism) is not necessary, also nonperfect diamagnets can levitate. In case of super conducting object the strength of the magnetic field must be smaller than the critical field destroying the super conductivity; this condition is a crucial limitation for PK based on super conductivity.

A rough order of magnitude estimate for the needed magnetic field strengths is obtained in the following manner. Meissner force is the gradient of the magnetic field energy regarded as a function of the position of the object located in the field. For simplicity, assume that (wormhole) magnetic field depends linearly on the coordinate z in the direction of gravitational field

$$B = B_0(1+\frac{z}{h}) \ , \tag{5.6.1}$$

where h is the characteristic scale of variation for the wormhole magnetic field.

The Meissner force experienced by an object having size much smaller than scale h, so that the magnetic field is essentially constant in the volume of the object, is from a rough order of magnitude estimate

$$\begin{aligned} F &\sim -\frac{dE_{magn}}{dz} \ , \\ E_{magn}(z) &\simeq \frac{1}{2}B^2V = \frac{B_0^2V}{2}(1+\frac{z}{h})^2 \ , \end{aligned} \tag{5.6.2}$$

where E_{magn} is the magnetic field energy contained in the volume V of the object. For the lifting of an object with mass m in the gravitational field, this force must have a magnitude larger than the gravitational force $F = mg$, where g is gravitational acceleration. This gives an order of magnitude estimate for the minimum magnetic field B_0 making the lifting of the object possible:

$$B_0 \sim \sqrt{\rho g h} \ , \tag{5.6.3}$$

where ρ is the density of the object. Note that in the approximation that magnetic field is essentially constant in the volume of the object, the estimate does not depend on the size or form of the object. More generally, the gradient of B is roughly the gravitational force divided by the average magnetic field B_0: $\frac{dB}{dz} \sim \frac{\rho g}{B_0}$.

An order of magnitude estimate is obtained by putting $\rho \sim 10^3\ kg/m^3$ (density of water roughly) and $h \sim 10^{-2}\ meters$ (object could be a sheet considerably thinner than one centimeter). In this case magnetic field B_0 of order $10^{-5}\ Tesla$ is needed.

Consider first ordinary super conductivity and ordinary magnetic fields (assuming object to be super conductor). Hudson claims that the critical magnetic fields for ORME superconductivity are of the order of Earth's magnetic field, about $10^{-7}\ Tesla$. The claim concerns ordinary magnetic field, not wormhole magnetic fields, and thus electronic superconductivity should be in question. If the claim gives general order of magnitude then the needed magnetic field would destroy the electronic super conductivity. By reducing the thickness of the object to the cell length scale of order $10^{-6}\ meters$, one finds that the needed magnetic field is of order $10^{-7}\ Tesla$ so that the effect might be possible below cell length scales and cell nucleus might control the motion of cell organelles by PK based on the ordinary magnetic fields and electronic super conductivity.

Second case corresponds to wormhole super conductivity (object must be wormhole super conductor). Since wormhole magnetic fields are new physics, one can make only order of magnitude guesses. "Ordinary" wormhole magnetic fields can exist in arbitrarily short p-adic length scales and there is no obvious upper bound for the critical wormhole magnetic field in this case. Since Z^0 classical fields appear only in the p-adic length scales not smaller than the cell length scale, p-adic length scale hypothesis suggests that the critical wormhole magnetic field is in this case *at most* of the order $1/L(cell)^2$ in units ($\hbar = c = 1$). This gives $B_0 \leq 10^{-4}\ Tesla$. This would be enough in the previous example with a sheet like object having the density of water and thickness below one centimeter. Note that thin sheets are ideal objects for the experimental verification of the effect.

5.6.2 Alternative Models Of Psychokinesis

The manner TGD solves the energy problem of GRT is simple: energy momentum tensor is replaced by a collection of vector fields so that the energy defined as an integral over 3-space is coordinate independent scalar quantity. Vector field nature however implies that the sign of the energy depends on the time orientation of the space-time sheet and one can quite well consider the possibility that the time orientation of the space-time sheet is not always same as the natural time orientation of the future light-cone. This would make possible negative energies and “buy now, pay later” type mechanism of energy production by the generation of negative energy space-time sheets of possibly finite time duration. One can even consider the possibility that entire universe is generated from vacuum and has vanishing total quantum numbers.

In [K103] this mechanism is discussed as an explanation for certain peculiar looking claims about energy production occurring with efficiency larger than one. (the N-machine of DePalma [H6] and the space energy generator of [H3]). The model also explains why the rotation of a system consisting of a conductor disk rigidly attached to a cylindrical magnet generates potential difference between the axis and rim of the conducting disk. This effect, observed already by Faraday, has no satisfactory explanation in ordinary electrodynamics. In TGD framework the explanation is simple: the mere rotation of the 3-surface generates the radial electric field automatically. The divergence of the electric field associated with the Faraday disk is non-vanishing and gives rise to vacuum charge density and this in turn implies the necessity of second space-time sheet with opposite charge density and possibly opposite time orientation.

One can consider the possibility that “mind-like” space-time sheets could have negative time orientation so that pairs of space-time sheets with opposite time orientations could be the basic characteristic of living matter. In fact, only this option could make possible the realization of Boolean mind relying on electron positron pairs. Note that also wormhole magnetic fields could correspond to pairs of space-time sheets having opposite time orientation. If this picture is correct, psychokinetic effects could occur spontaneously in living systems when mind-like space-time sheets with negative time orientation are generated and material space-time sheet receives compensating positive energy. This mechanism would make possible “poltergeist” effects involving generation of kinetic energy from “nowhere” and would make possible to affect the physical world by mere thought! There also legends about the magic feats of the trained yogis. Sceptics have of course strong opinions concerning these stories: I would be happy if I could share with the sceptics their access to deeper knowledge making life so simple. I do no even know whether we might be affecting everydaily that part of the physical world which we identify as our physical body by this mechanism!

TGD suggest also a third mechanism of PK. Space-time sheets form a hierarchy. Our space-time sheet is usually glued to the space-time sheet of Earth so that we feel the gravitational force of Earth. One could however consider the possibility that “our” space-time sheet could in some manner get glued to a larger space-time sheet at which Earth's gravitational field is not felt appreciably. This would make possible levitation. This kind of effect would also make the apparent fusion of solid bodies and an effect that might be called “Houdini effect”. The occurrence of this effect in atomic length scales makes possible to bypass Coulomb walls and has been suggested as a mechanism of cold fusion in [K94].

5.6.3 Experimental Tests

The basic concept is topological field quantization implying the decomposition of magnetic field to flux tubes. This indeed occurs in super conductors. Actually, it might be that this phenomenon can be demonstrated using just child's toy magnet! The ferrite powder on table indeed concentrates on lines in the vicinity of magnet. I do not know whether this phenomenon has a more mundane explanation or is it really a direct manifestation of topological field quantization.

The simplest experimental proof for the wormhole flux tube idea is to make them visible! One could achieve the situation in which atoms are condensed on wormhole flux tubes and form exotic atoms so that also electronic alchemy occurs: one can hardly imagine more dramatic proof of the concept! A second possibility is the interaction of laser light with wormhole flux tubes if the proposed explanation of phantom DNA effect is correct. The recent progress in understanding of high T_c superconductivity [K9, K10] gives indeed very strong indirect support for the notion of wormhole contact as parton-antiparton pair as well as for the notion of dark matter as large $\hbar$ phase of ordinary matter.

There are two possible realizations for PK in the proposed model. Either in terms of ordinary topologically quantized magnetic field and super conductivity or in terms of wormhole super conductivity and corresponding magnetic fields, which always appear on *two* space-time sheets simultaneously and thus forming twin structures. The essential requirement is that magnetic field is on the space-time sheet at which the object has suffered topological condensation. Also the restrictions from p-adic quantum entanglement and from many-sheetedness of the space-time could be decisive and explain why the phenomenon is so rare.

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If PK-able persons can control also ordinary magnetic fields created by ordinary charges then one can consider an experiment in which PK-able person tries to affect the state of an ordinary super conductor.

The simplest experimental proof for the wormhole flux tube idea is to make them visible. One could achieve the situation in which atoms are condensed on wormhole flux tubes and form exotic atoms so that also electronic alchemy occurs: one can hardly imagine more dramatic proof of the concept! A second possibility is the interaction of laser light with wormhole flux tubes if the proposed explanation of phantom DNA effect is correct.

Also an experiment in which PK-able person tries to affect the motion of ORMEs [H7] (material possible containing exotic atoms predicted by TGD), could be considered. Actually, peculiar levitation effects have been claimed and also the proposed interpretations have been based on some kind of magnetic levitation and super conductivity. The original explanation was in terms of electronic super conductivity but on the light of recent results wormhole super conductivity seems to be a more plausible explanation. PK effect could be involved also with the claimed fluctuations in the weight of the ORMEs [H7] . PK effect might lead to an fluctuations in the high precision measurements of the value of gravitational constant. An interesting possibility is whether also ORMEs exhibit phantom ORME effect analogous to phantom DNA effect [I50] having explanation in terms of wormhole super conductivity.

Part III

DARK MATTER AND LIVING MATTER

Chapter 6

Dark Nuclear Physics and Condensed Matter

6.1 Introduction

The unavoidable presence of classical long ranged weak (and also color) gauge fields in TGD Universe has been a continual source of worries for more than two decades. The basic question has been whether electro-weak charges of elementary particles are screened in electro-weak length scale or not. The TGD based view about dark matter assumes that weak charges are indeed screened for ordinary matter in electro-weak length scale but that dark electro-weak bosons correspond to much longer symmetry breaking length scale.

The large value of $\hbar$ in dark matter phase implies that Compton lengths and -times are scaled up. In particular, the sizes of nucleons and nuclei become of order atom size so that dark nuclear physics would have direct relevance for condensed matter physics. It becomes impossible to make a reductionistic separation between nuclear physics and condensed matter physics and chemistry anymore.

In its original form this chapter was an attempt to concretize and develop ideas related to dark matter by using some experimental inputs with emphasis on the predicted interaction between the new nuclear physics and condensed matter. As the vision about dark matter became more coherent and the nuclear string model developed in its recent form, it became necessary to update the chapter and throw away the obsolete material. I have also divided the material to two chapters such that second chapter focuses to dark weak and color forces and their implications. I dare hope that the recent representation is more focused than the earlier one.

6.1.1 Dark Rules

I have done a considerable amount of trials and errors in order to identify the basic rules allowing to understand what it means to be dark matter is and what happens in the phase transition to dark matter. It is good to try to summarize the basic rules of p-adic and dark physics allowing to avoid obvious contradictions.

Could basic quantum TGD imply the hierarchy of Planck constants?

The implications of the hierarchy of Planck constants depend on whether one assumes it as an independent additional postulate or as a consequence of basic quantum TGD. The first option originally motivated by physical anomalies would allow both singular coverings and factor spaces. The latter option, which emerged five years after the basic idea, would allow only singular coverings. They would provide only a convenient tool to describe the fact that the correspondence between canonical momentum densities and time derivatives of the embedding space coordinates at the ends of space-time sheets is not one-to-one. As a matter fact, this observation forced the idea about quantum physics as classical physics in the "world of classical worlds" for two decades ago. The quantization of Planck constant as integer multiples of its standard value would be an effective phenomenon for this option holding true at the sheets of the covering. These options lead to different predictions and one can in principle test whether either of them is correct.

The notion of field body

The notion of "field body" implied by topological field quantization is essential piece of classical TGD. It seems possible to assign to physical systems field identities- that is separate magnetic and electric field bodies identifiable as flux quanta. This is not possible in Maxwell's electrodynamics. The first naive guess was that one can speak of separate em, Z^0, W, gluonic, and gravitonic field bodies, each characterized by its own p-adic prime. The tight constraints coming from the fact that the induced gauge fields are expressible in terms of CP_2 coordinates and their derivatives implies however strong correlations between classical gauge fields. For instance, the vanishing of classical Kähler field for vacuum extremals implies that em and Z^0 fields are proportional to each other. The non-vanishing of induced Kähler field in turn implies non-vanishing classical color fields. This gives rise at least to two basic types of field bodies predicting a lot of new physics even in macroscopic length scales. For instance, electric and magnetic flux tubes must have at their ends quarks and antiquarks serving as sources of classical color fields unless one believes that vacuum charge densities serve as sources of these fields. In the similar way neutrinos and antineutrinos are needed to create classical Z^0 fields associated with almost vacuum extremal flux tubes. These fields could be interpreted also as vacuum polarization effects and one could distinguish them from fields created by genuine sources. For instance, the unavoidable classical color fields associated with the flux tubes of electromagnetic field body which is not vacuum extremal would represent vacuum polarization in macroscopic scale.

What is interesting that the conceptual separation of interactions to various types would have a direct correlate at the level of space-time topology. From a different perspective inspired by the general vision that many-sheeted space-time provides symbolic representations of quantum physics, the very fact that we make this conceptual separation of fundamental interactions could reflect the topological separation at space-time level.

The p-adic mass calculations for quarks encourage to think that the p-adic length scale characterizing the mass of particle is associated with its electromagnetic body and in the case of neutrinos with its Z^0 body. Z^0 body can contribute also to the mass of charged particles but the contribution would be small. It is also possible that these field bodies are purely magnetic for color and weak interactions. Color flux tubes would have exotic fermion and anti-fermion at their ends and define colored variants of pions. This would apply not only in the case of nuclear strings but also to molecules and larger structures so that scaled variants of elementary particles and standard model would appear in all length scales as indeed implied by the fact that classical electro-weak and color fields are unavoidable in TGD framework.

One can also go further and distinguish between magnetic field body of free particle for which flux quanta start and return to the particle and "relative field" bodies associated with pairs of particles. Very complex structures emerge and should be essential for the understanding the space-time correlates of various interactions. In a well-defined sense they would define space-time correlate for the conceptual analysis of the interactions into separate parts. In order to minimize confusion it should be emphasized that the notion of field body used in this chapter relates to those space-time correlates of interactions, which are more or less *static* and related to the formation of *bound states.*

What dark variant of elementary particle means

It is not at all clear what the notion of dark variant of elementary particle or of larger structures could mean.

1. *Are only field bodies dark?*

One variety of dark particle is obtained by making some of the field bodies dark by increasing the value of Planck constant. This hypothesis could be replaced with the stronger assumption that elementary particles are maximally quantum critical systems so that they are same irrespective of the value of the Planck constant. Elementary particles would be represented by partonic 2-surfaces, which belong to the universal orbifold singularities remaining invariant by all groups

$G_a \times G_b$ for a given choice of quantization axes. If $G_a \times G_b$ is assumed to leave invariant the choice of the quantization axes, it must be of the form $Z_{n_a} \times Z_{n_b} \subset SO(3) \times SU(3)$. Partonic 2-surface would belong to $M^2 \times CP_2/U(1) \times U(1)$, where M^2 is spanned by the quantization axis of angular momentum and the time axis defining the rest system.

A different way to say this is that the CP_2 type extremal representing particle would suffer multiple topological condensation on its field bodies so that there would be no separate "particle space-time sheet".

Darkness would be restricted to particle interactions. The value of the Planck constant would be assigned to a particular interaction between systems rather than system itself. This conforms with the original finding that gravitational Planck constant satisfies $\hbar = GM_1M_2/v_0$, $v_0 \simeq 2^{-11}$. Since each interaction can give rise to a hierarchy dark phases, a rich variety of partially dark phases is predicted. The standard assumption that dark matter is visible only via gravitational interactions would mean that gravitational field body would not be dark for this particular dark matter.

Complex combinations of dark field bodies become possible and the dream is that one could understand various phases of matter in terms of these combinations. All phase transitions, including the familiar liquid-gas and solid-liquid phase transitions, could have a unified description in terms of dark phase transition for an appropriate field body. At mathematical level Jones inclusions would provide this description.

The book metaphor for the interactions at space-time level is very useful in this framework. Elementary particles correspond to ordinary value of Planck constant analogous to the ordinary sheets of a book and the field bodies mediating their interactions are the same space-time sheet or at dark sheets of the book.

2. Can also elementary particles be dark?

Also dark elementary particles themselves rather than only the flux quanta could correspond to dark space-time sheet defining multiple coverings of $H/G_a \times G_b$. This would mean giving up the maximal quantum criticality hypothesis in the case of elementary particles. These sheets would be exact copies of each other. If single sheet of the covering contains topologically condensed space-time sheet, also other sheets contain its exact copy.

The question is whether these copies of space-time sheet defining classical identical systems can carry different fermionic quantum numbers or only identical fermionic quantum numbers so that the dark particle would be exotic many-fermion system allowing an apparent violation of statistics (N fermions in the same state).

Even if one allows varying number of fermions in the same state with respect to a basic copy of sheet, one ends up with the notion of N-atom in which nuclei would be ordinary but electrons would reside at the sheets of the covering. The question is whether symbolic representations essential for understanding of living matter could emerge already at molecular level via the formation of N-atoms.

What happens in charge fractionization?

The hierarchy of Planck constants suggests strongly charge fractionization. What happens for binding energies is however not obvious. The first guess is that one just replaces $\hbar$ with its scaled value in the standard formulas. One can however ask whether the resulting expression applies to single sheet of covering or to the sum of binding energies associated with the sheets of covering. In the case of factor space analogous problem is not encountered.

If the coverings follow from basic quantum TGD one can deduce unique rules for what happens. These rules can be assumed also in the more general case. Since the sheets of the singular covering co-incide at the partonic 2-surfaces associated with ends of CD the time evolution and also "evolution" in space-like direction means instability of in the sense that partonic 2-surface decomposes to $r = \hbar/\hbar_0 = n_an_b$ sheets. This implies fractionization of all total quantum numbers such as energy and momentum. From this one can also deduce what happens to various binding energies. For instance, the total (!) cyclotron energy is indeed multiplied by factor and the total(!) binding energy of dark hydrogen atom is what the naive scaling of $\hbar$ would give. The reason is that the mass of particle is fractionized: $m \rightarrow m/n_an_b$. Therefore the original guesses would be correct. In particular, the expression of the total gravitational binding energy essential for the original Bohr model of planetary orbits is consistent with the new more precise rules.

Criterion for the transition to dark phase

The naive criterion $\alpha Q_1 Q_2 > 1$ (or its generalization) for the transition to dark matter phase relates always to the interaction between two systems and the interpretation is that when the field strength characterizing the interaction becomes too strong, the interaction is mediated by dark space-time sheets which define $n = n(G_a) \times n(G_b)$-fold covering of $M^4 \times CP_2/G_a \times G_b$. The sharing of flux between different space-time sheets reduces the field strength associated with single sheet below the critical value.

For the option in which singular coverings follow from basic quantum TGD this criterion or its appropriate generalization has very concrete interpretation. At the ends of CD the partonic 2-surface is unstable against decay to n_a sheets when some of the quantum numbers of the partonic 2-surface are too large. A similar decay to n_b sheets would happen also when one moves in space-like direction.

One can ask whether this instability could have something to do with N-vertices of generalized Feynman diagrams in which decay of a partonic 2-surfaces to N-1 surfaces takes place. For instance, could it be that 3-vertex- possibly the only fundamental vertex, correspond to this process and could higher vertices have an interpretation in terms of the hierarchy of Planck constants? This would mean analogy with Jones inclusions for which $n \geq 3$ holds true. The assumption that exact fractionization of quantum numbers takes place is not consistent with the identification in terms of Feynman diagrams. Also the huge values of $n_a n_b$ disfavor this identification unless one restricts it to $n_a n_b = 2$.

There are considerations suggesting that in the vertices of generalized Feynman diagrams a re-distribution of the sheets of the coverings can take place in such a way that the total number of sheets is conserved. The leakage of between different sectors of WCW would in turn mean analogs of self-energy vertices in which n_a and n_b are replaced with their factors or with integers containing them as factors.

Mersenne hypothesis

The generalization of the embedding space means a book like structure for which the pages are products of singular coverings or factor spaces of CD (causal diamond defined as intersection of future and past directed light-cones) and of CP_2 [K81]. This predicts that Planck constants are rationals and that given value of Planck constant corresponds to an infinite number of different pages of the Big Book, which might be seen as a drawback. If only singular covering spaces are allowed the values of Planck constant are products of integers and given value of Planck constant corresponds to a finite number of pages given by the number of decompositions of the integer to two different integers.

TGD inspired quantum biology and number theoretical considerations suggest preferred values for $r = \hbar/\hbar_0$. For the most general option the values of $\hbar$ are products and ratios of two integers n_a and n_b. Ruler and compass integers defined by the products of distinct Fermat primes and power of two are number theoretically favored values for these integers because the phases $exp(i2\pi/n_i)$, $i \in \{a, b\}$, in this case are number theoretically very simple and should have emerged first in the number theoretical evolution via algebraic extensions of p-adics and of rationals. p-Adic length scale hypothesis favors powers of two as values of r.

One can however ask whether a more precise characterization of preferred Mersennes could exist and whether there could exists a stronger correlation between hierarchies of p-adic length scales and Planck constants. Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1+i)k-1$, $k \in \{113, 151, 157, 163, 167, 239, 241..\}$ are expected to be physically highly interesting and up to $k = 127$ indeed correspond to elementary particles. The number theoretical miracle is that all the four scaled up electron Compton lengths with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm). The question has been whether these define scaled up copies of electro-weak and QCD type physics with ordinary value of $\hbar$. The proposal that this is the case and that these physics are in a well-defined sense induced by the dark scaled up variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$.

What induction means is that dark variant of exotic nuclear physics induces exotic physics with ordinary value of Planck constant in the new scale in a resonant manner: dark gauge bosons transform to their ordinary variants with the same Compton length. This transformation is natural since in length scales below the Compton length the gauge bosons behave as massless and free particles. As a consequence, lighter variants of weak bosons emerge and QCD confinement scale becomes longer.

This proposal will be referred to as Mersenne hypothesis. It leads to strong predictions about EEG [K15] since it predicts a spectrum of preferred Josephson frequencies for a given value of membrane potential and also assigns to a given value of $\hbar$ a fixed size scale having interpretation as the size scale of the body part or magnetic body. Also a vision about evolution of life emerges. Mersenne hypothesis is especially interesting as far as new physics in condensed matter length scales is considered: this includes exotic scaled up variants of the ordinary nuclear physics and their dark variants. Even dark nucleons are possible and this gives justification for the model of dark nucleons predicting the counterparts of DNA, RNA, tRNA, and amino-acids as well as realization of vertebrate genetic code [K104].

These exotic nuclear physics with ordinary value of Planck constant could correspond to ground states that are almost vacuum extremals corresponding to homologically trivial geodesic sphere of CP_2 near criticality to a phase transition changing Planck constant. Ordinary nuclear physics would correspond to homologically non-trivial geodesic sphere and far from vacuum extremal property. For vacuum extremals of this kind classical Z^0 field proportional to electromagnetic field is present and this modifies dramatically the view about cell membrane as Josephson junction. The model for cell membrane as almost vacuum extremal indeed led to a quantitative breakthrough in TGD inspired model of EEG and is therefore something to be taken seriously. The safest option concerning empirical facts is that the copies of electro-weak and color physics with ordinary value of Planck constant are possible only for almost vacuum extremals - that is at criticality against phase transition changing Planck constant.

6.1.2 Some Implications

As already noticed, the detailed implications of the hierarchy of Planck constants depend on whether one brings in the hierarchy of singular coverings and factor spaces of the embedding space as an independent postulate or whether one assumes that singular coverings emerge as an effective description from basic quantum TGD

Dark variants of nuclear physics

One can imagine endless variety of dark variants of ordinary nuclei and every piece of data is well-come in attempts to avoid a complete inflation of speculative ideas. The book metaphor for the extended embedding space is useful in the attempts to imagine various exotic phases of matter. For the minimal option atomic nuclei would be ordinary whereas field bodies could be dark and analogous to n-sheeted Riemann surfaces. One can imagine that the nuclei are at the "standard" page of the book and color bonds at different page with different p-adic length scale or having different Planck constant $\hbar$. This would give two hierarchies of nuclei with increasing size.

Color magnetic body of the structure would become a key element in understanding the nuclear binding energies, giant dipole resonances, and nuclear decays. Also other field bodies are in a key role and there seems to be a field body for every basic interaction (classical gauge fields are induced from spinor connection and only four independent field variables are involved so that this is indeed required).

Nothing prevents from generalizing the nuclear string picture so that color bonds could bind also atoms to molecules and molecules to larger structures analogous to nuclei. Even hydrogen bond might be interpreted in this manner. Molecular physics could be seen as a scaled up variant of nuclear physics in a well-defined sense. The exotic features would relate to the hierarchy of various field bodies, including color bonds, electric and weak bonds. These field bodies would play key role also in biology and replaced molecular randomness with coherence in much longer length scale.

In the attempt to make this vision quantitative the starting point is nuclear string model [L2] and the model of cold fusion based on it forcing also to conclude the scaled variants of electro-weak bosons are involved. The model of cold fusion requires the presence of a variant electro-weak interactions for which weak bosons are effectively massless below the atomic length scale.

$k = 113$ p-adically scaled up variant of ordinary weak physics which is dark and corresponds to $\hbar = r\hbar_0$, $r = 2^{k_d}$, $k_d = 14 = 127 - 113$ is an option consistent with Mersenne hypothesis and gives weak bosons in electron length scale. Another possibility is defined by $k = 113$ and $k_d = 24 = 113 - 89 = 151 - 127$ and corresponds to the p-adic length scale $k = 137$ defining atomic length scale. This would give rise to weak bosons with masses in keV scale and these would be certainly relevant for the physics of condensed matter.

Anomalies of water could be understood if one assumes that color bonds can become dark with suitable values of $r = 2^{k_d}$ and if super-nuclei formed by connecting different nuclei by the color bonds are possible. Tetrahedral and icosahedral water clusters could be seen as magic super-nuclei in this framework. Color bonds could connect either proton nuclei or water molecules.

The model for partially dark condensed matter deriving from exotic nuclear physics and exotic weak interactions could allow to understand the low compressibility of the condensed matter as being due to the repulsive weak force between exotic quarks, explains large parity breaking effects in living matter (chiral selection), and suggests a profound modification of the notion of chemical bond having most important implications for bio-chemistry and understanding of bio-chemical evolution.

Could the notion of dark atom make sense?

One can also imagine several variants of dark atom. Book metaphor suggest one variant of dark atom.

1. Nuclei and electrons could be ordinary but classical electromagnetic interactions are mediated via dark space-time sheet "along different page of the book". The value of Planck constant would be scaled so that one would obtain a hierarchy of scaled variants of hydrogen atom. The findings of [D41] could find an explanation in terms of a reduced Planck constant if singular factor spaces are assumed to be possible. An alternative explanation is based on the notion of quantum-hydrogen atom obtained as q-deformation of the ordinary hydrogen atom.

2. A more exotic variant if atom is obtained by assuming ordinary nuclei but dark, not totally quantum critical, electrons. Dark space-time surface is analogous to n-sheeted Riemann surface and if one assumes that each sheet could carry electron, one ends up with the notion of N-atom. This variant of dark atom is more or less equivalent with that following from the option for which the singular coverings of embedding space are effective manner to describe the many-valuedness of the time derivatives of the embedding space coordinates as functions of canonical momentum densities.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L5].

6.2 A Generalization Of The Notion Of Embedding Space As ARealization Of The Hierarchy Of Planck Constants

6.2.1 Hierarchy Of Planck Constants And The Generalization Of The Notion Of Embedding Space

In the following the recent view about structure of embedding space forced by the quantization of Planck constant is summarized. The question is whether it might be possible in some sense to replace H or its Cartesian factors by their necessarily singular multiple coverings and factor spaces. One can consider two options: either M^4 or the causal diamond CD. The latter one is the more plausible option from the point of view of WCW geometry.

The evolution of physical ideas about hierarchy of Planck constants

The evolution of the physical ideas related to the hierarchy of Planck constants and dark matter as a hierarchy of phases of matter with non-standard value of Planck constants was much faster than the evolution of mathematical ideas and quite a number of applications have been developed during last five years.

1. The starting point was the proposal of Nottale [E2] that the orbits of the 4 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 [K91] 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 [K92]. 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 embedding 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 [K52].

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 [K89]. 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 [E2] can be understood. Dark matter would resemble to a high degree matter in black holes replaced in TGD framework by light-like partonic 2-surfaces with a minimum size of order Schwartschild radius r_S of order scaled up Planck length $l_{Pl} = \sqrt{\hbar_{gr}G} = GM$. Black hole entropy is inversely proportional to $\hbar$ and predicted to be of order unity so that dramatic modification of the picture about black holes is implied.

6. Perhaps the most fascinating applications are in biology. The anomalous behavior ionic currents through cell membrane (low dissipation, quantal character, no change when the membrane is replaced with artificial one) has a natural explanation in terms of dark supra currents. This leads to a vision about how dark matter and phase transitions changing the value of Planck constant could relate to the basic functions of cell, functioning of DNA and amino-acids, 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 [L2, K52], [L2].

The most general option for the generalized embedding space

Simple physical arguments pose constraints on the choice of the most general form of the embedding space.

1. The fundamental group of the space for which one constructs a non-singular covering space or factor space should be non-trivial. This is certainly not possible for M^4, CD, CP_2, or H. One can however construct singular covering spaces. The fixing of the quantization axes implies a selection of the sub-space $H_4 = M^2 \times S^2 \subset M^4 \times CP_2$, where S^2 is geodesic sphere of CP_2. $\hat{M}^4 = M^4 \backslash M^2$ and $\hat{CP}_2 = CP_2 \backslash S^2$ have fundamental group Z since the codimension of the excluded sub-manifold is equal to two and homotopically the situation is like that for a punctured plane. The exclusion of these sub-manifolds defined by the choice of quantization axes could naturally give rise to the desired situation.

2. CP_2 allows two geodesic spheres which left invariant by $U(2$ *resp.* $SO(3)$. The first one is homologically non-trivial. For homologically non-trivial geodesic sphere $H_4 = M^2 \times S^2$ represents a straight cosmic string which is non-vacuum extremal of Kähler action (not necessarily preferred extremal). One can argue that the many-valuedness of $\hbar$ is un-acceptable for non-vacuum extremals so that only homologically trivial geodesic sphere S^2 would be acceptable. One could go even further. If the extremals in $M^2 \times CP_2$ can be preferred non-vacuum extremals, the singular coverings of M^4 are not possible. Therefore only the singular coverings and factor spaces of CP_2 over the homologically trivial geodesic sphere S^2 would be possible. This however looks a non-physical outcome.

   (a) The situation changes if the extremals of type $M^2 \times Y^2$, Y^2 a holomorphic surface of CP_3, fail to be hyperquaternionic. The tangent space M^2 represents hypercomplex sub-space and the product of the Kähler-Dirac gamma matrices associated with the tangent spaces of Y^2 should belong to M^2 algebra. This need not be the case in general.

   (b) The situation changes also if one reinterprets the gluing procedure by introducing scaled up coordinates for M^4 so that metric is continuous at $M^2 \times CP_2$ but CDs with different size have different sizes differing by the ratio of Planck constants and would thus have only piece of lower or upper boundary in common.

3. For the more general option one would have four different options corresponding to the Cartesian products of singular coverings and factor spaces. These options can be denoted by $C-C$, $C-F$, $F-C$, and $F-F$, where C (F) signifies for covering (factor space) and first (second) letter signifies for CD (CP_2) and correspond to the spaces $(\hat{CD}\hat{\times}G_a) \times (\hat{CP}_2\hat{\times}G_b)$, $(\hat{CD}\hat{\times}G_a) \times \hat{CP}_2/G_b$, $\hat{CD}/G_a \times (\hat{CP}_2\hat{\times}G_b)$, and $\hat{CD}/G_a \times \hat{CP}_2/G_b$.

4. The groups G_i could correspond to cyclic groups Z_n. One can also consider an extension by replacing M^2 and S^2 with its orbit under more general group G (say 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 embedding space to another one.

1. How the gluing of copies of embedding space at $M^2 \times CP_2$ takes place? It would seem that the covariant metric of CD factor proportional to $\hbar^2$ must be discontinuous at the singular manifold since only in this manner the idea about different scaling factor of CD metric can make sense. On the other hand, one can always scale the M^4 coordinates so that the metric is continuous but the sizes of CDs with different Planck constants differ by the ratio of the Planck constants.

2. One might worry whether the phase transition changing Planck constant means an instantaneous change of the size of partonic 2-surface in M^4 degrees of freedom. This is not the case. Light-likeness in $M^2 \times S^2$ makes sense only for surfaces $X^1 \times D^2 \subset M^2 \times S^2$, where X^1 is light-like geodesic. The requirement that the partonic 2-surface X^2 moving from one sector of H to another one is light-like at $M^2 \times S^2$ irrespective of the value of Planck constant requires that X^2 has single point of M^2 as M^2 projection. Hence no sudden change of the size X^2 occurs.

3. A natural question is whether the phase transition changing the value of Planck constant can occur purely classically or whether it is analogous to quantum tunnelling. 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.

	$C-C$	$F-C$	$C-F$	$F-F$
r	$n_a n_b$	$\frac{n_a}{n_b}$	$\frac{n_b}{n_a}$	$\frac{1}{n_a n_b}$

Preferred values of Planck constants

Number theoretic considerations favor the hypothesis that the integers corresponding to Fermat polygons constructible using only ruler and compass and given as products $n_F = 2^k \prod_s F_s$, where $F_s = 2^{2^s} + 1$ are distinct Fermat primes, are favored. The reason would be that quantum phase $q = exp(i\pi/n)$ is in this case expressible using only iterated square root operation by starting from rationals. The known Fermat primes correspond to $s = 0, 1, 2, 3, 4$ so that the hypothesis is very strong and predicts that p-adic length scales have satellite length scales given as multiples of n_F of fundamental p-adic length scale. $n_F = 2^{11}$ corresponds in TGD framework to a fundamental constant expressible as a combination of Kähler coupling strength, CP_2 radius and Planck length appearing in the expression for the tension of cosmic strings, and the powers of 2^{11} was proposed to define favored as values of n_a in living matter [K15].

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 scaled up electron Compton lengths $L_e(k) = \sqrt{5}L(k)$ with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm) define scaled up copies of electro-weak and QCD type physics with ordinary value of $\hbar$ and that these physics are induced by dark variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$, and the resulting picture finds support from the ensuing models for biological evolution and for EEG [K15]. This hypothesis - to be referred to as Mersenne hypothesis - replaces the rather ad hoc proposal $r = \hbar/\hbar_0 = 2^{11k}$ for the preferred values of Planck constant.

How Planck constants are visible in Kähler action?

$\hbar(M^4)$ and $\hbar(CP_2)$ appear in the commutation and anti-commutation 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 embedding space sector with given values of Planck constants are proportional to the corresponding Planck. 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.

6.3 General Ideas About Dark Matter

In the sequel general ideas about the role of dark matter in condensed matter physics are described.

6.3.1 How The Scaling Of $\hbar$ Affects Physics And How To Detect Dark Matter?

It is relatively easy to deduce the basic implications of the scaling of $\hbar$.

1. If the rate for the process is non-vanishing classically, it is not affected in the lowest order. For instance, scattering cross sections for say electron-electron scattering and e^+e^- annihilation are not affected in the lowest order since the increase of Compton length compensates for the reduction of α_{em}. Photon-photon scattering cross section, which vanishes classically and is proportional to $\alpha_{em}^4\hbar^2/E^2$, scales down as $1/\hbar^2$.

2. Higher order corrections coming as powers of the gauge coupling strength α are reduced since $\alpha = g^2/4\pi\hbar$ is reduced. Since one has $\hbar_s/\hbar = \alpha Q_1Q_2/v_0$, αQ_1Q_2 is effectively replaced with a universal coupling strength v_0. In the case of QCD the paradoxical sounding implication is that α_s would become very small.

6.3.2 General View About Dark Matter Hierarchy And Interactions Between Relatively Dark Matters

The identification of the precise criterion characterizing dark matter phase is far from obvious. TGD actually suggests an infinite number of phases which are dark relative to each other in some sense and can transform to each other only via a phase transition which might be called de-coherence or its reversal and which should be also characterized precisely.

A possible solution of the problem comes from the general construction recipe for S-matrix. Fundamental vertices correspond to partonic 2-surfaces representing intersections of incoming and outgoing light-like partonic 3-surfaces.

1. If the characterization of the interaction vertices involves all points of partonic 2-surfaces, they must correspond to definite value of Planck constants and more precisely, definite groups G_a and G_b characterizing dark matter hierarchy. Particles of different G_b phases could not appear in the same vertex since the partons in question would correspond to vacuum extremals. Hence the phase transition changing the particles to each other analogous could not be described by a vertex and would be analogous to a de-coherence.

   The phase transition could occur at the incoming or outgoing particle lines. At space-time level the phase transition would mean essentially a leakage between different sectors of embedding space and means that partonic 2-surface at leakage point has CP_2 projection reducing to the orbifold point invariant under G or alternatively, its $M^4_\pm$ projection corresponds to the tip of $M^4_\pm$. Relative darkness would certainly mean different groups G_a and G_b. Note that $\hbar(M^4)$ *resp.* $\hbar(CP_2)$ can be same for different groups G_a *resp.* G_b and that only the ratio of $\hbar(M^4)/\hbar(M^4)$ appears in the Kähler action.

2. One can represent a criticism against the idea that relatively dark matters cannot appear at the same interaction vertex. The point is that the construction of S-matrix for transitions transforming partonic 2-surfaces in different number fields involves only the rational (algebraic) points in the intersection of the 2-surfaces in question. This idea applies also to the case in which particles correspond to different values of Planck constant. What is only needed that all the common points correspond to the orbifold point in M^4 or CP_2 degrees of freedom and are thus intermediate between two sectors of embedding space. In this picture phase transitions would occur through vertices and S-matrix would characterize their probabilities. It seems that this option is the correct one.

If the matrix elements for real-real transitions involve all or at least a circle of the partonic 2-surface as stringy considerations suggest [K72], then one would have clear distinction between quantum phase transitions and ordinary quantum transitions. Note however that one could understand the weakness of the quantal interactions between relatively dark matters solely from the fact that the CP_2 type extremals providing space-time correlates for particle propagators must in this case go through an intermediate state with at most point-like CP_2 projection.

What does one mean with dark variants of elementary particle?

It is not at all clear what one means with the dark variant of elementary particle. In this respect p-adic mass calculations provide a valuable hint. According to the p-adic mass calculations [K31], $k = 113$ characterizes electromagnetic size of u and d quarks, of nucleons, and nuclei. $k = 107$ characterizes the QCD size of hadrons. This is somewhat paradoxical situation since one would expect that quark space-time sheets would be smaller than hadronic space-time sheets.

The simplest resolution of the problem suggested by the basic characteristics of electro-weak symmetry breaking is that $k = 113$ characterizes the size of the electro-magnetic field body of the quark and that the prime characterizing p-adic mass scale labels the em field body of the particle. One can assign mass also the Z^0 body but this would be much smaller as the small scale of neutrino masses suggests. This size scale correspond to a length scale of order 10 μm, which conforms with the expectation that classical Z^0 force is important in biological length scales. The size of Z^0 body of neutrino could relate directly to the chirality selection in living matter. An interesting question is whether the Z^0 field bodies of also other elementary fermions are of this size.

If this picture is correct then dark variant of elementary particle would differ from ordinary only in the sense that its field body would be dark. This conforms with the general working hypothesis is that only field bodies can be dark.

Are particles characterized by different p-adic primes relatively dark?

Each particle is characterized by a collection of p-adic primes corresponding to the partonic 2-surfaces associate with the particle like 3-surface. Number theoretical vision supports the notion of multi-p p-adicity and the idea that elementary particles correspond to infinite primes, integers, or perhaps even rationals [K84, K96]. To infinite primes, integers, and rationals it is possible to associate a finite rational $q = m/n$ by a homomorphism. This would suggest generalization of p-adicity with q-adicity (q-adic topology does not correspond to number field) but this does not seem to be a promising idea.

The crucial observation is that one can decompose the infinite prime, call it P, to finite and infinite parts and distinguish between bosonic and fermionic finite primes of which infinite prime can be said to consist of [K106, K96, K32]. The interpretation is that bosonic and fermionic finite primes in the *infinite* part of P code for p-adic topologies of light-like partonic 3-surfaces associated with a given *real* space-time sheet whereas the primes in the *finite* part of P code for p-adic light-like partonic 3-surfaces.

This raises two options.

1. Two space-time sheets characterized by rationals having common prime factors can be connected by a $\#_B$ contact and can interact by the exchange of particles characterized by divisors of m or n since in this case partonic 2-surface with same p-adic or effective p-adic topology can be found. This is the only possible interaction between them.

2. The number theoretic vision about the construction of S-matrix however allows to construct S-matrix also in the case that partons belong to different number fields and one ends up with a very elegant description involving only finite number of points of partonic 2-surfaces belonging to their intersection consisting of rational (algebraic points of embedding space), which by algebraic universality could apply also to diagonal transitions. Also now the interactions mediated between propagators connecting partons with different effective p-adic topologies might be very slow so that this would give rise to relative darkness.

Hierarchy of infinite primes and dark matter hierarchy

In previous consideration only the simplest infinite primes at the lowest level of hierarchy were considered. Simple infinite primes allow a symmetry changing the sign of the finite part of infinite prime. A possible interpretation in terms of phase conjugation. One can consider also more complex infinite primes at this level and a possible interpretation in terms of bound states of several particles. One can also consider infinite integers and rationals: the interpretation would be as many particle states. Rationals might correspond to states containing particles and antiparticles. At the higher levels of the hierarchy infinite primes of previous take the role of finite primes at the previous level and physically these states correspond to higher level bound states of the particles of the previous level.

Thus TGD predicts an entire hierarchy of dark matters such that the many particle states at previous level become particles at the next level. This hierarchy would provide a concrete physical identification for the hierarchy of infinite primes identifiable in terms of a repeated second quantization of an arithmetic super-symmetric QFT [K96] including both free many-particle states and their bound states. The finite primes about which infinite prime is in a well defined sense a composite of would correspond to the particles in the state forming a unit of dark matter. Particles belonging to different levels of this hierarchy would obviously correspond to different levels of dark matter hierarchy but their interactions must reduce to the fundamental partonic vertices.

6.3.3 How Dark Matter And Visible Matter Interact?

The hypothesis that the value of $\hbar$ is dynamical, quantized and becomes large at the verge of a transition to a non-perturbative phase in the ordinary sense of the word has fascinating implications. In particular, dark matter, would correspond to a large value of $\hbar$ and could be responsible for the properties of the living matter. In order to test the idea experimentally, a more concrete model for the interaction of ordinary matter and dark matter must be developed and here of course experimental input and the consistency with the earlier quantum model of living matter is of considerable help.

How dark photons transform to ordinary photons?

The transitions of dark atoms naturally correspond to coherent transitions of the entire dark electron BE condensate and thus generate N_{cr} dark photons and behave thus like laser beams. Dark photons do not interact directly with the visible matter. An open question is whether even ordinary laser beams could be identified as beams of dark photons: the multiple covering property at the level of embedding space and the fact that MEs are possible in all sectors suggests that this is not the case. Note that the transition from dark to ordinary photons implies the scaling of wave length and thus also of coherence length by a factor n_b/n_a.

Dark $\leftrightarrow$ visible transition should have also a space-time correlate. The so called topological light rays or MEs ("massless extremals") represent a crucial deviation of TGD from Maxwell's ED and have all the properties characterizing macroscopic classical coherence. Therefore MEs are excellent candidates for the space-time correlate of BE condensate of dark photons.

MEs carry in general a superposition of harmonics of some basic frequency determined by the length of ME. A natural expectation is that the frequency of classical field corresponds to the generalized de Broglie frequency of dark photon and is thus $\hbar/\hbar_s$ times lower than for ordinary photons. In completely analogous manner de Broglie wave length is scaled up by $k = \hbar_s/\hbar$. Classically the decay of dark photons to visible photons would mean that an oscillation with frequency f inside topological light ray transforms to an oscillation of frequency f/k such that the intensity of the oscillation is scaled up by a factor k. Furthermore, the ME in question could naturally decompose into $1 < N_{cr} \leq 137$ ordinary photons in the case that dark atoms are in question. Of course also MEs could decay to lower level MEs and this has an interpretation in terms of hierarchy of dark matters to be discussed next.

About the criterion for the transition increasing the value of Planck constant

An attractive assumption is that the transition to dark matter phase occurs when the interaction strength satisfies the criticality condition $Q_1Q_2\alpha \simeq 1$. A special case corresponds to self interaction with $Q_1 = Q_2$. This condition applies only to gauge interactions so that particles can be characterized by gauge charges. A more general characterization would be that transition occurs when perturbation theory ceases to converge. The criterion cannot be applied to phenomenological QFT description of strong force in terms of, say, pion exchange.

Some examples are in order to test this view.

1. Transition from perturbative phase in QCD to hadronic phase is the most obvious application. The identification of valence quarks and gluons as dark matter would predict for them QCD size ($k = 107$ space-time sheet) of about electron Compton length. This does not change the QCD cross sections in the lowest order perturbation theory but makes them excellent predictions. It also provides completely new view about how color force determines the nuclear strong force indeed manifesting itself as long ranged harmonic oscillator potential, the long range of which becomes manifest in the case of neutron halos of size of 2.5×10^{-14} m [C31]. One can also understand tetraneutron in this framework. This criterion applies also in QCD plasma and explains the formation of liquid like color glass condensate detected in RHIC [C30]. A possible interpretation for QCD size would be as a length of the cylindrical magnetic walls defining the magnetic body associated with u and d type valence quarks, nucleons, and nuclei.

2. QCD size of quark must be distinguished from the electromagnetic size of quark associated with $k = 113$ space-time sheets of u and d quarks and assignable to the height of the magnetic body and defining the length scale of flux tubes feeding quark charges to $k = 113$ space-time sheets.

3. In the case of atomic nuclei the criterion would naturally apply to the electromagnetic interaction energy of two nucleon clusters inside nucleus or to self energy ($Q^2\alpha_{em} = 1$). Quite

generally, the size of the electromagnetic $k = 113$ space-time sheet would increase by a $n_F = 2^k \prod_s F_s$, where F_s are different Fermat primes (the known ones being $3, 5, 17, 257, 2^{16} + 1$), in the transition to large $\hbar$ phase. Especially interesting values of n_F seem to be of form $n_F = 2^{k11}$ and possibly also $n_F = 2^{k11} \prod_s F_s$. Similar criterion would apply in the plasma phase. Note that many free energy anomalies involve the formation of cold plasma [K51].

The criterion would give in the case of single nucleus and plasma $Z \geq 12$ if the charges are within single space-time sheet. This is consistent with cold fusion involving Palladium nuclei [C10]. Since u and d quarks have $k = 113$, they both and thus both neutrons and protons could make a transition to large $\hbar$ phase. This is consistent with the selection rules of cold fusion since the production of ^3He involves a phase transition pnp$_d \rightarrow$ pnp and the contraction of p_d to p is made un-probable by the Coulomb wall whereas the transition nnp$_d$ $\rightarrow$nnp producing tritium does not suffer from this restriction.

Strong and weak physics of nuclei would not be affected in the phase transition. Electromagnetic perturbative physics of nuclei would not be affected in the process in the lowest order in $\hbar$ (classical approximation) but the height of the Coulomb wall would be reduced by a factor $1/n_F$ by the increase in the electromagnetic size of the nucleus. Also Pd nuclei could make the transition and Pd nuclei could catalyze the transition in the case the deuterium nuclei.

6.3.4 Could One Demonstrate The Existence Of Large Planck Constant Photons Using Ordinary Camera Or Even Bare Eyes?

If ordinary light sources generate also dark photons with same energy but with scaled up wavelength, this might have effects detectable with camera and even with bare eyes. In the following I consider in a rather light-hearted and speculative spirit two possible effects of this kind appearing in both visual perception and in photos. For crackpotters I want to make clear that I love to play with ideas to see whether they work or not, and that I am ready to accept some convincing mundane explanation of these effects and I would be happy to hear about this kind of explanations. I was not able to find any such explanation from Wikipedia using words like camera, digital camera, lense, aberrations [D3].

Why light from an intense light source seems to decompose into rays?

If one also assumes that ordinary radiation fields decompose in TGD Universe into topological light rays ("massless extremals", MEs) even stronger predictions follow. If Planck constant equals to $\hbar = q \times \hbar_0$, $q = n_a/n_b$, MEs should possess Z_{n_a} as an exact discrete symmetry group acting as rotations along the direction of propagation for the induced gauge fields inside ME.

The structure of MEs should somewhat realize this symmetry and one possibility is that MEs has a wheel like structure decomposing into radial spokes with angular distance $\Delta\phi = 2\pi/n_a$ related by the symmetries in question. This brings strongly in mind phenomenon which everyone can observe anytime: the light from a bright source decomposes into radial rays as if one were seeing the profile of the light rays emitted in a plane orthogonal to the line connecting eye and the light source. The effect is especially strong if eyes are stirred. It would seem that focusing makes the effect stronger.

Could this apparent decomposition to light rays reflect directly the structure of dark MEs and could one deduce the value of n_a by just counting the number of rays in camera picture, where the phenomenon turned to be also visible? Note that the size of these wheel like MEs would be macroscopic and diffractive effects do not seem to be involved. The simplest assumption is that most of photons giving rise to the wheel like appearance are transformed to ordinary photons before their detection.

The discussions about this led to a little experimentation with camera at the summer cottage of my friend Samppa Pentikäinen, quite a magician in technical affairs. When I mentioned the decomposition of light from an intense light source to rays at the level of visual percept and wondered whether the same occurs also in camera, Samppa decided to take photos with a digital camera directed to Sun. The effect occurred also in this case and might correspond to decomposition to MEs with various values of n_a but with same quantization axis so that the effect is not smoothed out.

What was interesting was the presence of some stronger almost vertical "rays" located symmetrically near the vertical axis of the camera. In old-fashioned cameras the shutter mechanism determining the exposure time is based on the opening of the first shutter followed by closing a second shutter after the exposure time so that every point of sensor receives input for equally long time. The area of the region determining input is bounded by a vertical line. If macroscopic MEs are involved, the contribution of vertical rays is either nothing or all unlike that of other rays and this might somehow explain why their contribution is enhanced. The shutter mechanism is unnecessary in digital cameras since the time for the reset of sensors is what matters. Something in the geometry of the camera or in the reset mechanism must select vertical direction in a preferred position. For instance, the outer "aperture" of the camera had the geometry of a flattened square.

Anomalous diffraction of dark photons

Second prediction is the possibility of diffractive effects in length scales where they should not occur. A good example is the diffraction of light coming from a small aperture of radius d. The diffraction pattern is determined by the Bessel function

$$J_1(x) \ \ , \ \ x = kdsin(\theta) \ \ , \ \ k = 2\pi/\lambda .$$

There is a strong light spot in the center and light rings around whose radii increase in size as the distance of the screen from the aperture increases. Dark rings correspond to the zeros of $J_1(x)$ at $x = x_n$ and the following scaling law for the nodes holds true

$$sin(\theta_n) = x_n \frac{\lambda}{2\pi d} per.$$

For very small wavelengths the central spot is almost point-like and contains most light intensity.

If photons of visible light correspond to large Planck constant $\hbar = q \times \hbar_0$ transformed to ordinary photons in the detector (say camera film or eye), their wavelength is scaled by q, and one has

$$sin(\theta_n) \rightarrow q \times sin(\theta_n)$$

The size of the diffraction pattern for visible light is scaled up by q.

This effect might make it possible to detect dark photons with energies of visible photons and possibly present in the ordinary light.

1. What is needed is an intense light source and Sun is an excellent candidate in this respect. Dark photon beam is also needed and n dark photons with a given visible wavelength λ could result when dark photon with $\hbar = n \times q \times \hbar_0$ decays to n dark photons with same wavelength but smaller Planck constant $\hbar = q \times \hbar_0$. If this beam enters the camera or eye one has a beam of n dark photons which forms a diffraction pattern producing camera picture in the de-coherence to ordinary photons.

2. In the case of an aperture with a geometry of a circular hole, the first dark ring for ordinary visible photons would be at $sin(\theta) \simeq (\pi/36)\lambda/d$. For a distance of $r = 2$ cm between the sensor plane ("film") and effective circular hole this would mean radius of $R \simeq rsin(\theta) \simeq 1.7$ micrometers for micron wave length. The actual size of spots is of order $R \simeq 1$ mm so that the value of q would be around 1000: $q = 2^{10}$ and $q = 2^{11}$ belong to the favored values for q.

3. One can imagine also an alternative situation. If photons responsible for the spot arrive along single ME, the transversal thickness R of ME is smaller than the radius of hole, say of of order of wavelength, ME itself effectively defines the hole with radius R and the value of $sin(\theta_n)$ does not depend on the value of d for $d > R$. Even ordinary photons arriving along MEs of this kind could give rise to an anomalous diffraction pattern. Note that the transversal thickness of ME need not be fixed however. It however seems that MEs are now macroscopic.

4. A similar effect results as one looks at an intense light source: bright spots appear in the visual field as one closes the eyes. If there is some more mundane explanation (I do not doubt

this!), it must apply in both cases and explain also why the spots have precisely defined color rather than being white.

5. The only mention about effects of diffractive aberration effects are colored rings around say disk like objects analogous to colors around shadow of say disk like object. The radii of these diffraction rings in this case scale like wavelengths and distance from the object.

6. Wikipedia contains an article from which one learns that the effect in question is known as lens flares [D8]. The article states that flares typically manifest as several starbursts, circles, and rings across the picture and result in internal reflection and scattering from material inhomogenuities in lens (such as multiple surfaces). The shape of the flares also depends on the shape of aperture. These features conform at least qualitatively with what one would expect from a diffraction if Planck constant is large enough for photons with energy of visible photon.

   The article [D14] defines flares in more restrictive manner: lense flares result when *non-image* forming light enters the lens and subsequently hits the camera's film or digital sensor and produces typically polygonal shape with sides which depend on the shape of lense diaphgram. The identification as a flare applies also to the apparent decomposition to rays and this dependence indeed fits with the observations.

The experimentation of Samppa using digital camera demonstrated the appearance of colored spots in the pictures. If I have understood correctly, the sensors defining the pixels of the picture are in the focal plane and the diffraction for large Planck constant might explain the phenomenon. Since I did not have the idea about diffractive mechanism in mind, I did not check whether fainter colored rings might surround the bright spot.

1. In any case, the readily testable prediction is that zooming to bright light source by reducing the size of the aperture should increase the size and number of the colored spots. As a matter fact, experimentation demonstrated that focusing brought in large number of these spots but we did not check whether the size was increased.

2. Standard explanation predicts that the bright spots are present also with weaker illumination but with so weak intensity that they are not detected by eye. The positions of spots should also depend only on the illumination and camera. The explanation in terms of beams of large Planck constant photons predicts this if the flux of dark photons from any light source is constant.

6.3.5 Dark Matter And Exotic Color And Electro-Weak Interactions

The presence of classical electro-weak and color gauge fields in all length scales is an unavoidable prediction of TGD and the interpretation in terms of p-adic and dark matter hierarchies is also more or less unavoidable. The new element in the interpretation is based on the observation that the quark and antiquarks at the ends of flux tubes serving as sources of classical color gauge fields could be seen as a vacuum polarization effect. In the same manner neutrino pairs at the ends of flux tubes serving as sources of classical Z^0 fields could be seem as a vacuum polarization effect.

One of the many open questions is whether also p-adic hierarchy defines a hierarchy of confinement scales for color interactions and screening scales for weak interactions or whether only the hierarchy of Planck constants gives rise to this kind of hierarchy. It would look strange if all flux tubes of macroscopic size scale would always correspond to a large value of $\hbar$ and therefore singular covering and fractionized quantum numbers. Also the proposed dark rules involving hierarchy of Mersenne rules would support the view that both hierarchies are present and there is an interaction between them in the sense that phase transitions between dark and thus scaled up counterpart of p-adic length scale and non-dark scaled up p-adic length scale can take place. The proposed stability criteria certainly allow this.

Do p-adic and dark matter hierarchies provide a correct interpretation of long ranged classical electro-weak gauge fields?

For two decades one of the basic interpretational challenges of TGD has been to understand how the un-avoidable presence of long range classical electro-weak gauge fields can be consistent with the small parity breaking effects in atomic and nuclear length scales. Also classical color gauge fields are predicted, and I have proposed that color qualia correspond to increments of color quantum numbers [K16] . The proposed model for screening cannot banish the unpleasant feeling that the screening cannot be complete enough to eliminate large parity breaking effects in atomic length scales so that one one must keep mind open for alternatives.

p-Adic length scale hypothesis suggests the possibility that both electro-weak gauge bosons and gluons can appear as effectively massless particles in several length scales and there indeed exists evidence that neutrinos appear in several scaled variants [C29] (for TGD based model see [K26]).

This inspires the working hypothesis that long range classical electro-weak gauge and gluon fields are correlates for light or massless p-adically scaled up and dark electro-weak gauge bosons and gluons. Thus both p-adic and dark hierarchies would be involved. For the p-adic hierarchy the masses would be scaled up whereas for the dark hierarchy masses would be same. The essentially new element in the interpretation would be that these fields assignable to flux quanta could be seen as vacuum polarization effects in even macroscopic length scales. This vision would definitely mean new physics effects but the interpretation would be consistent with quantum field theoretic intuition.

1. In this kind of scenario ordinary quarks and leptons could be essentially identical with their standard counterparts with electro-weak charges screened in electro-weak length scale so that the problems related to the smallness of atomic parity breaking would be trivially resolved. The weak form of electric-magnetic duality allows to identify the screening mechanism as analog of confinement mechanism for weak isospin

2. In condensed matter blobs of size larger than neutrino Compton length (about 5 μm if $k = 169$ determines the p-adic length scale of condensed matter neutrinos) the situation could be different. Also the presence of dark matter phases with sizes and neutrino Compton lengths corresponding to the length scales defined as p-adically scaled up electron Compton lengths $L_e(k) = \sqrt{5}L(k)$, $k = 151, 157, 163, 167$ in the range 10 nm-2.5 μm are suggested by the number theoretic considerations (these values of k correspond to so called Gaussian Mersennes [K21]). Only a fraction of the condensed matter consisting of regions of size $L_e(k)$ need to be in the dark phase.

3. Dark quarks and leptons would have masses essentially identical to their standard model counterparts. Only the electro-weak boson masses which are determined by a different mechanism than the dominating contribution to fermion masses [K26, K26] would be small or vanishing. Below the dark or p-adic length scale in question gauge bosons would behave like massless quanta.

4. The large parity breaking effects in living matter would be due to the presence of dark nuclei and leptons. Later the idea that super-fluidity corresponds to Z^0 super-conductivity will be discussed it might be that also super-fluid phase corresponds to dark neutron phase.

The basic prediction of TGD based model of dark matter as a phase with a large value of Planck constant is the scaling up of various quantal length and time scales. Mersenne hypothesis allows a wide range of scales so that very rich structures are possible.

Dark photon many particle states behave like laser beams decaying to ordinary photons by de-coherence meaning a transformation of dark photons to ordinary ones. Also dark electro-weak bosons and gluons would be massless or have small masses determined by the p-adic length scale in question. The decay products of dark electro-weak gauge bosons would be ordinary electro-weak bosons decaying rapidly via virtual electro-weak gauge boson states to ordinary leptons. Topological light rays ("massless extremals") for which all classical gauge fields are massless are natural space-time correlates for the dark boson laser beams. Obviously this means that the basic difference between the chemistries of living and non-living matter would be the absence of electro-weak symmetry breaking in living matter (which does not mean that elementary fermions would be massless).

Criterion for the presence of exotic electro-weak bosons and gluons

Classical gauge fields directly are space-time correlates of quantum states. The gauge fields associated with massless extremals ("topological light rays") decompose to free part and a part having non-vanishing divergence giving rise to a light-like Abelian gauge current. Free part would correspond to Bose-Einstein condensates and current would define a coherent state of dark photons.

The dimension D of the CP_2 projection of the space-time sheet serves as a criterion for the presence of long ranged classical electro-weak and gluon fields. D also classifies the (possibly asymptotic) solutions of field equations [K70].

1. For $D = 2$ induced gauge fields are Abelian and induced Kähler form vanishes for vacuum extremals: in this case classical em and Z^0 fields are proportional to each other. The non-vanishing Kähler field implies that induced gluon fields are non-vanishing in general. This raises the question whether long ranged color fields and by quantum classical correspondence also long ranged QCD accompany non-vacuum extremals in all length scales. This makes one wonder whether color confinement is possible at all and whether scaled down variants of QCD appear in all length scales.

   The possibility to add constants to color Hamiltonians appearing in the expression of the classical color gauge fields allows to have vanishing color charges in the case of an arbitrary space-time sheet. The requirement that color quantum numbers of the generator vanish allows to add the constant only to the Hamiltonians of color hyper charge and isospin so that for $D = 2$ extremals color charges can be made vanishing. This might allow to understand how color confinement is consistent with long ranged induced Kähler field.

2. For $D \geq 3$ all classical long ranged electro-weak fields and non-Abelian color fields are present. This condition is satisfied when electric and magnetic fields are not orthogonal and the instanton density $A \wedge J$ for induced Kähler form is non-vanishing. The rather strong conclusion is that in length scales in which exotic electro-weak bosons are not present, one has $D = 2$ and gauge fields are Abelian and correspond trivially to fixed points of renormalization group realized as a hydrodynamic flow at space-time sheets [L28].

Quantum classical correspondence suggests the existence of electro-weak gauge bosons with mass scale determined by the size of the space-time sheets carrying classical long range electro-weak fields. This would mean the existence of new kind of gauge bosons.

The obvious objection is that the existence of these gauge bosons would be reflected in the decay widths of intermediate gauge bosons. The remedy of the problem is based on the notion of space-time democracy suggested strongly by the fact that the interactions between space-time sheets possessing different p-adic topologies proceed with very slow rates simply because the number of common rational (algebraic) points of partonic 2-surfaces appearing in the vertex is small.

For light exotic electro-weak bosons also the corresponding leptons and quarks would possess a large weak space-time sheet but lack the ordinary weak partonic 2-surface so that there would be no direct coupling to electro-weak gauge bosons. These space-time sheets are dark in weak sense but need not have a large value of $\hbar$. This picture implies the notion of partial darkness since any space-time sheets with different ordinary of Gaussian primes are dark with respect to each other.

Do Gaussian Mersennes define a hierarchy of dark electro-weak physics?

Gaussian Mersennes are defined as Gaussian primes of form $g_n = (1 + i)^n - 1$, where n must be prime. They have norm squared $g\overline{g} = 2^n - 1$. The list of the first Gaussian Mersennes corresponds to the following values of n.

2, 3, 5, 7, 11, 19, 29, 47, 73, 79, 113, 151, 157, 163, 167, 239, 241, 283, 353, 367, 379, 457, 997, 1367, 3041, 10141, 14699, 27529, 49207, 77291, 85237, 106693, 160423 and 203789.

The Gaussian primes $k = 113, 151, 157, 163, 167$ correspond to length scales which are of most obvious interest but in TGD framework one cannot exclude the twin prime $239, 241$ corresponds to length scales $L_e(k) \simeq 160$ km and 320 km. Also larger primes could be of relevant for bio-systems and consciousness. Also the secondary and higher length scales associated with $k < 113$ could be of importance and their are several length scales of this kind in the range of biologically interesting length scales. Physics and biology inspired considerations suggests that particular Gaussian primes correspond to a particular kind of exotic matter, possibly also to large $\hbar$ phase.

$k = 113$ corresponds to the electromagnetic length scale of u and d quarks and nuclear p-adic length scale. For dark matter these length scales are scaled up by a factor $r \sim 2^{k_d}$, with k_d fixed by Mersenne hypothesis.

On basis of biological considerations (large parity breaking in living matter) there is a temptation to assign to these length scales a scaled down copy of electro-weak physics and perhaps also of color physics. The mechanism giving rise to these states would be a phase transition transforming the ordinary $k = 89$ Mersenne of weak space-time sheets to a Gaussian Mersenne and thus increasing its size dramatically.

If given space-time sheet couples considerably only to space-time sheets characterized by same prime or Gaussian prime, the bosons of these physics do not couple directly to ordinary particles, and one avoids consistency problems due to the presence of new light particles (consider only the decay widths of intermediate gauge bosons [K29]) even in the case that the loss of asymptotic freedom is not assumed.

A question arises about the interpretation of structures of the predicted size. The strong interaction size of u and d quarks, hadrons, and nuclei is smaller than $L(k = 113) \simeq 2 \times 10^{-4}$ m for even heaviest nuclei if one accepts the formula $R \sim A^{1/3} \times 1.5 \times 10^{-15}$ m. A natural interpretation for this length scale would be as the size of the field body/magnetic body of system defined by its topologically quantized gauge fields/magnetic parts of gauge fields. The (possibly dark) p-adic length scale characterizes also the lengths of flux tubes feeding gauge fluxes from elementary particle to the space-time sheet in question. The de-localization due these flux tubes in p-adic length scale in question would determine the scale of the contribution to the mass squared of the system as predicted by p-adic thermodynamics.

6.3.6 Anti-Matter And Dark Matter

The usual view about matter anti-matter asymmetry is that during early cosmology matter-antimatter asymmetry characterized by the relative density difference of order $r = 10^{-9}$ was somehow generated and that the observed matter corresponds to what remained in the annihilation of quarks and leptons to bosons. A possible mechanism inducing the CP asymmetry is based on the CP breaking phase of CKM matrix.

The TGD based view about energy [K103, K92] forces the conclusion that all conserved quantum numbers including the conserved inertial energy have vanishing densities in cosmological length scales. Therefore fermion numbers associated with matter and antimatter must compensate each other. Therefore the standard option seems to be excluded in TGD framework.

The way out could be based on the many-sheeted space-time and the possibility of cosmic strings. One particular TGD inspired model involves a small matter-antimatter asymmetry induced by the Kähler electric fields of cosmic strings [K73]. The topological condensation of fermions and anti-fermions at space-time sheets carrying Kähler electric field of say cosmic string gives rise to a binding energy which is of different sign for fermions and anti-fermions and therefore should induce the asymmetry. The outcome of the annihilation period would be matter outside cosmic strings and antimatter inside them.

One can also imagine that in a given Kähler electric field matter develops large binding energy and antimatter large positive interaction energy which induces instability leading to the splitting of partonic 2-surfaces to dark space-time sheets implying fractionization and reduction of the energy at given sheet of the covering. Dark antimatter would interact very weakly with ordinary matter so that the non-observability of antimatter would find an elegant explanation. One can imagine also the generation of local asymmetries inside Kähler electric flux tubes leading to flux tube states with matter and antimatter condensed at the opposite ends of the flux tubes.

6.4 Dark Variants Of Nuclear Physics

The book metaphor for the extended embedding space can be utilized as a guideline as one tries to imagine various exotic phases of matter. For the minimal option atomic nuclei can be assumed to be ordinary (in the sense of nuclear string model [K73] !) and only field bodies can be dark. If only singular coverings of M^4 and CP_2 are allowed the value of Planck constant is product of two integers. Ruler and compass hypothesis restricts these integers considerably and Mersenne hypothesis provides further constraints on the model. Nuclei can be visualized as residing at the "standard" pages of the book and dark color-/weak-/em- bonds are at different pages with different p-adic length scale or having different Planck constant. This would give two hierarchies of nuclei with increasing size.

6.4.1 Constraints From The Nuclear String Model

In the case of exotic nuclei nuclear string model [L2], [L2] is a safe starting point. In this model nucleons are connected by color flux tubes having exotic light fermion and anti-fermion at their ends. Whether fermion is quark or colored excitation of lepton remains open question at this stage. The mass of the exotic fermion is much smaller than 1 MeV (p-adic temperature $T = 1/n < 1$). This model predicts large number of exotic states since color bonds, which can be regarded as colored pions, can have em charges (1, -1, 0). In particular, neutral variant of deuterium is predicted and this leads to a model of cold fusion explaining its basic selection rules. The earlier model for cold fusion discussed in [K94], which served as a constraint in the earlier speculations, is not so simple than the model of [L2], [L2].

What is important that the model requires that weak bosons for which Compton length is of order atomic size are involved. Weak bosons would behave as massless particles below the Compton and the rates for the exchanges of weak bosons would be high in the length scales considered. Weak bosons would correspond to scaled up variants of the ordinary weak bosons: scaling could be p-adic in which mass scale is reduced and weak interaction rates even above Compton length would be scaled up as $1/M_W^4$. The scaling could result also from the scaling of Planck constant in which case masses of weak bosons nor weak interaction rates in the lowest order would not be affected. If only dark scaling is involved, weak interactions would be still extremely weak above dark Compton length of weak bosons. Of course, both scalings can be imagined.

The scale of the color binding energy is $E_s = .2$ MeV for ordinary ^4He strings [K73]. $k = 151, 157, 163, 167$ define Gaussian Mersennes $G_{M,k} = (1+i)^k - 1$ and excellent candidates for biologically important p-adic length scales. There are also higher Gaussian Mersennes such as those corresponding to $k = 239, 241$ and also these seem to be interesting biologically (see [K15] where a vision about evolution and generalized EEG based on Gaussian Mersennes is described). Let us assume that these scales and also those corresponding to $k = 89, 107, 113, 127$ allow scaled variants of electroweak and color interactions with ordinary value of Planck constant. If M_{127} is scaled up to Gaussian Mersenne $M_{G,167}$, one obtains cell-nucleus sized (2.58 μm) exotic nuclei and the unit of color binding energy is still.2 eV. For p-adic length scale of order 100 μm (size of large neuron) the energy scale is still around thermal energy at room temperature.

In the case of dark color bonds it is not quite clear how the unit E_s of the color binding energy scales. If color Coulomb energy is in question, one expects $1/\hbar^2$ scaling. Rather remarkably, this scaling predicts that the unit for the energy of $A < 4$ color bond scales down to.5 eV which is the energy of hydrogen bond so that hydrogen bonds, and also other molecular bonds, might involve color bonds between proton and oxygen.

6.4.2 Constraints From The Anomalous Behavior Of Water

$H_{1.5}O$ behavior of water with respect to neutron and electron scattering is observed in atto-second time scale which corresponds to 3 Angstrom length scale, defining an excellent candidate for the size scale of exotic nuclei and Compton length of exotic weak interactions.

What happens to the invisible protons?

A possible explanation for the findings is that one fourth of protons forms neutral multi-proton states connected by possibly negatively charged color bonds of length differing sufficiently from the length of ordinary O-H bond. Although the protons are ordinary, neutron diffraction reflecting the crystal like order of water in atomic length scales would not see these poly-proton super-nuclei if they form separate closed strings.

k_d	24	20	18
$k_{eff} = 116 + k_d$	140	136	134

Table 6.1: The integers k_{eff} characterize the effective p-adic length scales for some dark variants of color magnetic bodies for ^4He and $A < 4$ color magnetic bodies corresponding to $k \in \{127, 118\}$ and for the dark variants of $k = 116$ electromagnetic body for nuclear strings. Dark variants correspond to $k_d \in \{24 = 113 - 89 = 151 - 127, 20 = 127 - 107, 18 = 107 - 89\}$ allowed by Mersenne hypothesis.

1. For the ordinary nuclei the p-adic length scale associated with the color bonds between ^4He corresponds to M_{127}, and one can imagine exotic nuclear strings obtained by connecting two ordinary nuclei with color bonds. If second exotic nucleus is neutral (the model of cold fusion assumes that D nucleus is neutral) this could work since the Coulomb wall is absent. If the exotic nuclei have opposite em charges, the situation improves further. New super-dense phases of condensed matter would be predicted.

   If one fourth of hydrogen nuclei of water combine to form possibly neutral nuclear strings with average distance of nuclei of order $L(127)$, they are not visible in diffraction at atomic length scale because the natural length scale is shortened by a factor of order 32 but could be revealed in neutron diffraction at higher momentum exchanges. The transition between this kind of phase and ordinary nuclei would be rather dramatic event and the exchanges of exotic weak bosons with Compton lengths of order atomic size induce the formation of this kind of nuclei (this exchange is assumed in the model of cold fusion).

2. If dark color magnetic bonds are allowed, a natural distance between the building blocks of super-nuclei is given by the size scale of the color magnetic body. In nuclear string model the size scales of color magnetic bodies associated with nuclear strings consisting of ^4He and $A < 4$ nuclei color magnetic bodies correspond to $k = 127$ and $k = 118$ whereas em magnetic body corresponds to $k = 116$ [L2], [L2]. For dark variants of magnetic bodies the sizes of these magnetic bodies are scaled. There are several options to consider: consider only $k_d = 113 - 89 = 24$, $k_d = 127 - 107 = 20$ and $k_d = 107 - 89 = 18$. Note that one has $h_{eff} = nh$, where n is product of distinct Fermat primes and power 2^{k_d}. **Table 6.1** below summarizes the effective dark p-adic length scales involved.

3. Consider $k_d = 24$ as an example. From **Table 6.1** the scaled up p-adic length scales of the magnetic bodies would be $L(127 + 24 = 151) = 10$ nm, $L(118 + 24 = 142) = 4.4$ Angstrom, and $L(116 + 24 = 140) = 2.2$ Angstrom. The first scale equals to the thickness of cell membrane which suggests a direct connection with biology. The latter two scales correspond to molecular length scales and it is not clear why the protons of dark nuclear strings of this kind would not be observed in electron and neutron scattering. This would leave only nuclear strings formed from ^4He nuclei into consideration.

   The crucial parameter is the unit E_s of the color binding energy. Since this parameter should correspond to color Coulombic potential it could transform like the binding energy of hydrogen atom and therefore scale as $1/\hbar^2$. This would mean that $E_s = 2.2$ MeV deduced from the deuteron binding energy would scale down to .12 eV for $r = 2^{24}$.

The transition between the dark and ordinary nuclei would be favored by the minimization of Coulomb energy and energy differences would be small because of darkness. The transitions in which ordinary proton becomes dark and fuses to super-nuclear string or vice versa could be the basic control mechanism of bio-catalysis. Metabolic energy quantum.5 eV should relate to this transition.

Magic nuclei could have fractally scaled up variants in molecular length scale and tetrahedral and icosahedral water clusters could correspond to $A = 8$ and $A = 20$ magic nuclei with color bonds connecting nucleons belonging to different dark nuclei.

About the identification of the exotic weak physics?

The model of cold fusion requires exotic weak physics with the range of weak interaction of order atomic radius.

One can consider the possibility of $k = 113$ dark weak physics with $r = 2^{24}$ ($89 \rightarrow 113$ in Mersenne hypothesis) implying that the dark weak scale corresponds to p-adic length scale $k = 137$. Weak Compton length for $k = 113$ dark weak bosons would be about 3 Angstrom. Below $L(137)$ weak bosons would behave as massless particles. Above $L(137)$ weak bosons would have the mass scale $2^{-12}m_W \sim 25$ MeV and weak rates would be scaled up by 2^{48}. Bohr radius would represent a critical transition length scale and exotic weak force could have dramatic implications for the behavior of the condensed matter in high pressures when exotic weak force would become visible. In particular, chiral selection in living matter could be understood in terms of large parity breaking implied. These physics would manifest themselves only at criticality for the phase transitions changing Planck constant and would correspond to almost vacuum extremals defining a phase different from that assignable to standard model physics.

To sum up, it would seem that the variant of ordinary nuclear physics obtained by making color bonds and weak bonds dark is the most promising approach to the $H_{1.5}O$ anomaly and cold fusion. Exotic weak bosons with Compton wave length of atomic size and the most natural assumption is that they are dark $k = 113$ weak bosons with $k_d = 24 = 113 - 89$. One variant of exotic atoms is as atoms for which electromagnetic interaction between ordinary nuclei and ordinary electrons is mediated along dark topological field quanta.

6.4.3 Exotic Chemistries And Electromagnetic Nuclear Darkness

The extremely hostile and highly un-intellectual attitude of skeptics stimulates fear in anyone possessing amygdala, and I am not an exception. Therefore it was a very pleasant surprise to receive an email telling about an article published in April 16, 2005 issue of New Scientist [D71]. The article gives a popular summary about the work of the research group of Walter Knight with Na atom clusters [D38] and of the research group of Welford Castleman with Al atom clusters [D30].

The article tells that during last two decades a growing evidence for a new kind of chemistry have been emerging. Groups of atoms seem to be able to mimic the chemical behavior of single atom. For instance, clusters of 8, 20, 40, 58 or 92 sodium atoms mimic the behavior of noble gas atoms [D38]. By using oxygen to strip away electrons one by one from clusters of Al atoms it is possible to make the cluster to mimic entire series of atoms [D30]. For aluminium cluster-ions made of 13, 23 and 37 atoms plus an extra electron are chemically inert.

One can imagine two explanations for the findings.

1. The nuclei are dark in the sense that the sizes of nuclear space-time sheets are scaled up implying the smoothing out of the nuclear charge.

2. Only electrons are dark in the sense of having scaled up Compton lengths so that the size of multi-electron bound states is not smaller than electron Compton length and electrons “see” multi-nuclear charge distribution.

If darkness and Compton length is assigned with the em field body, it becomes a property of interaction, and it seems impossible to distinguish between options 1) and 2).

What one means with dark nuclei and electrons?

Can the idea about dark nuclei and electrons be consistent with the minimalist picture in which only field bodies are dark? Doesn't the darkness of nucleus or electron mean that also multi-electron states with n electrons are possible?

The proper re-interpretation of the notion Compton length would allow a consistency with the minimalist scenario. If the p-adic prime labelling the particle actually labels its electromagnetic body as p-adic mass calculations for quark masses encourage to believe, Compton length corresponds to the size scale of the electromagnetic field body and the models discussed below would be consistent with the minimal scenario. Electrons indeed “see” the external charge distribution by their electromagnetic field body and field body also carries this distribution since CP_2 extremals do not carry it. One could also defend this interpretation by saying that electrons is operationally only what can be observed about it through various interactions and therefore Compton length (various Compton length like parameters) must be assigned with its field body (bodies).

Also maximal quantum criticality implies that darkness is restricted to field bodies but does not exclude the possibility that elementary particle like structures can possess non-minimal quantum criticality and thus possess multi-sheeted character.

Option I: nuclei are electromagnetically dark

The general vision about nuclear dark matter suggests that the system consists of super-nuclei analogous to ordinary nuclei such that electrons are ordinary and do not screen the Coulomb potentials of atomic nuclei.

The simplest possibility is that the electromagnetic field bodies of nuclei or quarks become dark implying de-localization of nuclear charge. The valence electrons would form a kind of mini-conductor with electrons de-localized in the volume of the cluster. The electronic analog of the nuclear shell model predicts that full electron shells define stable configurations analogous to magic nuclei. The model explains the numbers of atoms in chemically inert Al and Ca clusters and generalizes the notion of valence to the level of cluster so that the cluster would behave like single super-atom.

The electromagnetic $k = 113$ space-time sheets (em field bodies) of quarks could have scaled up size $\sqrt{r}L(113) = L(113 + k_d) = 2^{k_d/2} \times 2 \times 10^{-14}$ m. One would have atomic size scale .8 Angstroms for $r = 2^{k_d}$, $k_d = 24$- an option already introduced. A suggestive interpretation is that the electric charge of nuclei or valence quarks assignable to their field bodies is de-localized quantum mechanically to atomic length scale. Electrons would in a good approximation experience quantum mechanically the nuclear charges as a constant background, jellium, whose effect is indeed modellable using harmonic oscillator potential.

One can test the proposed criterion for the phase transition to darkness. The unscreened electromagnetic interaction energy between a block of partially ionized nuclei with a net em charge Z with Z electrons would define the relevant parameter as $r \equiv Z^2\alpha$. For the total charge $Z \geq 12$ the condition $r \geq 1$ is satisfied. For a full shell with 8 electrons this condition is not satisfied.

Option II: Electrons are electro-magnetically dark

Since the energy spectrum of harmonic oscillator potential is invariant under the scaling of $\hbar$ accompanied by the opposite scaling of the oscillator frequency ω, one must consider also the em bodies of electrons are in large $\hbar$ phase (one can of course ask whether they could be observed in this phase!). The rule would be that the size of the bound states is larger than the scaled up electron Compton length.

The Compton wavelength of electrons would be scaled up by a factor r where r is product of different Fermat primes and power of 2 for ruler and compass hypothesis. For Mersenne hypothesis one would have $r = 2^{k_d}$. For $k_d = 24$ the effective p-adic scale of electron would be to about $L(151) = 10$ nm. The atomic cluster of this size would contain roughly $10^6 \times (a_0/a)^3$ atoms where a is atomic volume and $a_0 = 1$ Angstrom is the natural unit.

The shell model of nucleus is in TGD framework a phenomenological description justified by nuclear string model with string tension responsible for the oscillator potential. This leads to ask whether the electrons of jellium actually form analogs of nuclear strings with electrons connected by color bonds.

6.5 Has Dark Matter Been Observed?

In this section two examples about anomalies perhaps having interpretation in terms of quantized Planck constant are discussed. The first anomaly belongs to the realm of particle physics and hence does not quite fit the title of the chapter. Second anomaly relates to nuclear physics.

6.5.1 Optical Rotation Of A Laser Beam In A Magnetic Field

The group of G. Cantatore has reported an optical rotation of a laser beam in a magnetic field [D29]. The experimental arrangement involves a magnetic field of strength $B = 5$ Tesla. Laser beam travels 22000 times forth and back in a direction orthogonal to the magnetic field travelling 1 m during each pass through the magnet. The wavelength of the laser light is 1064 nm (the energy is 1.1654 eV). A rotation of $(3.9 \pm .5) \times 10^{-12}$ rad/pass is observed.

Faraday effect [D4] is optical rotation which occurs when photon beam propagates in a direction parallel to the magnetic field and requires parity breaking guaranteeing that the velocities of propagation for two circular polariations are different. Now however the laser beam is orthogonal to the magnetic field so that Faraday effect cannot be in question.

The proposed interpretation for the rotation would be that the component of photon having polarization parallel to the magnetic field mixes with QCD axion, one of the many candidates for dark matter. The mass of the axion would be about 1 meV. Mixing would imply a reduction of the corresponding polarization component and thus in the generic case induce a rotation of the polarization direction. Note that the laser beam could partially transform to axions, travel through a non-transparent wall, and appear again as ordinary photons.

The disturbing finding is that the rate for the rotation is by a factor 2.8×10^4 higher than predicted. This would have catastrophic astrophysical implications since stars would rapidly lose their energy via axion radiation.

What explanations one could imagine for the observations in TGD framework if one accepts the hierarchy of Planck constants?

1. The simplest model that I have been able to imagine does not assume axion like states. The optical rotation would be due to the leakage of the laser photons to dark pages of the Big Book at the ends of the magnet where the space-time sheet carrying the magnetic field becomes locally a vacuum extremal. This explanation would not mean direct seeing of dark matter but the observation of a transformation of ordinary matter to dark matter. Quite generally, this experimental approach might be much better strategy to the experimental proof of the existence of the dark matter than the usual approaches and is especially attractive in living matter.

2. TGD could also provide a justification for the axion based explanation of the optical rotation involving parity breaking. TGD predicts the existence of a hierarchy of QCD type physics based on the predicted hierarchy of scaled up variants of quarks and also those of color excited leptons. The fact that these states are not seen in the decay widths of intermediate gauge bosons can be understood if the particles in question are dark matter with non-standard value of Planck constant and hence residing at different page of the book like structure formed by the embedding space. I have discussed in detail the general model in the case of lepto-hadrons consisting of colored excitation of ordinary lepton and explaining quite an impressive bundle of anomalies [K101]. Since lepto-pion has quantum numbers of axion and similar couplings, it is natural to propose that the claimed axion like particle -if it indeed exists- is a pion like state consisting either exotic light quarks or leptons.

   The dark variants of hadron physics are suggestive in living matter. By p-adic length scale hypothesis one expects that the mass of axion-like state identifiable as a scaled variant of pion would relate by a power of $\sqrt{2}$ to pion mass. For 1 meV axion like particle, call it A, the mass ratio is $m(\pi)/m(A) = 2^{37} \times 1.004$ and indeed very near to a power of 2.

3. Rather interestingly, years later emerged evidence for an axion like particle interpreted as dark matter and having mass $m(A) = .11$ meV. The decays of this particle in the electric field of Josephson junction generate photon absorbed by Cooper pair are claimed to induce resonantly an anomalous Josephson current [D19] (`http://tinyurl.com/yck3qeyb`). If there exists several dark copies of hadron physics, it would not be surprising if the pions of these copies would behave like axions. Interpretation as scaled variant of electro-pion however yields a mass ratio nearer to a power of two: it consists of electron and positron and has mass $m(\pi_L) \simeq 2m_e$ given $m(\pi_L)(m(A) \simeq 1.08$. For ordinary pion the ratio is $m(\pi)(m(A) \simeq 1.14$.

4. The TGD inspired model would differ from the above model only in that the leakage to the dark sector would take place by a transformation of the laser photon to a pionlike state so that

no parity breaking would take place. But the basic point is that vacuum extremals through which the leakage can occur, break the parity strongly by the presence of classical Z^0 fields. The idea about leakage together with the non-constancy of pion-type field appearing in the coupling to the instanton density imply that the space-time sheet representing the magnetic field is vacuum extremal -at least in some regions- and this assumption looks un-necessarily strong. Also detailed assumptions about the dependence of the basic parameters appearing in PCAC hypothesis must be made.

What raised the hopes was the intriguing observation that the ratio of laser photon frequency to the cyclotron frequency of electron in the magnetic field considered equals to $r = 2^{11}$: this put bells ringing in the p-adically tuned mind and inspired the question whether one could have $\hbar/\hbar_0 = 2^{11}$. It must be however emphasized that this assumption about the values of $\hbar$ might be too restrictive. The assumption of cyclotron condensate of electron pairs at dark space-time sheet must be however justified and one must answer at least the question why it is needed. A possible answer would be that the leakage occurs via Bose-Einstein condensation to a coherent state of cyclotron photons. But this would mean return to the original model where laser photons leak! Obviously the model becomes too complicated for Occam and therefore I have dropped out the model.

The simplest model should start just from the finding that the linear polarization parallel to the magnetic field seems to leak with a certain rate as it traverses the magnet. The leakage of laser photons to a dark matter space-time sheet is what comes mind first in TGD context. A killer test for this explanation is to use polarization parallel to the magnetic field: in this case no optical rotation should take place.

1. The leakage should take place along the intersection of the pages of the Big Book which correspond to geodesically trivial geodesic sphere of CP_2 so that induced Kähler field vanishes and vacuum extremals or nearly vacuum extremals are in question. Leakage could occur within magnet or the ends of the magnet could involve this kind of critical membrane like region and as the photon passes through them the leakage could occur.

2. Since parity breaking takes place, the instanton density for the electromagnetic field provides a natural description of the situation. The interaction term is obtained by replacing either E in $E \cdot B$ with its quantized counterpart describing laser photons. This gives a linear coupling to photon oscillator operators completely analogous to a coupling to an external current and one can calculate the leakage rate using the standard rules.

3. The interaction term is total divergence and reduces to a 3-D Chern-Simons type term associated with the boundaries of the membrane like region or magnet in the general case and the leakage can be said to occur at the ends of the magnet for non-vacuum exremals.

One can ask whether one should use the instanton density of Kähler field rather than that of em field in the model. In this case Kähler gauge potential would couple the quantized em field via U(1) part of em charge. One would not have gauge invariance since for the induced Kähler field gauge degeneracy is replaced with spin glass degeneracy and gauge transformations of the vacuum extremals induced by symplectic transformations of CP_2 deform the space-time surface. In this case E in $E \cdot A$ would be replaced with the radiation field at the ends of the magnet. In order to have a non-vanishing leakage the instanton density within magnet must be non-vanishing meaning that CP_2 projection of the magnet's space-time sheet must be 4-D at least somewhere. For the first option it can be 2-D.

The coefficient K of the instanton term defining the action should depend on the value of Planck constant. $1/e^2$ proportionality of the ordinary Maxwell action means that the coefficient of the instanton term could be propertional to $\hbar$. The most general dependence $K = k(e^2\hbar/4\pi)/e^2 \equiv f(\alpha_{em}r)/e^2$, $r = \hbar/\hbar_0$. Since non-perturbative effect is in question $k((\alpha_{em}r) \propto 1/(\alpha_{em}r)$ is suggestive and guarantees that the leakage probability becomes small for large values of Planck constant.

This option will not be discussed further but it might have also relevance to the parity breaking in biology. In fact, I have proposed that the realization of genetic code based on nuclelotide dependent optical rotation of polarization of photons proposed by Gariaev [I19] could be based on Faraday effect or its analogy [K52].

One can consider also a generalization of this model by assuming that photon transforms to dark pion-like state in the leakage. In this case the action does not however reduce to a total divergence and the condition that the entire magnet corresponds to vacuum extremal seems to be unrealistic.

6.5.2 Do Nuclear Reaction Rates Depend On Environment?

Claus Rolfs and his group have found experimental evidence for the dependence of the rates of nuclear reactions on the condensed matter environment [C18]. For instance, the rates for the reactions ^{50}V(p, n)^{50}Cr and ^{176}Lu(p, n) are fastest in conductors. The model explaining the findings has been tested for elements covering a large portion of the periodic table.

Debye screening of nuclear charge by electrons as an explanation for the findings?

The proposed theoretical explanation [C18] is that conduction electrons screen the nuclear charge or equivalently that incoming proton gets additional acceleration in the attractive Coulomb field of electrons so that the effective collision energy increases so that reaction rates below Coulomb wall increase since the thickness of the Coulomb barrier is reduced.

The resulting Debye radius

$$R_D = 69\sqrt{\frac{T}{n_{eff}\rho_a}} \ , \tag{6.5.1}$$

where ρ_a is the density of atoms per cubic meter and T is measured in Kelvins. R_D is of order.01 Angstroms for $T = 373$ K for $n_{eff} = 1$, $a = 10^{-10}$ m. The theoretical model [C5, C32] predicts that the cross section below Coulomb barrier for $X(p,n)$ collisions is enhanced by the factor

$$f(E) = \frac{E}{E+U_e}exp(\frac{\pi\eta U_e}{E}) \ . \tag{6.5.2}$$

E is center of mass energy and η so called Sommerfeld parameter and

$$U_e \equiv U_D = 2.09\times 10^{-11}(Z(Z+1))^{1/2}\times(\frac{n_{eff}\rho_a}{T})^{1/2} \ eV \tag{6.5.3}$$

is the screening energy defined as the Coulomb interaction energy of electron cloud responsible for Debye screening and projectile nucleus. The idea is that at R_D nuclear charge is nearly completely screened so that the energy of projectile is $E + U_e$ at this radius which means effectively higher collision energy.

The experimental findings from the study of 52 metals support the expression for the screening factor across the periodic table.

1. The linear dependence of U_e on Z and $T^{-1/2}$ dependence on temperature conforms with the prediction. Also the predicted dependence on energy has been tested [C18].

2. The value of the effective number n_{eff} of screening electrons deduced from the experimental data is consistent with $n_{eff}(Hall)$ deduced from quantum Hall effect.

The model suggests that also the decay rates of nuclei, say beta and alpha decay rates, could be affected by electron screening. There is already preliminary evidence for the reduction of beta decay rate of ^{22}Na β decay rate in Pd [C17], metal which is utilized also in cold fusion experiments. This might have quite far reaching technological implications. For instance, the artificial reduction of half-lives of the radioactive nuclei could allow an effective treatment of radioactive wastes. An interesting question is whether screening effect could explain cold fusion [C10] and sono-fusion [C20]: I have proposed a different model for cold fusion based on large $\hbar$ in [K94].

Could quantization of Planck constant explain why Debye model works?

The basic objection against the Debye model is that the thermodynamical treatment of electrons as classical particles below the atomic radius is in conflict with the basic assumptions of atomic physics. On the other hand, it is not trivial to invent models reproducing the predictions of the Debye model so that it makes sense to ask whether the quantization of Planck constant predicted by TGD could explain why Debye model works.

TGD predicts that Planck constant is quantized in integer multiples: $\hbar = n\hbar_0$, where $\hbar_0$ is the minimal value of Planck constant identified tentatively as the ordinary Planck constant. The preferred values for the scaling factors n of $\hbar$ correspond to n-polygons constructible using ruler and compass. The values of n in question are given by $n_F = 2^k \prod_i F_{s_i}$, where the Fermat primes $F_s = 2^{2^s}+1$ appearing in the product are distinct. The lowest Fermat primes are $3, 5, 17, 257, 2^{16}+1$. In the model of living matter the especially favored values of $\hbar$ come as powers 2^{k11} [K79, K15].

It is not quite obvious that ordinary nuclear physics and atomic physics should correspond to the minimum value $\hbar_0$ of Planck constant. The predictions for the favored values of n are not affected if one has $\hbar(stand) = 2^k\hbar_0$, $k \geq 0$. The non-perturbative character of strong force suggests that the Planck constant for nuclear physics is not actually the minimal one [K94]. As a matter fact, TGD based model for nucleus implies that its "color magnetic body" has size of order electron Compton length. Also valence quarks inside hadrons have been proposed to correspond to non-minimal value of Planck constant since color confinement is definitely a non-perturbative effect. Since the lowest order classical predictions for the scattering cross sections in perturbative phase do not depend on the value of the Planck constant one can consider the testing of this issue is not trivial in the case of nuclear physics where perturbative approach does not really work.

Suppose that one has $n = n_0 = 2^{k_0} > 1$ for nuclei so that their quantum sizes are of order electron Compton length or perhaps even larger. One could even consider the possibility that both nuclei and atomic electrons correspond to $n = n_0$, and that conduction electrons can make a transition to a state with $n_1 < n_0$. This transition could actually explain how the electron conductivity is reduced to a finite value. In this state electrons would have Compton length scaled down by a factor n_0/n_1.

For instance, if one has $n_0 = 2^{11k_0}$ as suggested by the model for quantum biology [K15] and by the TGD based explanation of the claimed detection of dark matter [D29], the Compton length $L_e = 2.4 \times 10^{-12}$ m for electron would reduce in the transition $k_0 \to k_0 - 1$ to $L_e = 2^{-11}L_e \simeq 1.17$ fm, which is rather near to the proton Compton length since one has $m_p/m_e \simeq .94 \times 2^{11}$. It is not too difficult to believe that electrons in this state could behave like classical particles with respect to their interaction with nuclei and atoms so that Debye model would work.

The basic objection against this model is that anyonic atoms should allow more states that ordinary atoms since very space-time sheet can carry up to n electrons with identical quantum numbers in conventional sense. This should have been seen.

Electron screening and Trojan horse mechanism

An alternative mechanism is based on Trojan horse mechanism suggested as a basic mechanism of cold fusion [K94]. The idea is that projectile nucleus enters the region of the target nucleus along a larger space-time sheet and in this manner avoids the Coulomb wall. The nuclear reaction itself occurs conventionally. In conductors the space-time sheet of conduction electrons is a natural candidate for the larger space-time sheet.

At conduction electron space-time sheet there is a constant charged density consisting of n_{eff} electrons in the atomic volume $V = 1/n_a$. This creates harmonic oscillator potential in which incoming proton accelerates towards origin. The interaction energy at radius r is given by

$$V(r) = \alpha n_{eff}\frac{r^2}{2a^3} , \tag{6.5.4}$$

where a is atomic radius.

The proton ends up to this space-time sheet by a thermal kick compensating the harmonic oscillator energy. This occurs below with a high probability below radius R for which the thermal energy $E = T/2$ of electron corresponds to the energy in the harmonic oscillator potential. This gives the condition

$$R = \sqrt{\frac{Ta}{n_{eff}\alpha}a} . \quad (6.5.5)$$

This condition is exactly of the same form as the condition given by Debye model for electron screening but has a completely different physical interpretation.

Since the proton need not travel through the nuclear Coulomb potential, it effectively gains the energy

$$E_e = Z\frac{\alpha}{R} = \frac{Z\alpha^{3/2}}{a}\sqrt{\frac{n_{eff}}{Ta}} . \quad (6.5.6)$$

which would be otherwise lost in the repulsive nuclear Coulomb potential. Note that the contribution of the thermal energy to E_e is neglected. The dependence on the parameters involved is exactly the same as in the case of Debye model. For $T = 373$ K in the ^{176}Lu experiment and $n_{eff}(Lu) = 2.2 \pm 1.2$, and $a = a_0 = .52 \times 10^{-10}$ m (Bohr radius of hydrogen as estimate for atomic radius), one has $E_e = 28.0$ keV to be compared with $U_e = 21 \pm 6$ keV of [C18] ($a = 10^{-10}$m corresponds to 1.24×10^4 eV and 1 K to 10^{-4} eV). A slightly larger atomic radius allows to achieve consistency. The value of $\hbar$ does not play any role in this model since the considerations are purely classical.

An interesting question is what the model says about the decay rates of nuclei in conductors. For instance, if the proton from the decaying nucleus can enter directly to the space-time sheet of the conduction electrons, the Coulomb wall corresponds to the Coulomb interaction energy of proton with conduction electrons at atomic radius and is equal to $\alpha n_{eff}/a$ so that the decay rate should be enhanced.

6.5.3 Refraction Of Gamma Rays From Silicon Prism?

The following considerations were inspired by to a popular article [D17] (`http://tinyurl.com/ydautan4`) telling about refraction of gamma rays from silicon prisms. This should not be possible and since I love anomalies I got interested. Below I discuss the discovery from the point of standard physics and TGD point of view.

What happens in refraction?

Absorption, reflection, and refraction are basic phenomena of geometric optics (see `http://tinyurl.com/y7bqfu8m`) [D5] describing the propagation of light in terms of light rays and neglecting interference and diffraction making it possible for light to "go around the corner". The properties of medium are described in terms of refraction index n which in general is a complex quantity. The real part of n gives the phase velocity of light in medium using vacuum velocity c as unit, which - contrary to a rather common misconception - can be also larger than c as a phase velocity which cannot be assigned to energy transfer. The imaginary part characterizes absorption. n depends in general on frequency of the incoming light and the resonant interactions of light with the atoms of medium make themselves manifest in the frequency dependence of n - in particular in absorption described by the imaginary part of n.

What happens in the boundary of two media - reflection or refraction - is characterized the refraction index boundary conditions for radiation fields at the boundary, which are essentially Maxwell's equations at the discontinuity. Snell's law tells what happens to the direction of the beam and states essentially that only the momentum component of incoming photon normal to the boundary changes in these processes since only the translational symmetry in normal direction is changed.

How refractive index is determined?

What determines the index of refraction (see `http://tinyurl.com/qcdk687`) [D7] ? To build a microscopic theory for n one must model what happens for the incoming beam of light in medium. One must model the scattering of light from the atoms of the medium.

In the case of condensed matter X ray diffraction is excellent example about this kind of theory. In this case the lattice structure of the condensed matter system makes the situation simple. For infinitely large medium and for an infinitely wide incoming beam the scattering amplitude is just the Fourier transform of the density of atoms for the change of the wave vector (or equivalently momentum) of photon, which must be a vector in the resiprocal lattice of the crystal lattice. Therefore the beam is split into beams in precisely defined directions. The diffracted beam has a sharp maximum in forward direction and the amplitude in this direction is essentially the number of atoms.

In less regular situation such as for water or bio-matter for which regular lattice structure typically exists only locally the peaking to forward direction, is even more pronounced, and in the first approximation the beam travels in the direction that it has after entering to the system and only the phase velocity is changed and attenuation takes place. Diffraction patterns are however present also now and allow to deduce information about the structure of medium in short length scales. For instance, Delbrueck diffraction from biological matter allowed to deduce structural information about DNA and deduce its structure.

This description contains an important implicit assumption. The width and length of the incoming photon beam must be so large that the number of atoms inside it is large enough. If this condition is not satisfied, the large scale interference effects crucial for diffraction do not take place. For very narrow beams the situation approaches to a scattering from single atom and one expects that the beam is gradually widened but that it does not make sense to speak about refraction index and that the application of Snell's law does not make sense. Incoming photons see individual atoms rather than the lattice of atoms. For this reason the prevailing wisdom has been that it does not make sense to speak about bending of gamma rays from solid state. A gamma ray photon with energy of one MeV corresponds to a wavelength λ of about 10^{-12} meters which is of same order as electron Compton length. One expects that the width and length of gamma ray beam is measured using λ as a natural unit. Even width of 100 wavelengths corresponds to 1 Angstrom which corresponds to the size scale of single atom.

Surprise

The real surprise was that gamma rays bend in prisms made from silicon! The discovery (see `http://tinyurl.com/ydautan4`) was made by a group of scientists working in Ludwig-Maximilians-Universität in Munich [D17, D16, D35]. The group was led by Dietrich Habs. The gamma ray energies where in the range.18-2 MeV. The bending known as refraction was very small using every day standards. The value of the refractive index which gives the ratio c/v for light velocity c to the light velocity v in silicon is $1 + 10^{-9}$ as one learns from another popular article (see `http://tinyurl.com/p4zy9a6`) [D16]. When compared to the predictions of the existing theory, the bending was however anomalously large. By the previous argument it should not be even possible to talk about bending.

Dietrich Habs suggests that so called Delbrueck scattering of gamma rays from virtual electron positron pairs created in the electric fields of atoms could explain (see `http://tinyurl.com/ydautan4`) the result. This scattering would be diffraction (scattering almost totally in forward direction as for light coming through a hole). This cannot however give rise to an effective scattering from a many-atom system unless the gamma ray beam is effectively or in real sense scaled up. The scattering would be still from single atom or even part of single atom. One could of course imagine that atoms themselves have hidden structure analogous to lattice structure but why virtual electron pairs could give rise to it?

In the following I discuss two TGD inspired proposals for how the diffraction that should not occur could occur after all?

Could gamma rays scatter from quarks?

There is another strange anomaly that I discussed for a couple of years ago christened as the incredibly shrinking proton (see `http://tinyurl.com/y9aklsbk`) [K30]. It was found that protons charge distribution deviates slightly from the expected one. The TGD inspired explanation was based on the observation that quarks in proton are rather light having masses of 5 and 20 MeV. These correspond to gamma ray energies. Therefore the Compton wave lengths of quarks are also rather long, much longer than the Compton length of proton itself! Parts would be larger than the whole! The explanation for this quantum mystical fact would be that the Compton length corresponds to length scale assignable to color magnetic body of quark. Could it be that the scattering gamma rays see the magnetic bodies of $3 \times 14 = 42$ valence quarks of 14 nucleons of Si nucleus. The regular structure of atomic nucleus as composite of quark magnetic would induce the diffractive pattern. If so, we could do some day nuclear physics and perhaps even study the structure of proton by studying diffraction patterns of gamma rays on nuclei!

Could part of gamma beam transform to large $\hbar$ gamma rays?

Also the hierarchy of Planck constants (see `http://tinyurl.com/y7c8e6x8`) [K81] comes in mind. Scaling of $\hbar$ for a fixed photon energy scales up the wavelength of gamma ray. Could some fraction of incoming gamma rays suffer a phase transition increasing their Planck constant? The scaling of Planck constant make gamma rays to behave like photons with scaled up wavelength. Also the width of the beam would be zoomed up. As a result the incoming gamma ray beam would see a group of atoms instead of single atom and for a large enough value of Planck constant one could speak of diffraction giving rise to refraction.

For years ago I considered half jokingly the possibility that hierarchy of Planck constants could imply quantum effects in much longer scales than usually [K81]. Diffraction would be a typical quantum effect involving interference. Perhaps even the spots seen sometimes in ordinary camera lense could be analogous to diffractive spots generated by diffraction of large $\hbar$ visible photons through a hole (they should usually appear in the scale of visible wavelength about few microns [K80]. Take this as a joke!

I also proposed that strong classical em fields provide the environment inducing increase of Planck constant at some space-time sheets. The proposal was that Mother Nature is theoretician friendly [K81]. As perturbation expansion in powers of $1/\hbar$ fails, Mama Nature scales up $\hbar$ to make the life of her theorizing children easier, one might say. Strong electric and magnetic fields of atomic nuclei believed by Habs to be behind the diffraction might provide the manner to generate large Planck constant phases and dark matter.

6.6 Water And New Physics

In this section the previous ideas are applied in an attempt to understand the very special properties of water.

6.6.1 The 41 Anomalies Of Water

The following list of 41 anomalies of water taken from [D64] should convince the reader about the very special nature of water. The detailed descriptions of the anomalies can be found in [D64]. As a matter fact, the number of anomalies had grown to 63 when I made my last visit to the homepage of Chaplin.

The many anomalies of water need not be all due to the presence of the dark matter. As suggested already fifteen years ago, p-adic length scale hierarchy forces to replace ordinary thermodynamics with a p-adic fractal hierarchy of thermodynamics and this means that one must speak about thermodynamics in a given length scale rather than mere thermodynamics of continuous matter.

Instead of listing just the anomalies I suggest also a possible interpretation based on the assumption that some fraction of protons (and perhaps also OH^- ions) is dark. This hypothesis is motivated by the scattering data suggesting that $H_{1.5}O$ is the proper chemical formula for water in atto-second time scale and explained by assuming that about 1/4 of protons are dark in the experimental situation. It is natural to assume that the increase of temperature or pressure reduces the dark portion. Unless the establishment of equilibrium ratio for dark and ordinary phase is very fast process, water can be regarded as a two-phase system mathematically. A continuous spectrum of metastable forms of water and ice distinguished by the ratio of the densities of ordinary and dark phase is expected. Complex phase diagrams is also a natural outcome.

Dark portion is expected to induce long range correlations affecting melting/boiling/critical points, viscosity, and heats of vaporization and fusion. Anomalous behaviors under the changes of temperature and pressure and anomalies in compressibility and thermal expansivity are expected. Specific heats and transport properties are affected by the presence of dark degrees of freedom, and the coupling of electromagnetic radiation to dark degrees of freedom influences the di-electric properties of water.

In order to systematisize the discussion I have classified the anomalous to different groups.

1. Anomalies suggesting the presence of dark phase inducing long range correlations.

   (a) Water has unusually high melting point.
   (b) Water has unusually high boiling point.
   (c) Water has unusually high critical point.
   (d) Water has unusually high surface tension and can bounce.
   (e) Water has unusually high viscosity.
   (f) Water has unusually high heat of vaporization.

   Comment: The presence of dark portion implies long range correlations and they could help to restore solid/liquid phase, raise the critical point, increase surface tension, increase viscosity and require more energy to achieve vaporization. The ability to bounce would suggest that dark portion of water -at least near the surface- is in solid phase. Dark water is in rubber-like phase also in the interior below a length scale defined by the length of dark flux tubes.

2. Anomalies related to the effect of temperature increase.

   (a) Water shrinks on melting.
   (b) Water has a high density that increases on heating (up to 3.984°C).
   (c) The number of nearest neighbors increases on melting.
   (d) The number of nearest neighbors increases with temperature.
   (e) Water shows an unusually large viscosity increase but diffusion decrease as the temperature is lowered.
   (f) At low temperatures, the self-diffusion of water increases as the density and pressure increase.
   (g) Water has a low coefficient of expansion (thermal expansivity).
   (h) Water's thermal expansivity reduces increasingly (becoming negative) at low temperatures.

   Comment: The increase of temperature induces shrinking of the flux tubes connecting water molecules in the phase transition reducing Planck constant and brings the molecules closer to each other. This could explain shrinking on melting, the increase of the density in some temperature range above which the normal thermal expansion would win the shrinking tendency, the increase of nearest neighbors on melting and with the increase of temperature. Concerning the shrinking on melting one can however argue that the regular lattice like structure of ice is not that with minimum volume per molecule so that no new physics would be needed unless it is needed to explain why the volume per molecule is not minimum.

   The unusually large viscosity increase with reduce temperature would be due to the increase of the large $\hbar$ portion inducing long range correlations. If the diffusion takes place only in the normal phase the anomalous reduction of diffusion could be due to the reduction of the density of the normal phase. Similar explanation applies to the behavior of self-diffusion.

   The low value of coefficient of thermal expansion could be understood in terms of the phase transitions reducing the flux tube lengths and bringing the molecules near to each other and thus reducing the normal thermal expansion. At low enough temperatures the expansivity would become negative since this effect would overcome the normal thermal expansion.

3. Anomalies related to the effects of pressure.

(a) Pressure reduces its melting point (13.35 MPa about 133.5 times the standard atmospheric pressure) gives a melting point of -1°C)

(b) Pressure reduces the temperature of maximum density.

(c) D_2O and T_2O differ from H_2O in their physical properties much more than might be expected from their increased mass; e.g. they have increasing temperatures of maximum density (11.185°C and 13.4°C respectively).

(d) Water's viscosity decreases with pressure (at temperatures below 33°C).

Comment: The reduction of melting point, temperature of maximum density, and viscosity with pressure could be due to the reduction of the dark portion as pressure increases. Pressure would induce the phase transition reducing the value of Planck constant for the flux tubes connecting water molecules. That the situation is different for D_2O and T_2O could be understood if dark D and T are absent. The question is what happens in the transition to solid phase. The reduction of the density would conform with the idea that the portion of dark phase increases. The reduction of viscosity with pressure would would follow from the reduction of dark phase causing long range correlations.

4. Anomalies related to compressibility.

   (a) Water has unusually low compressibility.

   (b) The compressibility drops as temperature increases down to a minimum at about 46.5°C. Below this temperature, water is easier to compress as the temperature is lowered.

   Comment: The anomalously high compressibility below 46.5°C could be understood if only the standard phase responds to pressure appreciably. In this case the effective density is smaller than the net density and make it easier to compress the water as the temperature is lowered. The increase of temperature would increase the effective density as dark matter is transformed to ordinary one and reduce the compressibility. Above 46.5°C the effect of dark matter would be overcome by the increase of compressibility due to the increase of temperature.

   (c) The speed of sound increases with temperature (up to a maximum at 73°C).

   Comment: The speed of sound is given by the expression

$$c^2 = \frac{\partial p}{\partial \rho} \quad .$$

   Pressure p is essentially the density of thermal energy associate with the ordinary matter. When the fraction of ordinary matter increases the pressure effectively increases and this leads to the increase of c.

   (d) Under high pressure water molecules move further away from each other with increasing pressure.

   Comment: The behavior under increasing high pressure is in conflict with the hypothesis that pressure tends to reduce the portion of dark phase. The question is why the increase of pressure at high enough pressures would induce phase transition increasing the value of Planck constant for the flux tubes connecting the molecules? If the dark matter does not respond to pressure appreciably, the increase of the portion of dark matter might allow the minimization of energy. Does this mean that the work done by the high enough pressure to reduce the volume is larger than the energy needed to induce the tunnelling to the dark phase?

5. Anomalies related to the heat capacity.

   (a) Water has over twice the specific heat capacity of ice or steam.

   (b) The specific heat capacity (C_P and C_V) is unusually high.

   (c) Specific heat capacity C_P has a minimum.

Comment: The anomalously high heat capacity of water could be understood in terms of dark non-translational degrees of freedom even if the dark phase is rubber-like below the length scale of the dark flux tubes. The energy pumped to the system would go to these degrees of freedom. The small heat capacity of solid phase would suggest that the freezing means also freezing of these degrees of freedom meaning the reduction of the contribution to heat capacity.

6. Anomalies related to phase transitions

   (a) Supercooled water has two phases and a second critical point at about -91°C.

   (b) Liquid water may be supercooled, in tiny droplets, down to about -70°C. It may also be produced from glassy amorphous ice between -123°C and - 149°C and may coexist with cubic ice up to -63°C.

   (c) Solid water exists in a wider variety of stable (and metastable) crystal and amorphous structures than other materials.

   (d) The heat of fusion of water with temperature exhibits a maximum at -17°C.

   Comment: The presence of both dark and ordinary phase with varying ratio of densities could help to understand the richness of the structures below freezing point. For instance, one can imagine that either the ordinary or dark phase is super-cooled and the other freezes.

7. Anomalies of solutions of water.

   (a) Solutes have varying effects on properties such as density and viscosity.

   (b) None of its solutions even approach thermodynamic ideality; even D_2O in H_2O is not ideal.

   (c) The solubilities of non-polar gases in water decrease with temperature to a minimum and then rise.

   Comment: The different interactions of solutes with the dark phase could explain these findings. For instance, the probability that the presence of solute induces a phase transition reducing the portion of the dark phase could depend on solute. The decrease of the solubilities of non-polar gases in water with temperature could be due to the fact that the solubility is at low temperatures basically due to the presence of the dark phase. At higher temperatures higher thermal energies of the solute molecules would increase the solubility.

8. Anomalies in transport properties.

   (a) NMR spin-lattice relaxation time is very short at low temperatures.

      Comment: The transfer of magnetic energy to the dark degrees of freedom could dominate the relaxation process. If synchrotron Bose-Einstein condensates are present in dark degrees of freedom this might make sense.

   (b) Hot water may freeze faster than cold water; the Mpemba effect [D10]. For instance, water sample in 100 C freezes faster than that in 35 C.

      Comment: This effect seems to be in conflict with thermodynamics and remains poorly understood. The possibility of having continuum of metastable two-phase systems suggests a possible solution to the mystery. The freezing of the dark portion of water should occur slower than the freezing of the ordinary portion since the heat transfer rate is expected to be lower for a larger value of Planck constant. The very naïve just-for-definiteness estimate is that the transfer rate for energy to the cold system is inversely proportional to $1/\hbar$. If the formation of dark phase is a slow process as compared to the transfer of energy to the cold phase, the freezing of hot water would lead to a metastable ice consisting mostly of ordinary water molecules and takes place faster than the freezing of cold water already containing the slowly freezing dark portion.

(c) Proton and hydroxide ion mobilities are anomalously fast in an electric field.

Comment: Mobility is of form $a\tau$, where a the acceleration a in the electric field times the characteristic time τ for motion without collisions. If part of protons move along dark flux tubes this time is longer. The high mobility of OH_- ions would suggest that also these can be in dark phase.

(d) The electrical conductivity of water rises to a maximum at about 230°C and then falls.

Comment: Electrical conductivity is closely related to mobility so that the same argument applies.

(e) The thermal conductivity of water is high and rises to a maximum at about 130°C.

Comment: The anomalously high thermal conductivity could be due to the motion of heat carriers along dark flux tubes with low dissipation.

(f) Warm water vibrates longer than cold water.

Comment: This could be due to the faster transfer of vibrational energy to the dark vibrational of magnetic degrees of freedom. If the number of these degrees of freedom is higher than the number of ordinary degrees of freedom, one can understand also the anomalously high heat capacity. Vibration could continue in dark degrees of freedom in which case the effect would be apparent. If its only the ordinary water which vibrates in the original situation then equipartition of energy with dark degrees of freedom implies apparent dissipation.

9. Anomalous electromagnetic properties of water.

(a) X-ray diffraction shows an unusually detailed structure.

Comment: This would not be surprising if two phases with possibly varying ratio are present. For instance, the different X-ray diffraction patterns for water obtained by a rapid freezing from high and low temperatures could serve as a test for the proposed explanation of Mpemba effect.

(b) The dielectric constant is high and behaves anomalously with temperature.

Comment: This could relate to the interaction of photons with dark portion of water. Dielectric constant characterizes the coupling of radiation to oscillatory degrees of freedom and is sum of terms proportional to $1/(\omega^2 - \omega_i^2)$, where ω_i is resonance frequency. If the resonance frequencies ω_i scale as $1/\hbar$, dark portion gives a larger contribution at frequencies $\omega < \omega_i$. In particular the static dielectric constant increases.

(c) The refractive index of water has a maximum value at just below 0°C.

Comment: It is not quite clear whether this maximum corresponds to room pressure or appears quite generally. Let us assume the first option. In any case the dependence of the freezing temperature on pressure is very weak. The maximal interaction with the dark portion of water at freezing point combined with the above argument would predict that refractive index increases down to the freezing point. The reduction of the density at freezing point would reduce the refractive index since dynamic susceptibility is proportional to the density of atom so that a maximum would be the outcome.

These examples might serve as a motivation for an attempt to build a more detailed model for the dark portion of water. The model to be discussed was one of the first attempts to understand the implications of the idea about hierarchy of Planck constants. Since five years have passed is badly in need of updating.

6.6.2 The Model

Networks of directed hydrogen bonds $H - O - H \cdots OH_2$ with positively charged H acting as a binding unit between negatively charged O (donor) and OH_2 (acceptor) bonds explaining clustering of water molecules can be used to explain qualitatively many of the anomalies at least qualitatively [D64].

The anomaly giving evidence for anomalous nuclear physics is that the physical properties D_2O and T_2O differ much more from H_2O than one might expect on basis of increased masses of water molecules. This suggests that dark protons could be responsible for the anomalies. That heavy water in large concentrations acts as a poison is consistent with the view that the macroscopic quantum phase of dark protons is responsible for the special biological role of water.

What proton darkness could mean?

In the experimental situation one fourth of protons of water are not seen in neither electron nor neutron scattering in atto-second time scale which translates 3 Angstrom wavelength scale suggesting that in both cases diffraction scattering is in question. This of course does not mean that the fraction of dark protons is always 1/4 and it is indeed natural to assume that it is reduced at higher temperatures. Both nuclear strong interactions and magnetic scattering contribute to the diffraction which is sensitive to the intra-atomic distances. The minimal conclusion is that the protons form a separate phase with inter-proton distance sufficiently different from that between water molecules and are not seen in neutron and electron diffraction in the atto-second time scale at which protons of water molecule are visible. The stronger conclusion is that they are dark with respect to nuclear strong interactions.

The previous considerations inspired by the model of nuclei as nuclear strings suggests possible explanations.

1. Hydrogen atoms form analogs of nuclear strings connected by color bonds.

2. Nuclear protons form super-nuclei connected by dark color bonds or belong to such super-nuclei (possibly consisting of ^4He nuclei). If color bonds are negatively charged, closed nuclear strings of this kind are neutral and not visible in electron scattering: this assumption is however un-necessarily strong for invisibility in diffractive scattering in atto-second time scale. Only the field bodies of proton carrying weak and color fields could be dark and electromagnetic field body has ordinary value of Planck constant so that dark protons could give rise to ordinary hydrogen atoms.

Could also the color flux tubes connecting quarks inside dark protons be dark?

The first option is that only the color flux tubes connecting protons are dark and of length of atomic size scale. The second possibility is that also the color flux tubes connecting quarks are dark and have length of order atomic size scale. Dark nucleons could be visualized as strings formed from three quarks of order atom size scale connected by color flux tubes. The generalization of the nuclear string model leads to a model of dark nucleon discussed in detail [L2, K19, K104], [L2]. Dark nucleons would in turn form dark nuclei as string like objects.

The amazing finding is that the states of nucleon assumed to be neutral (for definiteness) are in one-one-correspondence with DNA, RNA, mRNA, tRNA and amino-acids and that a physically natural pairing of DNA codons and amino-acids exists and consistent with vertebrate genetic code. Same applies also to nucleons having the charge of proton. The nuclear strings formed from either dark neutrons or dark protons could in principle realize genetic code. This realization would be more fundamental than the usual chemical realization and would force to modify profoundly the ideas about prebiotic evolution. The prebiotic evolution could be evolution of water and the recent evolution could involve genetic engineering based on virtual world experimentation with the dark variant variant of the genetic apparatus. The minimum requirement would be the transcription of at dark DNA defined by nuclear strings to ordinary DNA. Dark nuclear strings could be able to diffuse without difficulties through cell membranes and the transcription of the dark genes to ordinary ones followed by gluing and pasting to genome could make possible the genetic engineering at the level of germ cells.

Another natural hypothesis is that the magnetic bodies assignable to the nuclear strings are responsible for water memory [K19] and that the mechanism of water memory relies on the mimicry of biologically active molecules by dark proton strings. The frequencies involved with water memory are low and nothing to do with molecular energy levels. This is consistent with the identification as cyclotron frequencies so that it would be enough to mimic only the cyclotron spectrum. The mechanism would be similar to that of entrainment of brain to external frequencies and based on the variation of the thickness of magnetic flux tubes or sheets inducing the change of magnetic field and cyclotron frequency. One could perhaps say that magnetic bodies of dark genes as living creatures with some amount of intelligence and ability to planned actions. The evolution of cells up to the neurons of cortex could be accompanied by the evolution of the magnetic bodies of dark nuclear strings realized as the emergence of higher values of Planck constant.

Concerning the mechanism of the debated homeopathic effect itself the situation remains unclear. Homeopathic remedy is obtained by a repeated dilution and succussion of the solution containing the molecules causing the symptoms of the disease [K19]. If the cyclotron frequencies of the magnetic body alone are responsible for the biological effect, one can wonder why the homeopathic remedy does not have the same undesired effects as the original molecule. A more reasonable hypothesis is that the cyclotron frequency spectrums serves only as a signature of the molecule and the homeopathic remedy only activates the immune system of the organism by cheating it to believe that the undesired molecules are present. The immune system is known to be subject to very fast genetic evolution, and dark nuclear strings forming representations of biologically active molecules and dark genome could be actively involved with this evolution.

What inspires to take these speculations more than as a poor quality entertainment is that the recent findings of the group led by HIV Nobelist Montagnier related to water memory provide support for the hypothesis that a nonstandard realization of genetic code indeed exists [I25]. These findings will be discussed later in this section.

Model for super-nuclei formed from dark protons

Dark protons could form super nuclei with nucleons connected by dark color bonds with $\hbar = r\hbar_0$ with $r = 2^{k_d}$, $k_d = 151 - 127 = 24$. The large distance between protons would eliminate isospin dependent strong force so that multi-proton states are indeed possible. The interpretation would be that nuclear p-adic length scale is zoomed up to $L(113+24 = 137) \sim .78$ Angstroms. Dark color bonds could also connect different nuclei. The earlier hypothesis $r = 2^{11k}$ encourages to consider also $k_d = 22$, which is also one of the favored dark scalings allowed by Mersenne hypothesis ($22 = 18 + 4 = 107 - 89 + 167 - 163$) giving p-adic scale .39 Angstroms.

The predictions of the model for bond energy depend on the transformation properties of E_s under the scaling of $\hbar$.

1. For small perturbations harmonic oscillator approximation $V \propto kR^2/2 \propto \alpha R^2/2$ makes sense and is invariant under the scalings $\alpha_s \to \alpha_s/r$ and $R \to \sqrt{r}R$ -at least if the scalings are not too large. Bonds with different values of Planck constant have nearly identical energies, which would be indeed consistent with the idea about criticality against the change of Planck constant.

   One can arrive the same conclusion follows also in different manner. The parameter ω corresponds to a quantity of form $\omega = v/L$, where L is a characteristic length scale and v a characteristic velocity. The scaling law of homeopathy [K19] would suggest the dependence $v = c/\sqrt{r}$ and $L \propto \sqrt{r}L$ giving predicting that energy is invariant.

   The result also conforms with the idea that classical perturbative theory does not involve Planck constant. This behavior does not however allow to identify hydrogen as color bonds since the resulting bond energies would be in MeV range.

2. The interpretation of E_s as color Coulombic potential energy α_s/R would suggest that E_s behaves under scaling like the binding energy of hydrogen atom ($1/r^2$ scaling). This interpretation implies non-perturbative effects since in semiclassical approximation energy should not depend on r. Color force is non-perturbative so that one can defend this assumption.

   (a) For $k_d = 24$ E_s would be about.12 eV and considerably lower than the nominal energy of the hydrogen bond.

   (b) For $k_d = 22$ one would obtain energy .48 eV. This energy is same as the universal metabolic energy quantum so that the basic metabolic processes might involve transitions dark-ordinary transition for protons. This would however suggest that the length of color bond is same as that of hydrogen bond so that the protons in question would not be invisible in diffraction in atto-second time scale. The interpretation of color bonds between atoms as hydrogen bonds is much more attractive. Of course, for large values of Planck the invariance of oscillator spectrum implies very large force constant so that the color bond would become very rigid.

These two interpretations are not contradictory if one interprets the non-perturbative contribution to the color binding energy as an additional constant contribution to the harmonic oscillator Hamiltonian which does not contribute the spectrum of excitations energies but only to the ground state energy.

The notion of flux tube state

An approach based more heavily on first principles that the above order of magnitude estimates is inspired by two steps of progress several years after these speculations.

1. Weak form of electric-magnetic duality

The weak form of electric magnetic duality led to an identification of a concrete mechanism of electroweak screening based on the pairing of homological Kähler magnetic monopoles formed by fermion wormhole throats with oppositely magnetically charged wormhole throats carrying quantum numbers of neutrino pair and screening the weak isospin and leaving only electromagnetic charge.

1. The size scale of the Kähler magnetic flux tubes connecting the magnetic monopoles would be of order intermediate gauge boson Compton length. For dark variants of elementary fermions it would be scaled up by $\sqrt{\hbar/\hbar_0}$. The new weak physics involving long range weak fields would be associated with magnetic flux tube like structures. Same conclusion applies also to new QCD type physics since also color confinement would be accompanied Kähler magnetic confinement. This allows to pose very strong restrictions on the models. For instance, it is quite possible that the notion of neutrino atom does not make sense expect if one can assume that the dark quarks feed their weak Z^0 gauge fluxes through a spherically symmetric flux collection of radial flux tubes allowing Coulombic Z^0 gauge potential as an approximate representation inside the radius defined by the length of the flux tubes.

2. It is important to notice that the screening leaves the vectorial coupling to classical Z^0 field proportional to $sin^2(\theta_W)Q_{em}$. This could have non-trivial physical implications perhaps allowing to kill the model.

   (a) For space-time surfaces near vacuum extremals the classical Z^0 fields are strong due to the condition that the induced Kähler field is very weak. More explicitly, from the equations for classical induced gauge fields in terms of Kähler form and classical Z^0 field [L1], [L1]

   $$\gamma = 3J - \tfrac{p}{2}Z^0 \ , \quad Q_Z = I_L^3 - pQ_{em} \ , \quad p = sin^2(\theta_W) \tag{6.6.1}$$

   it follows that for the vacuum extremals the part of the classical electro-weak force proportional to the electromagnetic charge vanishes for $p = 0$ so that only the left-handed couplings to the weak gauge bosons remain. The vanishing of induced Kähler form gives

   $$Z^0 = -\frac{2}{p}\gamma \ . \tag{6.6.2}$$

   The condition implies very large effective coupling to the classical electromagnetic field since electromagnetic charge is effectively replaced with

   $$Q_{em,eff} = Q_{em} - \frac{2}{p}(I_L^3 - pQ_{em}) \ . \tag{6.6.3}$$

   (b) The proposed model for cell membrane as a Josephson junction relies on almost vacuum extremals and dark nuclei in the sense that the weak space-time sheet associated with the nuclei of biological important ions (at least) are dark [K41]. It is is assumed that quarks are dark in the length scale considered so that also their weak isospin remains unscreened. In the case of nuclei this means that there is contribution from the vectorial part of weak isospin given by $(Z-N)/4$ proportional to the difference of proton number and neutron number. The dominating contribution comes from Q_{em} term for heavier nuclei. It is essential that weak space-time sheets of electrons are assumed to be ordinary.

(c) One can ask whether the nuclei could be ordinary nuclei. If so, one must still assume that the electrons of the nuclei do not couple to the classical fields assignable to the cell membrane space-time sheet since without this assumption the coupling to Z^0 field would be proportional to the total em charge of the ion rather than nuclear em charge. It is difficult to justify this assumption. In any case, for this option I_L^3 contribution would be totally absent. This affects the effective couplings of biologically important ions to the membrane potential somewhat and modifies the nice quantitative predictions of the model of photoreceptors predicting correctly the frequencies of visible light with maximal response.

2. The notion of flux tube state

The TGD inspired explanation for the finding that the measurement of Lamb shift for muonic hydrogen atom gives proton radius which is 4 per cent smaller than that deducible from ordinary hydrogen atom led to the notion of flux tube state in which muon or electric is confined inside flux tube [K29]. In non-relativistic approximation based on Schrödinger equation, the model leads to wave functions expressible in terms of Airy and "Bairy" functions and WKB approximation allows to deduce an estimate for the energy eigenvalue spectrum. This model works as such also as a model for flux tubes states in which also classical electroweakandcolor fields are involved. Color holonomy is quite generally Abelian for classical color fields and for 2-D CP_2 projection electroweak fields are also Abelian so that the model is expected to be mathematically reasonably simple even when induced spinors are assumed.

The concept of flux tube state is very general and allow to model at least some chemical bonds. In particular, valence bonds might allow description as flux tube states of valence electrons. Hydrogen bonds are responsible for the clustering of water molecules and an obvious question is whether these bonds could be modeled as dark flux tube states of valence electrons. The model is testable since one can predict the energy spectrum of excited states for given thickness of the flux tube and the value of electric flux through it. Also the flux tube states of say electrons assignable to the magnetic flux tubes assumed to connect DNA nucleotides and lipids of cell membrane in the model of DNA as topological quantum computer [K66] could be relevant.

Two kinds of bonds are predicted

Duppose that dark bonds are associated with the electro-magnetic field body. If classical Z^0 field vanishes, em field is proportional to Kähler field as are also the components of the classical color field. The bonds involving classical color gauge fields could have quark and antiquark at the opposite ends of the flux tube as the source of the color gauge field. This is indeed assumed in the model of DNA as topological quantum computer [K66].

If one wants vanishing or very weak color gauge fields, one must allow almost vacuum extremals. This implies that classical Z^0 force is strong and the situation assumed to prevail for the cell membrane would hold also for hydrogen bonds. For almost vacuum extremals the ratio of electric and Z^0 fluxes is so small- of order $1/50$ for the small value of Weinberg angle $p = .0295$ (rather than $p \simeq .23$) if appearing as the parameter of the model. The molecule can serve as the source of classical Z^0 and electromagnetic fields in two ways.

1. The almost vacuum flux tubes could have many neutrino state and its conjugate at the opposite ends of the flux tube acting as the source of the classical Z^0 field. This kind of flux tubes would traverse through the cell membrane.

2. The molecule would be accompanied by two kinds of flux tubes. Some of them would be almost vacuum extremals carrying an electric flux much smaller than elementary charge e. Some of them would be accompanied by very weak Z^0 field and electromagnetic field plus color gauge fields generated by the above mechanism. These flux tubes would connect cell membrane and genome.

Two kinds of hydrogen bonds

There is experimental evidence for two different hydrogen bonds. Li and Ross represent experimental evidence for two kinds of hydrogen bonds in ice in an article published in Nature 1993 [D62]. The ratio of the force constants K associated with the bonds is 1: 2.

The proposed scaling law $\omega \rightarrow \omega/r$ predicts $\omega \propto 1/r$ so that $k_d \rightarrow k_d + 1$ would explain the reduction of the force constant by factor 1/2. The presence of two kinds of bonds could be also seen as a reflection of quantum criticality against change of Planck constant.

Can one understand the finding in terms of dark color bonds?

1. The model is consistent with the identification of the two bonds in terms different values of Planck constant. The proposed scaling law for ω predicts $\omega \propto 1/r$ so that $k_d \rightarrow k_d + 1$ would explain the reduction of the force constant by factor 1/2. above described general model for which bond energy contains perturbative harmonic oscillator contribution and non-perturbative Coulombic contribution.

2. The identification of hydrogen bond as dark color bond is however questionable. If bond energy contains a color binding energy scaling as $1/r^2$ contributing only constant shift to the harmonic oscillator Hamiltonian, the behavior of the force constant is consistent with the model. If one assumes that the harmonic oscillator spectrum remains invariant under large scalings of $\hbar$, the force constant becomes extremely strong and the color bond would be by a factor r^2 more rigid than hydrogen bond if one takes seriously the proposed estimates for the value of r. The alternative interpretation would be in terms of almost vacuum extremal property reducing the force constant to a very small value already from the beginning.

The possibility to divide the bonds to two kinds of bonds in an arbitrary manner brings in a large ground state degeneracy given by $D = 16!/(8!)^2$ unless additional symmetries are assumed and give for the system spin glass like character and explain large number of different amorphous phases for ice [D64]. This degeneracy would also make possible information storage and provide water with memory.

Hydrogen bonds as color bonds between nuclei?

The original hypothesis was that there are two kinds of hydrogen bonds: dark and "ordinary". The finding that the estimate for the energy of dark nuclear color bond with $k_d = 22$ equals to the energy of typical hydrogen bond raises the question whether all hydrogen bonds are associated with color bonds between nuclei. Color bond would bind the proton to electronegative nucleus and this would lead to the formation of hydrogen bond at the level of valence electrons as hydrogen donates its electron to the electronegative atom. The electronic contribution would explain the variation of the bond energy.

If hydrogen bonds connect H-atom to O-atom to acceptor nucleus, if E_s for p-O bond is same as for p-n color bond, and if color bonds are dark with $k_d = 22$, the bond energy $E_s = .5$ eV. Besides this one must assume that the oscillator energy is very small and comparable to the energy of hydrogen bond - this could be due to almost vacuum extremal property.

Dark -possibly (almost unavoidably) colored or weakly charged- bonds could serve as a prerequisite for the formation of electronic parts of hydrogen bonds and could be associated also with other molecular bonds so that dark nuclear physics might be essential part of molecular physics. Dark color bonds could be also charged which brings in additional exotic effects. The long range order of hydrogen bonded liquids could due to the ordinary hydrogen bonds. An interesting question is whether nuclear color bonds could be responsible for the long range order of all liquids. If so dark nuclear physics would be also crucial for the understanding of the condensed matter.

In the case of water the presence of dark color bonds between dark protons would bring in additional long range order in length scale of order 10 Angstrom characteristic for DNA transversal scale: also hydrogen bonds play a crucial role in DNA double strand. Two kinds of bond networks could allow to understand why water is so different from other molecular liquids containing also hydrogen atoms and the long range order of water molecule clusters would reflect basically the long range order of two kinds of dark nuclei.

Recall that the model for dark nucleons predicts that nucleon states can be grouped to states in one-one correspondence with DNA, RNA, tRNA, and amino-acids and that the degeneracies of the vertebrate genetic code are predicted correctly. This led to suggestion that genetic code is realized already at the level of dark nuclei consisting of sequences of neutrons [L2, K104], [L2] . Neutrons were assumed in order to achieve stability and could be replaced with protons.

Tedrahedral and icosahedral clusters of water molecules and dark color bonds

Water molecules form both tetrahedral and icosahedral clusters. ^4He corresponds to tetrahedral symmetry so that tetrahedral cluster could be the condensed matter counterpart of ^4He. It the nuclear string model nuclear strings consist of maximum number of ^4He nuclei themselves closed strings in shorter length scale.

The p-adic length scales associated with ^4He nuclei and nuclear string are $k = 116$ and $k = 127$ The color bond between ^4He units has $E_s = .2$ MeV and $r = 2^{22}$ would give by scaling $E_s = .05$ eV which is the already familiar energy associated with cell membrane potential at the threshold for the nerve pulse generation. The binding energy associated with a string formed by n tetrahedral clusters would be $n^2 E_s$. This observation raises the question whether the neural firing is accompanied by the re-organization of strings formed by the tetrahedral clusters and possibly responsible for a representation of information and water memory.

The icosahedral model [D64] for water clusters assumes that 20 tetrahedral clusters, each of them containing 14 molecules, combine to form icosahedral clusters containing 280 water molecules. Concerning the explanation of anomalies, the key observation is that icosahedral clusters have a smaller volume per water molecule than tetrahedral clusters but cannot form a lattice structure.

The number 20 for the dark magic dark nuclei forming the icosahedron is also a magic number and a possible interpretation for tetrahedral and icosahedral water clusters would be as magic super-nuclei and the prediction would be that binding energy behaves as $n^2 E_s$ rather than being just the sum of the binding energies of hydrogen bonds (nE_s).

It is interesting to compare this model with the model for hexagonal ice which assumes four hydrogen bonds per water molecule: for two of them the molecule acts as a donor and for two of them as an acceptor. Each water molecule in the vertices of a tetrahedron containing 14 hydrogen atoms has a hydrogen bond to a water molecule in the interior, each of which have 3 hydrogen bonds to molecules at the middle points of the edges of the tetrahedron. This makes 16 hydrogen bonds altogether. If all of them are of first type with bonding energy $E_s = .5$ eV and if the bond network is connected one would obtain total bond energy equal to $n^2 E_s = 258 \times .5$ eV rather than only $nE_s = 16 \times .5$ eV. Bonds of second type would have no role in the model.

Tedrahedral and icosahedral clusters and dark electrons

An interesting question is whether one could interpret tetrahedral and icosahedral symmetries in terms of symmetries of the singular coverings or factor spaces of CD. This does not seem to be the case.

1. One cannot understand discrete molecular symmetries for factor space-space option since the symmetry related points of CD would correspond to one and same space-time point.

2. For the option allowing only singular coverings of $CD \times CP_2$ interpreted in terms of many-valuedness of the time derivatives of the embedding space coordinates as functions of canonical momentum densities this interpretation is not possible.

3. One can also consider the possibility that the singular coverings are over $(CD/G_a) \times (CP_2/G_b)$ rather than $CD \times CP_2$. This would predict Planck constant to be of form $r = n_a n_b$, with $n_a = 3$ for tetrahedral clusters and $n_a = 5$ for icosahedral clusters. n_a and n_b would correspond to the orders of maximal cyclic subgroups of the corresponding symmetry groups. There would be a deviation from the simplest proposal for preferred Planck constants. This option would require space-time surfaces to have exact discrete symmetries and this does not look plausible.

Note that synaptic contacts contain clathrin molecules which are truncated icosahedrons and form lattice structures and are speculated to be involved with quantum computation like activities possibly performed by microtubules. Many viruses have the shape of icosahedron.

It should be noticed that single nucleotide in DNA double strands corresponds to a twist of $2\pi/10$ per single DNA triplet so that 10 DNA strands corresponding to length $L(151) = 10$ nm (cell membrane thickness) correspond to $3 \times 2\pi$ twist. This could be perhaps interpreted as evidence for group C_{10} perhaps making possible quantum computation at the level of DNA.

6.6.3 Further Comments On 41 Anomalies

Some clarifying general comments -now in more standard conceptual framework- about the anomalies are in order. Quite generally, it seems that it is the presence of new degrees of freedom, the presence of icosahedral clusters, and possibly also macroscopic quantum coherence of dark matter, which are responsible for the peculiar properties of water.

The hydrogen bonds assigned to tetrahedral and icosahedral clusters should be same so that if the hydrogen bonds are assignable to dark protons this is the case for all clusters. Perhaps the number of dark protons and -perhaps equivalently- hydrogen bonds per volume is what distinguishes between these clusters and that the disappearance of dark protons leads to the disappearance of hydrogen bonds. Since it is quite possible that no new physics of proposed kind is involved, the following the explanation of anomalies uses only the notions of icosahedral and tetrahedral clusters and dark protons are mentioned only in passing.

1. Anomalies relating to the presence of icosahedral clusters

Icosahedral water clusters have a better packing ratio than tetrahedral lattice and thus correspond to a larger density. They also minimize energy but cannot cannot form a lattice [D64].

1. This explains the unusually high melting point, boiling point, critical point, surface tension, viscosity, heat of vaporization, shrinking on melting, high density increasing on heating, increase of the number of nearest neighbors in melting and with temperature. It is also possible to understand why X-ray diffraction shows an unusually detailed structure.

   The presence of icosahedral clusters allows to understand why liquid water can be super-cooled, and why the distances of water molecules increase under high pressure. The spin glass degeneracy implied by dark and ordinary hydrogen bonds could explain why ice has many glassy amorphous phases. The two phases of super-cooled water could correspond to the binary degree of freedom brought in by two different hydrogen bonds. For the first phase both hydrogen atoms of a given water molecule would be either dark or ordinary. For the second phase the first hydrogen atom would be dark and second one ordinary.

   Since icosahedral clusters have lower energy than a piece of ice of same size, they tend to super-cool and this slows down the transition to the solid phase. The reason why hot water cools faster would be that the number of icosahedral clusters is smaller: if cooling is carried with a sufficient efficiency icosahedral clusters do not form.

2. Pressure can be visualized as a particle bombardment of water clusters tending to reduce their volume. The collisions with particles can induce local transitions of icosahedral structures to tetrahedral structures with a larger specific volume and energy. This would explain the low compressibility of water and why pressure reduces melting point and the temperature of maximum density and viscosity.

3. The increase of temperature is expected to reduce the number of icosahedral clusters so that the effect of pressure on these clusters is not so large. This explains the increase of compressibility with temperature below 46.5°C. The fact that the collapse of icosahedral clusters opposes the usual thermal expansion is consistent with the low thermal expansivity as well as the change of sign of expansivity near melting point. Since the square of sound velocity is inversely proportional to compressibility and density, also the increase of speed of sound with temperature can be understood.

2. The presence of dark degrees of freedom and spin glass degeneracy

The presence of dark degrees of freedom and the degeneracy of dark nucleus ground states could explain the high specific heat capacity of water. The reduction of dark matter degrees of freedom for ice and steam would explain why water has over twice the specific heat capacity of ice or steam. The possibility to relax by dissipating energy to the dark matter degrees of freedom would explain the short spin-lattice relaxation time. The fact that cold water has more degrees of freedom explains why warm water vibrates longer than cold water.

Also the high thermal and electric conductivity of water could be understood. The so called Grotthuss [I13] [D64] explaining OH_- and H_+ mobilities (related closely to conductivities) is based on hopping of electron of OH_- and H_+ in the network formed by hydrogen bonds and generalizes to the recent case. The reduction of conductivity with temperature would be due to the storage of the transferred energy/capture of charge carriers to the water molecule clusters.

3. Macroscopic quantum coherence

The high value of dielectric constant could derive from the fact that dark nuclei and super-nuclei are quantum coherent in a rather long length scale. For curl free electric fields potential difference must be same along space-time sheets of matter and dark matter. The synchronous quantum coherent collective motion of dark protons (and possible dark electrons) in an oscillating external electric field generates dark photon laser beams (it is not clear yet whether these dark laser beams are actually ordinary laser beams) de-cohering to ordinary photons and yield a large dynamical polarization. As the temperature is lowered the effect becomes stronger.

6.6.4 The strange properties of water as indication for the existence of dark matter in TGD sense

The motivation for this brief comment came from a popular article telling that a new phase of water has been discovered in the temperature range 50-60 °C (see `http://tinyurl.com/h4wlf6o`. Also Gerald Pollack [L8] (see `http://tinyurl.com/oyhstc2`) has introduced what he calls the fourth phase of water. For instance, in this phase water consists of hexagonal layers with effective $H_{1.5}O$ stoichiometry and the phase has high negative charge. This phase plays a key role in TGD based quantum biology. These two fourth phases of water could relate to each other if there exist a deeper mechanism explaining both these phases and various anomalies of water.

Martin Chaplin (see `http://tinyurl.com/ye77f7d`) has an extensive web page about various properties of water. The physics of water is full of anomalous features and therefore the page is a treasure trove for anyone ready to give up the reductionistic dogma. The site discusses the structure, thermodynamics, and chemistry of water. Even academically dangerous topics such as water memory and homeopathy are discussed.

One learns from this site that the physics of water involves numerous anomalies (see `http://tinyurl.com/hs77fsh`). The structural, dynamic and thermodynamic anomalies form a nested in density-temperature plane. For liquid water at atmospheric pressure of 1 bar the anomalies appear in the temperature interval 0-100 °C.

Hydrogen bonding creating a cohesion between water molecules distinguishes water from other substances. Hydrogen bonds induce the clustering of water molecules in liquid water. Hydrogen bonding is also highly relevant for the phase diagram of H_2O coding for various thermodynamical properties of water (see `http://tinyurl.com/hr77ou5`). In biochemistry hydrogen bonding is involved with hydration. Bio-molecules - say amino-acids - are classified to hydrophobic, hydrophilic, and amphiphilic ones and this characterization determines to a high extent the behavior of the molecule in liquid water environment. Protein folding represents one example of this.

Anomalies are often thought to reduce to hydrogen bonding. Whether this is the case, is not obvious to me and this is why I find water so fascinating substance.

Examples of anomalies

Some examples about anomalies are in order.

1. The high cohesion between water molecules due to hydrogen bonds gives it exceptionally high freezing and boiling points. The high latent heat of evaporation implied by hydrogen

bond gives a high resistance to hydration and high evaporative cooling. Hydrogen bonds also give rise to an especially high surface tension.

Water has unique hydration properties with respect to the basic biomolecules. Hydration leads to the formation of gels, which can reversibly undergo gel-sol phase transitions important for the physics of life. Water ionizes easily and proton transfer reactions between molecules giving rise to rich interactions in biochemistry.

2. Solid (liquid) water has anomalously low (high) density so that the difference between densities of liquid and solid states is small. In the range 0-4 °C water compresses (becomes more dense than solid phase) when heated at constant pressure rather than expanding as other liquids. This anomaly is fundamental for life.

3. Water has anomalously high specific heat capacity $c_p = dC_p/dM$, $C_p = (dE/dT)_p$. This might be understood in terms of breaking of hydrogen bonds giving rise to new translational degrees of freedom as water molecules begin to move freely.

   The specific heat capacity c_p of liquid water at atmospheric pressure decreases in the interval 5-37 °C, and increases in the range 37-100 °C. The minimum is at physiological temperature (see `http://tinyurl.com/zfv22yz`) - hardly an accident. For other liquids c_p increases steadily in this interval. The compressibility of water depicts similar behavior distinguishing water from other liquids.

4. Mpemba effect (see `http://tinyurl.com/7h2h59p`) means that hot water freezes faster than cold water. The effect is maximal at 35 °C, which is remarkably close to the physiological temperature. Mpemba effect challenges the naïve views about what happens in freezing, and several explanations have been proposed.

The anomalies of water in TGD framework

What TGD can say about these anomalies? I have already earlier considered a model of water explaining some of the basic anomalies and it is interesting to see whether the recent understanding of TGD might allow more precise articulation of the basic ideas.

1. The TGD inspired model assumes that water consists of ordinary water plus dark water. Dark matter is identified in TGD framework as phases of ordinary matter but with effective Planck constant h_{eff}, which is integer multiple $h_{eff}/h = n$ of the ordinary Planck constant. This proposal is motivated by several experimental findings. In particular, Pollack effect leading to a generation of negatively charged exclusion zones (EZs) with effective stoichiometry of water to $H_{1.5}O$ would be due to the transfer of one-over-fourth of protons do dark protons at magnetic flux tubes.

   One must be careful in defining what "dark" means. Does dark matter include only the dark particles at flux tubes or does it include also the water molecules connected by these flux tubes? The following considerations suggest that the latter definition allowing to talk about dark water is more appropriate.

2. The dark matter at magnetic flux tubes could involve also other particles than protons (electrons and even ions) and would serve as the "boss" controlling biochemistry in TGD based view about biology. The communications between visible matter and dark particles at magnetic flux tubes would rely on dark photons with energy $E = h_{eff}f$, which can be above thermal energy for even EEG frequencies. This makes possible interaction between widely different length and time scales.

3. $h_{eff}/h = n$ phases would be generated at quantum criticality and serve as correlates for long range correlations and fluctuations at criticality. The transformation of ordinary protons to dark protons and vice versa could be essential for proton transfer reactions and even give rise to high Tc super-conductivity along dark flux tubes based on pairs of parallel flux tubes carrying the members of Cooper pairs.

4. Several values of h_{eff}/h are possible. The matter visible to us need not correspond to the minimal value of h. The hydrino atoms with scaled up binding energy spectrum claimed by Randell Mills [D41] could be understood if $h_{eff}/h = n$ for ordinary atomics equals to $n = 6$ and hydrino atoms have $n < 6$ [L13].

I am not trying to give any summary about various anomalies of water in the following but consider only the above mentioned examples from TGD point of view. Let us therefore make following assumptions (one could represent these assumptions also as questions).

1. Water consists of ordinary and dark fractions. Several values of $h_{eff}/h = n$ are possible and their fractions depend on pressure and temperature. These two fractions can be present in both solid and liquid states. The dark fraction of water - say dark proton sequences at magnetic flux tubes leading also to the notion of dark variant of genetic code inducing the ordinary chemical code [L11] - does not interact directly with ordinary water except via classical em fields (this is important!). More generally, phases with different values of n are dark relative to each other. The quantal interactions are only via exchange of dark photons transforming to ordinary photons identified in biology as bio-photons or vice versa. The additional assumption $h_{eff} = h_{gr}$, where h_{gr} is gravitational Planck constant [K88, K75], guarantees that the cyclotron energy spectrum of dark photons is universal and corresponds to that for bio-photons (visible and UV) [K61].

   The presence of dark protons implies the generation of negative electronic charge. Could repulsive Coulomb interactions become significant and lead to an expansion of water possibly relevant for the understanding of the anomalously low density of ice?

2. Hydrogen bond is thought to be essential for the understanding of the anomalies. Hydrogen bonds could correspond in TGD framework to short and rigid flux tubes. Large values of n scaling up the flux tube lengths would give rise to longer, possibly loop-like, magnetic flux tubes. Indeed, if the total magnetic energy is not changed the string tension defined as magnetic energy density is reduced like $1/n$. Flux tubes could form a dynamical network in which reconnections and phase transitions changing the value of n would make the topology of the network dynamical.

   This kind of flux tube network could give rise to TGD analog of tensor networks [L12] realizing quantum entanglement between the nodes of the network and to be central for the formation of gel phase explaining the quantum coherence of water in vivo. The generalization of the usual picture behind bio-chemistry in which one has only molecules to a flux tube network having various particles at its nodes would allow to understand the emergence of complexity in both condensed matter physics and biology [L12].

   Hydration, dehydration and gel-sol phase transition could involve a phase transition changing the value of n and transforming the hydrogen bonds to longer flux tubes and vice versa. These phase transitions would be also essential in bio-catalysis. It would seem that the natural formulation for various anomalies would be in terms of the flux tube network, whose connectivity depends on temperature and pressure.

3. Dark particles are generated at quantum criticality and quantum criticality could accompany also ordinary thermal phase transitions such as freezing of water.

4. One can imagine several models for the dark fraction of water. Since the temperature range 0-100 °C involves several anomalies, it is natural to assume that the dark fraction of water varies as function of p and T. It seems also safe to assume that the hydrogen bonding becomes maximal at freezing and the bonds identifiable as flux tubes become short. Since the anomalies are strongest around physiological temperature 37 °C, TGD inspired model of quantum biology suggests that dark fraction is highest near this temperature. One expects several fractions with different values of n depending on temperature and pressure.

5. Why water would be so special? Also other liquids could involve flux tubes but with small value of n and therefore much shorter than those in water. Hydrogen bonds in water would also have larger value of n than for other substances. Heavy water does not share the anomalies of ordinary water although the electronic chemistry is the same. The large mass

of deuterium probably prevents the formation of dark deuterium. Maybe the fact that the Compton length of (also dark) deuterium is 1/2 of that for (dark) proton could be significant and prevents the formation of dark deuterium bonds?

Hydrogen bonds are usually associated with electronegative atoms - usually F, O, and N (see `http://tinyurl.com/bntn28n`). Also hydrogen bond between hydrogen and carbon is possible when C is bound to electronegative atoms (chloroform $CHCl_3$ is one example). Note that H_2S, which is chemical analog of water, can form hydrogen with F but two H_2S molecules do not form hydrogen bonds so that H_2S based life is not possible.

Consider first a model for what could happen in the range $0-4$ °C under normal pressure.

1. The presence of negative electronic charge induced by the transfer of dark protons to magnetic flux tubes might explain the larger volume of ice as compared to liquid water above 4 °C. The standard explanation is in terms of hydrogen bonds leading to rigid clusters with average distance between water molecules longer than in ordinary water. If hydrogen bonds correspond to short rigid flux tubes these explanations are consistent. The positive charge of dark protons would generate classical Coulomb fields and neutralize this negative charge non-locally as a kind of smooth background so that neutralization would take place in longer length scale and lead to a lower density.

2. What would happen at the interval $0-4$ °C? Do the dark protons at flux tubes assigned to hydrogen bonds transform to ordinary ones and reduce the number of hydrogen bonds and lead to a reduction of the density? Or does the average value of n assignable to the flux tubes increase and increase the average length of flux tubes? Heating would transforms short and rigid flux tubes (hydrogen bonds) to longer and loopy ones. If the magnetic energy is conserved, string tension must scale down by $1/n$ leading to the melting of flux tubes. The melted loopy flux tubes would be longer but their ends could become nearer to each other.

   Melting would thus have a counterpart at the level of magnetic body. Could the freezing of the flux tubes induce the freezing of water? Could the dynamics of ordinary water fraction of water be governed by that of the dark fraction? TGD inspired biology assumes that magnetic body carrying dark matter serves as a template for biochemistry. Could this be true also for thermodynamics?

One can try to explain the anomalies of heat capacity in this picture.

1. Specific heat capacity defined as total heat capacity per mass $c_p = (dC_p/dM)$, $C_p = (dE/dT)_p$ at constant pressure. The large value of c_p for water is thought to be due to the splitting of hydrogen bonds by energy feed so that new translational degrees of freedom are created and the energy feed goes to these.

   Could this intuition generalize? Hydrogen bonds would be replaced with flux tube pairs with members carrying opposite fluxes and carrying dark protons and connecting two water molecules. There would be two phases of matter. Lonely water molecules possibly accompanied by short flux loops and pairs of water molecules connected by flux tube pairs. Also clusters of water molecules connected by flux tubes with several pairs of flux tubes emerging from each molecule are possible. Dark matter could be identified the molecule pairs or groups connected by flux tube pairs distinguishing between water and other liquids.

2. The reconnection for a pair of flux tubes with opposite fluxes creates molecules with U-shaped flux tubes, which could rapidly contract. This would lead to two free molecules of ordinary water. These molecules would take most of the feeded energy ΔE and heat the water by ΔT. Also part of the magnetic energy of the flux tubes would be transferred to the kinetic energy of liberated molecules. This energy could be small for short flux tubes at least. If the phase transition increasing the value of n preserves the total magnetic energy, this energy would be small also for long flux tubes.

3. Suppose that the fraction of flux molecules connected by flux tube pairs - dark matter - increases with temperature. c_p is determined by the rate of reconnections of flux tube pairs effectively transforming two dark water molecule pair to ordinary ones. c_p should be reduced

above 4 °C up to 37 °C. The value of the latter temperature suggests an increase of dark matter component so that the number of ordinary water molecules would decrease. The first guess is that the magnetic energy is of the order of the bond energy assignable to hydrogen bond and in the range .023-.05 eV. Note that membrane voltage eV corresponds to energy which is same order of magnitude. This interpretation is natural if the creation and annihilation of flux tube pairs is basic mechanism of biology.

The reconnection creates more ordinary water molecule pairs and only these absorb heat. The absorbed heat is shared between the ordinary water molecules. The energy is shared by a smaller number of ordinary water molecules so that ΔT for given ΔE is higher and c_p is smaller. Note that also the fact that total mass $M = M_{ord} + M_{dark}$ of water is larger than M_{ord} reduces c_p.

4. Why c_p would increase above 37 °C? The most straightforward explanation is that dark matter - that is the molecules connected by flux tube pairs begins to decrease above this temperature. The amount of dark matter - the connectivity of the web formed by flux tubes - is highest at 37 °C. The splitting of the flux tube pairs to pairs of loops would explain disappearance of dark matter above 37 °C. The heat is shared between larger number of ordinary molecules and ΔT is smaller for a given ΔE so that c_p becomes larger. Also the reduction of M_{dark} has similar effect.

Consider next the anomalous behavior of compressibility.

1. The reduction of compressibility K ($\Delta V = -(dlog(V)/dp)\Delta p = -K\Delta p$), which at zero pressure limit is maximal at 45 °C should have an explanation along the same lines. Compressibility is reduced if the increase in pressure produces ordinary water molecules, whose emergence tends to increase the volume filled n by ordinary water molecules. This is the case if the fraction of dark matter decreases with increasing pressure. The reason could be splitting of the flux tube pairs to loops. This predicts that anomalies are absent for high enough pressures as they indeed are.

2. What happens in evaporation? It would seem that the density of dark matter fraction becomes so small that the flux tube connections cannot anymore create the needed cohesion and water evaporates. Note that also the connectivity of the flux tube web is reduced.

What about Mpemba effect (see `http://tinyurl.com/7h2h59p`)? Why hot water would freeze faster than cold water and why the effect would be strongest around 35 °C?

1. The amount of dark matter seems to be essential for the effect. A possible mechanism of freezing would be reduction of lengths of dark flux tube pairs by quantum phase transitions reducing the value of n. This mechanism would contract the flux tubes to hydrogen bonds very rapidly. The resulting ice would serve as seeds inducing the freezing of the ordinary portion of water. Freezing would be fastest around 35 °C.

2. The freezing of dark portion eliminates it. The condition that dark and ordinary portion of water are in kinetic equilibrium could induce the transformation of ordinary matter to dark matter. If this process is fast enough, the freezing could take place via the cycle *ordinary water* $\rightarrow$ *dark water* $\rightarrow$ *ice* and be faster than freezing near freezing point where dark matter fraction is small.

6.6.5 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) [I25].

Basic findings at cell level

I try to list the essential points of the article. Apologies for biologists: I am not a specialist.

1. Certain pathogenic micro-organisms are objects of the study. The bacteria Mycoplasma Pirum and E. Choli belong to the targets of the study. The motivating observation was that some procedures aimed at sterilizing biological fluids can yield under some conditions the infectious micro-organism which was present before the filtration and absent immediately after it. For instance, one filtrates a culture of human lymphocytes infected by M. Pirum, which has infected human lymphocytes to make it sterile. The filters used have 100 nm and 20 nm porosities. M. Pirum has size of 300 nm so that apparently sterile fluids results. However if this fluid is incubated with a mycoplasma negative culture of human lymphocytes, mycoplasma re-appears within 2 or 3 weeks! This sounds mysterious. Same happens as 20 nm filtration is applied to a a minor infective fraction of HIV, whose viral particles have size in the range 100-120 nm.

2. These findings motivated a study of the filtrates and it was discovered that they have a capacity to produce low frequency electromagnetic waves with frequencies in good approximation coming as the first three harmonics of kHz frequency, which by the way plays also a central role in neural synchrony. What sounds mysterious is that the effect appeared after appropriate dilutions with water: positive dilution fraction varied between 10^{-7} and 10^{-12}. The uninfected eukaryotic cells used as controls did not show the emission. These signals appeared for both M. Pirum and E. Choli but for M. Pirum a filtration using 20 nm filter canceled the effect. Hence it seems that the nano-structures in question have size between 20 and 100 nm in this case.

   A resonance phenomenon depending on excitation by the electromagnetic waves is suggested as an underlying mechanism. Stochastic resonance familiar to physicists suggests itself and also I have discussed it while developing ideas about quantum brain [K43]. The proposed explanation for the necessity of the dilution could be kind of self-inhibition. Maybe a gel like phase which does not emit radiation is present in sufficiently low dilution but is destroyed in high dilutions after which emission begins. Note that the gel phase would not be present in healthy tissue. Also a destructive interference of radiation emitted by several sources can be imagined.

3. Also a cross talk between dilutions was discovered. The experiment involved two tubes. Donor tube was at a low dilution of E. Choli and "silent" (and carrying gel like phase if the above conjecture is right). Receiver tube was in high dilution (dilution fraction 10^{-9}) and "loud". Both tubes were placed in mu-metal box for 24 hours at room temperature. Both tubes were silent after his. After a further dilution made for the receiver tube it became loud again. This could be understood in terms of the formation of gel like phase in which the radiation does not take place. The effect disappeared when one interposed a sheath of mu-metal between the tubes. Emission of similar signals was observed for many other bacterial specials, all pathogenic. The transfer occurred only between identical bacterial species which suggests that the signals and possibly also frequencies are characteristic for the species and possibly code for DNA sequences characterizing the species.

4. A further surprising finding was that the signal appeared in dilution which was always the same irrespective of what was the original dilution.

Experimentation at gene level

The next step in experimentation was performed at gene level.

1. The killing of bacteria did not cancel the emission in appropriate dilutions unless the genetic material was destroyed. It turned out that the genetic material extracted from the bacteria filtered and diluted with water produced also an emission for sufficiently high dilutions.

2. The filtration step was essential for the emission also now. The filtration for 100 nm did not retain DNA which was indeed present in the filtrate. That effect occurred suggests that

filtration destroyed a gel like structure inhibiting the effect. When 20 nm filtration was used the effect disappeared which suggests that the size of the structure was in the range 20-100 nm.

3. After the treatment by DNAse enzyme inducing splitting of DNA to pieces the emission was absent. The treatment of DNA solution by restriction enzyme acting on many sites of DNA did not suppress the emission suggesting that the emission is linked with rather short sequences or with rare sequences.

4. The fact that pathogenic bacteria produce the emission but not "good" bacteria suggests that effect is caused by some specific gene. It was found that single gene - adhesin responsible for the adhesion of mycoplasma to human cells- was responsible for the effect. When the cloned gene was attached to two plasmids and the E. Choli DNA was transformed with the either plasmid, the emission was produced.

Some consequences

The findings could have rather interesting consequences.

1. The refinement of the analysis could make possible diagnostics of various diseases and suggests bacterial origin of diseases like Alzheimer disease, Parkinson disease, Multiple Sclerosis and Rheumatoid Arthritis since the emission signal could serve as a signature of the gene causing the disease. The signal can be detected also from RNA viruses such as HIV, influenza virus A, and Hepatitis C virus.

2. Emission could also play key role in the mechanism of adhesion to human cells making possible the infection perhaps acting as a kind of password.

The results are rather impressive. Some strongly conditioned skeptic might have already stopped reading after encountering the word "dilution" and associating it with a word which no skeptic scientist in his right mind should not say aloud: "homeopathy" ! By reading carefully what I wrote above, it is easy to discover that the experimenters unashamedly manufactured a homeopathic remedy out of the filtrate! And the motivating finding was that although filtrate should not have contained the bacteria, they (according to authors), or at least the effects caused by them, appeared within weeks to it! This is of course impossible in the word of skeptic.

The next reaction of the skeptic is of course that this is fraud or the experimenters are miserable crackpots. Amusingly, one of the miserable crackpots is Nobelist Luc Montagnier, whose research group discovered AIDS virus.

How TGD could explain the findings?

Let us leave the raging skeptics for a moment and sketch possible explanations in TGD framework.

1. Skeptic would argue that the filtration allowed a small portion of infected cells to leak through the filter. Many-sheeted space-time suggests a science fictive variant of this explanation. During filtration part of the infected cells is "dropped" to large space-time sheets and diffused back to the original space-time sheets during the next week. This would explain why the micro-organisms were regenerated within few weeks. Same mechanism could work for ordinary molecules and explain homeopathy. This can be tested: look whether the molecules return back to the diluted solution in the case of a homeopathic remedy.

2. If no cells remain in the filtrate, something really miraculous looking events are required to make possible the regeneration of the effects serving as the presence of cells. This even in the case that DNA fragments remain in the filtrate.

   (a) The minimum option is that the presence of these structures contained only the relevant information about the infecting bacteria and this information coded in terms of frequencies was enough to induce the signatures of the infection as a kind of molecular conditioning. Experimentalists can probably immediately answer whether this can be the case.

(b) The most radical option is that the infecting bacteria were actually regenerated as experimenters claim! The information about their DNA was in some form present and was transcribed to DNA and/or RNA, which in turn transformed to proteins. Maybe the small fragment of DNA (adhesin) and this information should have been enough to regenerate the DNA of the bacterium and bacterium itself. A test for this hypothesis is whether the mere nanoparticles left from the DNA preparation to the filtrate can induce the regeneration of infecting molecules.

The notion of magnetic body carrying dark matter quantum controlling living matter forms the basic element of TGD inspired model of quantum biology and suggests a more concrete model. The discovery of nanotubes connecting cells with distance up to 300 μ [I9] 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 [K66]. 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 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 $\sim$ 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 [L2], [L2] 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 amino-acids 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.

The findings of both Montagnier and Gariaev suggests that also the representation of genetic code in terms of dark photons is involved. How genetic code could be represented in terms of frequencies? The TGD based model of music harmony [L6] [K40] (see `http://tinyurl.com/zg3aaj7`) relies on the idea that 12-note scale is representable as a closed non-self-intersecting curve (Hamilton's cycle) at icosahedron having 12 vertices. The harmony assignable to a given Hamilton's cycle is characterized in terms of 3-chords assignable to the 20 faces (triangles) of the icosahedron once the 12-note scale is represented as a particular Hamilton's cycle.

Remarkably, the number of amino-acids is also 20! One indeed ends up with a model in which 20+20+20=60 DNA codons are represented by 3-chords for a triplet of harmonies defined by Hamilton's cycles predicting correctly the numbers of DNAs coding for a given amino-acid for vertebrate code. One must however assume that also tetrahedral harmony is present to get 64 DNA codons rather than only 60. TActually two variants of the code are predicted and altogether one obtains the standard 20 amino-acids plus two additional ones identified as Pyl and Sec known to be realized in living matter.

In music realization DNA codons can be represented as 3 dark photons or phonons with appropriate frequency ratios. This representation could explain the findings of Montagnier and Gariaev. There is also a connection with TGD inspired theory of consciousness. Music both expresses and induces emotions. The proposal is that the representation of DNA codons in terms of triplets of sounds or dark photons defines molecular level representation of emotions. There is large number of different harmonies and they could represent different moods.

6.6.6 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 [D70, D68, D66, D69] 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" [D70] told about the formation of exclusion zones around hydrophilic surfaces, typically gels in the experiments considered [D74]. The zones were in potential of about 100 meV with respect to surroundings (same order of magnitude as membrane potential) and had thickness ranging to hundreds of micrometers (the size of a large cell): the standard physics would suggests only few molecular layers instead of millions. Sunlight induced the effect. This finding allow to develop TGD based vision about how proto cells emerged and also the model for chiral selection in living matter by combining the finding with the anomalies of water about which I had learned earlier.

The article "Can water burn?" [D66] 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" [D69] 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 [D67]. 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 [D68]. 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 [K22].

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 [D64, D61, D72, D43]. 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 radio waves 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?" [D66] 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 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) [I21], and that even a realization of genetic code in terms of the time variation of polarization direction could be involved. TGD based model [K7, K52] 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 [D13]. 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 [D12] - 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 in the ealier 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.

   In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

6. The electrolysis of water and also cavitation produces what is known as Brown's gas which should consist of water vapour and there might be a connection to the burning of salt water. The properties of Brown's gas [H17] however do not support this interpretation: for instance, Brown's gas has temperature of about 130 C but is able to melt metals so that some un-known mechanism liberating energy must be involved explaining also the claims about over-unity energy production in water splitting using electrolysis. TGD inspired model for Brown's gas [K23] suggests that activated water and Brown's gas correspond to same phase involving polymer sequences formed from exotic water molecules for which one hydrogen nucleus is dark and defining the analogs of basic biopolymers. The bond binding protons to a polymer like sequence would serve as the counterpart of covalent bond.

   One also ends up with a more detailed TGD inspired view about basic mechanism of metabolism in living matter predicting a tight correlation between p-adic length scale hypothesis and hierarchy of Planck constants. The model differs in some aspects from the rough models considered hitherto assuming that metabolic energy is liberated as zero point kinetic energy when particle drops to a larger space-time sheet or as cyclotron energy when cyclotron quantum number decreases. Now a phase transition increasing the p-adic length scale of the space-time surface would liberate either kinetic energy of cyclotron energy. Quantum numbers would not change: rather, t the scale appearing as a parameter in the expression of kinetic or cyclotron energy would change adiabatically and in this manner guarantee coherence. Also a phase transition in which the changes of scale due to a reduction of Planck constant and increase of the p-adic length scale compensate each other liberate metabolic energy.

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.

6.7 Minimization of Gibbs free energy as thermodynamical variational principle in TGD framework

Minimization of Gibbs free energy is applied routinely in bio-chemistry as a thermodynamical variational principle. I have however not applied thermodynamical variational principles systematically in TGD inspired quantum biology. My excuse could be that it is not clear whether dark matter as $h_{eff} = n \times h_0$ phases is in thermal equilibrium with the ordinary matter. Therefore the arguments have been based mostly on energy minimization and make sense thermodynamically at zero temperature limit.

This article was inspired by highly interesting findings related to the stability of DNA double strand. It has been thought that hydrogen bonds between the bases of the two strands are responsible for the stability. This explanation has been challenged (for a popular article see `http://tinyurl.com/yyvkeq8y`). According to the article [I18] (see `http://tinyurl.com/y5kwo5b4`) of Bobo Feng *et al*, the experimental findings support the proposal that hydrophobic forces are actually responsible for the stability. The function of hydrogen bonds would be to take care of correct base pairing rather than stabilization.

In passive state DNA strands would bind together by hydrophobic forces keeping water out of the interior of DNA double strand forming a kind of dry pocket. When DNA is active - say replication or transcription is occurring - an appropriate enzyme opens DNA by splitting the hydrogen bonds and the interior parts get in contact with water. This process requires energy provided by ATP. After than the process could proceed in TGD Universe as discussed in [L30].

The attempt to gain an improved understanding of hydrophobic interactions led to the realization that I have not been considered the possibility that Gibbs free energy might provide a thermodynamical variational principle applicable also to dark matter as $h_{eff} = n \times h_0$ phases, in particular allowing to get a quantitative grasp on the model of water as a multi-phase system involving magnetic flux tubes with various values of h_{eff} [L26].

6.7.1 TGD based view about hydrophobia

Hydrophobic interactions play fundamental role in biology, and there are good motivations for gaining some understanding about the thermodynamics involved. Here the appropriate variational principle is minimization of Gibbs free energy G.

One hydrophobic in water

While reading the popular article I realized that my understanding about hydrophobic forces is rather limited. I decided to go to web and an found a rather nice article about hydrophobic forces (see `http://tinyurl.com/yyerhvte`).

1. Consider first what hydrophobia at molecular level means. Hydrophobic molecules do not dis-solve in water. When this kind of molecule is put into water, a water a chlathrate gage surrounding it is formed. Hydrogen bonds between water molecules surrounding the molecule are split and new hydrogen bonds giving rise to the chlathrate are created. Splitting requires heat energy which corresponds to a decrease of a thermodynamical function of state known as enthalpy: $\Delta H < 0$ (the formation of hydrogen bonds occurs spontaneously and must release energy). When the temperature is above $T = 0$, also entropy matters. Now entropy decreases since order is created in the formation of chlathrate.

2. Physicists and chemists love variational principles. Now the thermodynamical variational principle is minimization of Gibbs free energy G. Process occurs spontaneously if the change ΔG of Gibbs free energy in the process is negative: $\Delta G < 0$.

One has $\Delta G = \Delta H - T\Delta S$, where ΔS is the change of entropy. $\Delta H < 0$ is known to be small in the recent case but ΔS is large and negative due to the formation of the chlathrate cage generating order order. Hence one has $\Delta G > 0$ and the hydrophobic molecule does not dis-solve to water. Hydrophilic molecules in turn are polar and form bonds with water and dissolve.

3. Organic molecules tend to turn their polar parts towards water and non-polar parts (say long hydrocarbon sequences) inwards to form dry pockets. Double lipid layer giving rise to cell membrane is a good example. The lipids turn their charged ends to the water in the interior and exterior of cell and the hydrocarbon sequences of lipids reside in the interior layer containing no water. Protein folding in turn leads to a situation in which hydrophobic parts of protein are directed towards interior of the folded protein and hydrophilic parts bind with the surrounding water by hydrogen bonds.

Two hydrophobics in water

What happens when one puts two hydrophobics in water? It is easy to guess if one takes seriously what phobia means.

1. Hydrophobics are like two sociophobics in a big celebration. They seek protection from the crowd and can provide it to each other. Two hydrophobics in water come as close to each other as possible so that there is no water between them anymore. As they bind together, hydrogen bonds in the interior of the volume possessed by them are split. This requires energy ($\Delta H > 0$) but the entropy increases in the reduction of the size of the chlathrate area and the net effect is $\Delta G = \Delta H - T\Delta S < 0$ so that the process occurs spontaneously implying that hydrophobic substance does not dissolve.

One can apply this picture in order to understand the formation DNA double strand.

1. The formation of DNA double strands would be a process in which the hydrophobic sides of the strands become in a close contact and exclude the water from the interior of DNA. This would give rise to the helical double strand. The hydrogen bonds connecting the strands would not be responsible for the binding. Their formation generates order and the corresponding reduction of entropy should be smaller than the increase of entropy due to the splitting of hydrogen bonds of DNA strands with water.

2. The hydrophilic parts of DNA codons are directed towards the surrounding water. To open the double strand metabolic energy is needed. Also an enzyme catalyzing the process is needed but this is different story in which TGD view about quantum theory predicting mechanisms for how the reacting bio-molecules can find each other in the molecular crowd and how the potential wall making the reaction extremely slow can be overcome.

Is hydrophobia enough for the stability? My strong personal suspicion is that the stability of DNA is far from understood in bio-chemistry approach. In vitro DNA is unstable. The reason is that DNA nucleotides have negative charge and could cause instability of strands and double strand. In TGD based model the negatively region around DNA would be exclusion zone and represent ordered water. The model brings in dark matter as dark nuclei identified as dark proton sequences at flux tubes and generated in Pollack effect requiring metabolic energy feed.

The great surprise was that in a simple model for dark nuclei, the states of dark proton triplets correspond to DNA,RNA,tRNA, and amino-acids and vertebrate genetic code emerges [L20, L30]. Genetic code could be realized already at the level of water. In TGD framework the pairing of DNA strand with dark DNA strands carrying dark proton sequences with 3 proton units and charge of +3 units in 1-1 correspondence with DNA codons with total charge of -3 units could induce the stability. The formation of DNA could involve Pollack effect [L8] causing charge separation and forming negatively charged regions: part of protons would transform to dark protons at flux tubes.

6.7.2 Minimization of Gibbs free energy and TGD view about the role of water in life

Coherence of bio-matter is one of the characteristic of the living systems having no explanation in life-as-mere- bio-chemistry approach. The TGD based view of about water and its role in biology relies on the presence of long magnetic flux tubes containing dark protons as $h_{eff} = n \times h_0$ phases making possible quantum coherence in long scales. Flux tubes with varying values of h_{eff} would form a master-slave hierarchy having ordinary matter at the bottom. The quantum coherence of the master would induce the coherence of the ordinary matter serving as a slave.

All self-organizing systems generate long range correlations and an energy feed is necessary for the self-organization. Could they all be quantum critical with h_{eff} phases realizing the quantum criticality? If so, the energy feed would be needed to preserve the distribution of large h_{eff} phases: dark matter would be directly visible in the physics of every-day life [L35]!

This picture suggests that water involves several phases [L26]. These phases would correspond to the presence of long flux tubes characterized by the values of $h_{eff} = n \times h_0$ and n can have several values: already water would be a living system [L32], and dark proton sequences at the flux tubes might realize genetic code [L20]. Interesting questions relate to the description of the proposed long flux tubes perhaps giving also rise to long variants of hydrogen bonds having non-standard effective value $h_{eff} = n \times h_0$ of Planck constant.

1. Could one apply thermodynamical considerations to the situation? This would require that dark protons and dark ions at the flux tubes are in thermal equilibrium with ordinary matter. Assume that this is the case. Under what conditions one has $\Delta G = \Delta H - T\Delta S < 0$ so that the formation of dark flux tube network is possible thermodynamically?

2. What ΔH is now? ΔH should contain the sum of magnetic and volume energy of the flux tube. Magnetic flux is quantized so that the magnetic energy in a simple model is proportional to L/S, L the length of the flux tube and S its transversal area taken to be non-dynamical. Volume energy is proportional to SL so that one has $E = aSL + bS/L$. In equilibrium L is fixed from energy minimization with respect to L as $L = \sqrt{b/a}$. The energy in equilibrium is given by $E = 2\sqrt{ab}S = 2aSL$. The local value of the length scale dependent cosmological constant determines the ratio $\sqrt{b/a} = L$.

   The naïve expectation is that ΔH contains also the energy of dark matter at the flux tube. Quantum classical correspondence however suggests that classical energy equals to the energy of dark particles. For nuclei identified in TGD as nuclear strings [K73] this would mean that there is string tension which of order of m_p^2 (one proton mass m_p per proton Compton length $\hbar/m_p$). This is of same order of magnitude as hadronic string tension in the string model of hadrons. For dark proton sequences the tension would correspond to roughly one proton mass per electron Compton length: that this $2^{-11}m_p^2$.

3. There should be a contribution do the reduction of the total energy of the system due to the formation of the flux tube and this should win the energy of the flux tube. For instance, this energy could correspond to interaction energy of particles at the ends of the flux tube mediated by classical em fields along the flux tube.

   Coulomb energy between particles of opposite charge at the ends of the flux tube would be essentially that in 1-D world and proportional to the $q_1q_2L < 0$ and increase with the length of the flux tube. This would favor long flux tubes. The large interaction energy would be due to the channeling of the electric flux. There would be a competition between the negative Coulomb interaction energy and the energy of the flux tube. This energy should be included to the energy minimized and would modify the expression for the value of L obtained above to give $E = -Q^2e^2/L + S(aL + b/L)$. Energy minimum would correspond to $L = (b/(a + Q^2e^2/S))^{1/2}$. a is proportional to cosmological constant and b inversely proportional to Kähler coupling strength. a degreases as cosmological constant decreases so that also L increases. If volume energy is approximately constant ($SL = V_0 = constant$), one has $L^2a - bV_0 + L^3Q^2e^2 = 0$ in energy minimum and the term $Q^2e^2/S \propto L$ in the denominator reduces the value of L.

4. The naïve and optimistic expectation is that one has $\Delta H < 0$ also for the formation of long flux tubes possibly accompanied by the analogs of hydrogen bonds so that the process would be energetically favourable at low enough temperatures and take place spontaneously.

5. ΔG contains also the competing contribution $-T\Delta S$ and the formation of flux tube structures brings in order so that this term is positive and tends to prevent this process. Could there be a critical temperature T_c above which this term wins and the formation of the flux tube network is not possible anymore? Could T_c be around the physiological temperature as biology and also the findings about thermodynamical anomalies of water would suggest

   Living matter stays conscious in a rather narrow temperature range. Where does the lower bound on temperature come from? Quantum criticality indeed suggests that there is also a lower bound for this temperature. Could it be that at temperatures near critical temperature the magnetic body of the system is maximally flexible and can change its structure. Residing at the border of order and chaos would make the cellular water very sensitive to external perturbations and provide its magnetic body with sensory and motor system. The bio-chemical realizations of sensory and motor systems would have emerged later.

6.7.3 Snow flakes and macroscopic quantum self-organization

Thanks for Nikolina Benedikovic for a link (see `https://www.treehugger.com/natural-sciences/macro-photos-snowflakes-show-impossibly-perfect-designs.html`) representing images of snowflakes. This led to a very interesting discussion generating new details to the view about self-organization in TGD Universe. Also phase transitions liberating heat as a new manner to generate dark matter in TGD sense in phase transition liberating heat energy suggest themselves and could provide a way to generate artificial life in quantum sense.

The link told about snowflakes having incredibly precise symmetry. Their formation is still poorly understood and their precise symmetries remain a mystery. One would expect something like this in atomic length scales, where one has quantum coherence but certainly not in macroscopic scales. This inspires heretic questions. Could it be that the snowflakes reflect quantum coherence in their own size scale? Snowflakes are not macroscopically quantum coherent. What could be the quantum coherent system involved?

I can reveal my cards. This was mere rhetoric. I have made these questions 15 years ago but in different context. The outcome of these questions is TGD view about living matter and matter in general based now of adelic physics providing number theoretic vision about TGD [L17, L23] .

Magnetic body containing dark matter as $h_{eff} = nh_0$ phases ($h/h_0 = 6$ is a good guess [L13]) and inducing self-organization of ordinary matter with quantum coherence of dark matter inducing the ordinary long range coherence of ordinary matter. The relevance for quantum biology would be that the highly problematic quantum coherence of ordinary bio-matter would not be needed.

Could this explain snowflakes as impossibly perfect designs as self-organization patterns forced in ordinary matter by quantum coherent magnetic body of water? I remember that some-one has said that snowflakes are like zoom-ups of atomic systems reflecting basic molecular symmetries. They could be indeed analogous to zoom-ups of atomic systems with zooming factor given by n. Quite concretely, the lengths of hydrogen bonds would be scaled up by n.

Concerning a concrete model for snowflakes there is clear hint. The self-organization would increase the values of h_{eff} and this requires energy feed. Where does it come from?

Freezing of water liberates energy: this could serve as source of metabolic energy. More generally phase transitions liberating heat energy could generate h_{eff} ¿ h phases and generate highly ordered structures. Here might a possible method to create dark matter in TGD sense.

An interesting application is to the findings of Masaru Emoto [L29] that emotional expressions of humans seem to affect water at criticality for freezing. Angry voices are claimed to create ugly patterns and friendly voices beautiful ones. The metabolic energy needed to induce phase transition transforming ordinary matter to dark matter as exotic phase of water would come from the latent heat liberated in freezing. By macroscopic quantum coherence of MB the resulting dark parts of water's MB would be sensitive to human emotional expressions.

Could living systems utilize quantum critical phase transition liberating energy?

Wes Johnson commented about the ability of living systems to use heat as metabolic energy. Could phase transitions liberating heat produce this energy and lead to a generation of large h_{eff} phases?

1. In TGD Universe the efficiency of living matter to use heat as metabolic energy would a characteristic of not only life but all self-organizing systems. The distinction between living and in-animate would be only quantitative. The evolutionary aspect of self-organization would be generation of coherence in longer scales and would be induced by generation of large h_{eff} phases at magnetic body becoming thus quantum coherent in long scales. Energy feed would generate these phases and at criticality for a phase transition liberating heat energy (enthalpy) this is easy.

2. Living systems are conscious in a narrow temperature range. Perhaps this relates to the criticality for phase transition liberating energy in turn generating especially important h_{eff} phases. Water has special anomalies around the physiological temperature and looks like a two-phase system (at least). This kind of a phase transition of water could be fundamental for living matter.

   This could have a direct connection with the Pollack effect [**?**] creating charge separation: in TGD part of protons would become dark protons at magnetic flux tubes - dark nuclei providing a fundamental representation for genetic code [L30].

3. Carbohydrates are carriers of metabolic energy. Could this mean that they have molecular bonds (valence bonds) with non-standard value of Planck constant h_{eff} and that their energy is liberated when these bonds disappear in the splitting of these bonds or even in the reduction of h_{eff} , which would be basic element of bio-catalysis. I have indeed proposed a model for valence bonds in terms of dark flux tubes with $h_{eff} > h$ [L16]. The values of n involved would be relatively small and would correspond to the many-sheetedness for the space-time surface as covering of $H = M^4 \times CP_2$ coordinates would be n-valued. n would increase towards right end of the rows of the periodic end and this would explain the different roles of the molecules at opposite ends of the rows in biology.

The two aspects of self-organization

Note that these phase transitions producing phases with a non-standard value of h_{eff} represent evolution as a statistical increase of the dimension of extension of rationals and relying on "big" (ordinary) state function reductions (BSFRs). This active, evolutionary aspect could be seen as quantal aspect of self-organization.

There is also classical, passive, aspect assignable to the evolution of subsystem by "small" state function reductions (SSFRs) serving as counterparts of weak measurements. In TGD inspired theory of consciousness, motor-sensory duality corresponds to these two aspects. Motor actions correspond to BSFRs and sensory experience to SSFRs.

1. ZEO predicts that time reversal occurs in ordinary state function reductions (BSFRs) and that these reductions occur in all scales and look like ordinary classical evolutions leading to the final state smoothly and deterministically: this was discovered by Minev *et all* in atomic systems [L31]. This would remove the conflict between classicality and no-determinism at the level of conscious experience. Quantum systems would do their best to look like classical.

2. Self-organization as a generation of structures at space-time level (passive aspect) can be understood in terms of zero energy ontology (ZEO) alone [L36]. Self-organization (its sensory aspect) and metabolism (use of energy) could be seen as a dissipation in opposite direction of time: no separate models or mechanisms would be needed. Gradients would increase, structure would be generated. Basic biological processes at bio-molecular level would be controlled by magnetic bodies in time reversed states. The only challenge is to understand how living matter generates the sources of metabolic energy - how living system stores energy.

6.8 The experiments of Masaru Emoto with emotional imprinting of water

Sini Kunnas sent a link to a video telling about experiments of Masaru Emoto (see `http://tinyurl.com/pqy57jj`) with water, which is at criticality with respect to freezing and then frozen. Emoto reports is that words expressing emotions are transmitted to water: positive emotions tend to generate beautiful crystal structures and negative emotions ugly ones. Also music and even pictures are claimed to have similar effects. Emoto has also carried out similar experiments with rice in water. Rice subjected to words began to ferment and water subject to words expressing negative emotions began to rotten.

Remark: Fermentation is a metabolic process consuming sugar in absence of oxygen. Metabolism is a basic signature of life so that at least in this aspect the water+rice system would become alive. The words expressing positive emotions or even music would serve as a signal "waking up" the system.

One could define genuine skeptic as a person who challenges existing beliefs and pseudo-skeptic (PS in the sequel) as a person challenging - usually denying - everything challenging the mainstream beliefs. The reception of the claims of Emoto is a representative example about the extremely hostile reactions of PSs as aggressive watchdogs of materialistic science towards anything that challenges their belief system. The psychology behind this attitude is same as behind religious and political fanatism.

I must emphasize that I see myself as a thinker and regard myself as a skeptic in the old-fashioned sense of the word challenging the prevailing world view rather than phenomena challenging the prevailing world view. I do not want to be classified as believer or non-believer. The fact is that if TGD inspired theory of consciousness and quantum biology describes reality, a revolution in the world view is unavoidable. Therefore it is natural to consider the working hypothesis that the effects are real and see what the TGD based explanation for them could be.

The Wikipedia article about Masaru Emoto (see `http://tinyurl.com/pqy57jj`) provides a good summary of the experiments of Emoto and provides a lot of links so that I will give here only a brief sketch. According to the article Emoto believed that water was a "blueprint for our reality" and that emotional "energies" and "vibrations" could change the physical structure of water. The water crystallization experiments of Emoto consisted of exposing water in glasses to different words, pictures or music, and then freezing and examining the aesthetic properties of the resulting crystals with microscopic photography. Emoto made the claim that water exposed to positive speech and thoughts would result in visually "pleasing" crystals being formed when that water was frozen, and that negative intention would yield "ugly" crystal formations.

In 2008, Emoto and collaborators published and article titled "Double-Blind Test of the Effects of Distant Intention on Water Crystal Formation" about his about experiments with water in the Journal of Scientific Exploration, a peer reviewed scientific journal of the Society for Scientific Explorations (see `http://tinyurl.com/ycsnu2oc`). The work was performed by Masaru Emoto and Takashige Kizu of Emoto's own IHM General Institute, along with Dean Radin and Nancy Lund of the Institute of Noetic Sciences, which is on Stephen Barrett's Quackwatch (see `http://tinyurl.com/y99kol2e`) blacklist of questionable organizations. PSs are the modern jesuits and for jesuits the end justifies the means.

Emoto has also carried experiments with rice samples in water. There are 3 samples. First sample "hears" words with positive emotional meaning, second sample words with negative emotional meaning, and the third sample serving as a control sample. Emoto reports (see `https://youtu.be/Wc-ZmvxfBxE`) that the rice subjected to words with positive emotional content began to ferment whereas water subject to words expressing negative emotions began to rotten. The control sample also began to rotten but not so fast.

In the sequel I will consider the working hypothesis that the effects are real, and develop an explanation based on TGD inspired quantum biology [K59, K58, K57]. The basic ingredients of the model are following: magnetic body (MB) carrying dark matter as $h_{eff}/h = n$ phases of ordinary matter; communications between MB and biological body (BB) using dark photons able to transform to ordinary photons identifiable as bio-photons; the special properties of water explained in TGD framework by assuming dark component of water implying that criticality for freezing involves also quantum criticality, and the realization of genetic code and counterparts of the basic bio-molecules as dark proton sequences and as 3-chords consisting of light or sound providing a universal language allowing universal manner to express emotions in terms of bio-harmony realized as music of light or sound. The entanglement of water sample and the subject person (with MBs included) realized as flux tube connections would give rise to a larger conscious entity expressing emotions via language realized in terms of basic biomolecules in a universal manner by utilizing genetic code realized in terms of both dark proton sequences and music of light of light and sound.

6.8.1 The reception of the findings of Emoto

The findings of Emoto challenge the materialistic world view and have received both genuine criticism and "criticism".

Criticism and "criticism"

Commentators have criticized Emoto for insufficient experimental controls and for not sharing enough details of his approach with the scientific community. Prof. emeritus William A. Tiller, a researcher featured in the documentary "*What The Bleep Do We Know?*", states that experiments of Emoto fall short of proof, since they do not control for other factors in the supercooling of water. It is easy to agree that scientific proof is not in question. William Tiller claims that supercooling of water involved with the experiments might have delicate effects difficult to control.

Remark: Supercooling of water makes it critical system, even quantum critical and in TGD Universe, and this makes it ideal target of remote mental interactions.

A lot of experiments are needed: in particular, the possible dependence on the person who utters the words with emotional content, deserves to be studied. Just taking randomly chosen group of people and control system might not be enough to achieve a significant effect. Situation could be similar to that in the recent double slit experiments of Radin [L15] (see `http://tinyurl.com/y72b87p7`), in which subject person tries to intentionally affect the interference pattern for light travelling through slits. The effect is clear in the case of experienced meditators. That very few of us are not concert pianists, cannot be used to argue that there are no concert pianists.

There is also the authoritative "criticism", which carefully avoids stating anything about contents of the work and directs the efforts on rhetoric tricks. These "criticisms" do not deserve serious attention except as perfect examples of the empty rhetorics so typical for PSs. The following examples are citations from the Wikipedia article (see `http://tinyurl.com/pqy57jj`).

> Emoto has been criticized for designing his experiments in ways that leave them prone to manipulation or human error influencing the findings. Biochemist and Director of Microscopy at University College Cork William Reville wrote, "*It is very unlikely that there is any reality behind claims of Emoto.*". Reville noted the lack of scientific publication and pointed out that anyone who could demonstrate such a phenomenon would become immediately famous and probably wealthy.

Remark:The absence of scientific publication (in respected journal of course) often reflects the fact that PSs have reached their goal to prevent publishing anything challenging their beliefs. I have experienced this myself during four decades very concretely. At nineties it became even impossible to get anything into arXiv.

> Writing about Emoto's ideas in the Skeptical Inquirer, physician Harriet A. Hall concluded that it was "*hard to see how anyone could mistake it for science*". Commenting on Emoto's ideas about clearing water polluted by algae, biologist Tyler Volk stated, "*What he is saying has nothing to do with science as I know it.*" Stephen Kiesling wrote in Spirituality & Health Magazine, "*Perhaps Emoto is an evangelist who values the message of his images more than the particulars of science; nevertheless, this spiritual teacher might focus his future practice less on gratitude and more on honesty.*".

Needless to restate that these comment say nothing about contents.

Emoto is not the only victim of pseudo-skepticism

The criticism of the experiments of Emoto mostly reflects the prevailing materialistic dogmas, which do not allow these effects so that depending on the authority Emoto is concluded to be mad, charlatan, or evangelist. The rage of PSs is really frightening and demonstrates how powerful effects ideology can have.

Emoto shares the fate of experimenters studying water memory and homeopathy. "Homeopathy" is indeed a word making skeptic growl and drool: one can hardly imagine a more impressive demonstration of words on water than this! An almost- Nobelist Benveniste was labelled as swindler as he announced about experiments providing support for water memory and homeopathy. Magician Randi - Randi again(!) - participated the investigation of the mind-police of science, in which Benveniste and laboratory staff was treated like criminals unless otherwise proven.

There is a lot of support about the representation of water memory as extremely low frequencies (ELF) of radiation associated with water [I15, I16]. These ELF frequencies can be stored electronically and they produce the same effects as the bio-active chemical, whose presence induced these frequencies in water. These facts PSs simply neglect because they do not fit the belief system of PSs dating back to 18th century. At the age of IT the idea about the existence of representations of bio-active molecules as frequency patterns able to induce the biological effects of molecules without the presence of molecules should not raise aggressions.

Few years ago HIV Nobelist Montagnier did experiments giving support for water memory and the procedure involved a part very similar to that used in preparing homeopathic remedies [I26] [L3]. In TGD framework these frequencies wuold correspond to cyclotron frequencies assignable to MBs of molecules, and immune system is proposed to have emerged from the ability of water to mimic the magnetic bodies of invader molecules and learning to recognize them [K19]. This interpretation could mean a breakthrough in biology but unfortunately the time is not mature for this yet.

Remote mental interactions/paranormal phenomena [K59] belong also to the pariah phenomena having no place in materialistic world and people having the courage to challenge this view are labelled as science criminals by PSs.

Analyzing the mindset of PS

People calling themselves skeptics are rarely skeptics in the original meaning of the word but believers, even fanatic believers. The basic un-challengeable belief is materialism stating that consciousness is only an epiphenomenon - illusion as David Dennett puts it without explaining what he means with the claim that consciousness does not exist but is only one particular phenomenon of consciousness - namely illusion. There is no free will and there are no genuine intentional actions. Moral and ethics are illusions. And certainly, human can have no intentional effects on water since even genuine intentional effects on our own body are impossible. This leads to the notion of objectivity as PS understands it.

This notion of objectivity implies that the outcome of given experiment cannot depend on who carries it or on who the subject persons are. If this turns out to not be the case, the experiment is not well-done and experimenter can be ridiculed. Water is dead matter for PS, even the PS himself should be dead matter if the materialistic logic is taken to its bitter end. I dare guess that most PSs privately believe - without even realizing that this is the case - that their intentions genuinely affect the sack of water with some chemicals that is called their body. It is extremely difficult pretend that one is not conscious when one is conscious.

The conclusion of the PS is that the outcome of Emoto's experiments with water and rice cannot depend at all on the person who utters the words expressing positive or negative emotions. PS calls this assumption objectivity but is actually only an assumption that there is no such thing as intentional free will and that we live in a deterministic world of billiard balls. This view is known to be wrong: quantum entanglement has been verified for cell sized system in macroscopic scales and quantum world is non-deterministic - mentioning this fact is carefully avoided in text books. PSs also unashamedly put under the rug hundreds of anomalies related to the physics of water.

If human intention and emotion can have effects on water, the first question is whether the intention and emotion of some humans these effects are stronger. Belief moves mountains and since Emoto believes that intention can have effects, it would be only natural that the effects are stronger. If this is true, one cannot demand the repeatability of the experiment anymore. In paranormal research the experimenter effect is well-known - some experimenters are more successful than others without being charlatans - as also in medicine. This is the case always when living systems are involved. There is another amusing example demonstrating the shallowness of the thinking of PSs: PSs love to say that the effects of healing practices produce nothing but placebo effects without realizing that placebo effect as such is a fascinating mind-over-matter effect begging for explanation!

Of course, if Emoto believed that the emotions have effects on water, his desire to prove this belief might have produced these effects - not by cheating but by intentional rather than emotional imprinting based on remote mental interactions affecting water. The words as such need not have caused the effect. This would represent an example of remote mental interactions. Note however that also music and even pictures were reported to have effects on water and it is not easy to explain this as experimenter effect.

An amusing "experiment" on rice was carried out by a hard-nosed skeptic Carry Poppy (see `http://tinyurl.com/y8g9jgal`). The extremely nasty tone of the article reveals the hatred of Poppy towards Emoto and people challenging the materialist world view. The outcome of the "experiment" carried by Poppy was of course negative. Perhaps not surprising, the outcome would express faithfully the real intention and desire of the experimenter!

6.8.2 TGD based model for Emoto's findings

In TGD based view the notion of magnetic body (MB) is central [K58, K57]. MB carries dark phases of matter identified as phases of ordinary matter with $h_{eff}/h = n$ making possible macroscopic quantum coherence explaining the coherence of living matter not understandable in the biochemistry based approach. The interactions between MB and biological body (BB) are essential remote mental interactions based on signalling using dark photons. Therefore the basic mechanisms of quantum biology would be also mechanisms of remote mental interactions - only the target would be non-standard. We are mostly water and it would not be surprising if these mechanisms would allow intentional and emotional imprinting of also water outside our body and in quantum critical state.

Basic incredients of the model

In TGD universe water is very special substance in that it contains both ordinary water and its dark variant. What makes it dark is that dark magnetic flux tubes representing long hydrogen bonds are present for some portion of water [L26] (see `http://tinyurl.com/y8fvwbp9`): the length of bonds scales as n or perhaps even n^2. The presence of these flux tubes makes any liquid phase a network like structure and one ends up with a model explaining an anomaly of thermodynamics of liquids at criticality known already in Maxwell's time. This leads to a model explaining the numerous anomalies of water in terms of the dark matter.

For instance, the dark part of water with non-standard Planck constant transforms to ordinary water in freezing. As a consequence, a large amount of energy is liberated. This explains why water has anomalously large latent heat of fusion. One can also understand why the volume of water increases in freezing and decreases in heating in the interval 0-4 °C. The anomalies of water are largest at physiological temperature $T_{phys} \sim 37$ °C suggesting that the dark portion of water is largest at T_{phys}. Dark fraction of water would be essential for life.

Dark protons sequences at flux tubes representing genetic code and the analogs of basic biomolecules are realized in water. Pollack effect [L8] (see `http://tinyurl.com/oyhstc2`) requiring feed of energy - as IR radiation for instance - generates so called exclusion zones (EZs), which are negatively charged regions. A fraction of protons from water must go somewhere and the TGD inspired proposal [L8] (see `http://tinyurl.com/gwasd8o`) is that the protons transform to dark protons at magnetic flux tubes. The dark variants of particles quite generally have higher energies than ordinary ones and energy feed provides the needed metabolic energy go make the protons dark. In the case of homeopathy and water memory mechanical agitation creates provides the metabolic energy and would generate EZs accompanied by dark proton sequencies at flux tubes [K19].

Remote expression of emotions as crystal patterns - emotional imprinting - is required and communication requires a code so that receiver and sender have same interpretation for the signal. Genetic code would provide the fundamental code making possible universal meanings. TGD leads to two basic proposals predicting the numbers of DNA codons coding for given AA rather successfully.

1. The first proposal [L11] relies on TGD view about dark matter as $h_{eff}/h = n$ phases of ordinary matter [K81, K75, K88] motivated by adelic physics extending physics to include also the correlates of cognition [L17, L18] (see `http://tinyurl.com/ycbhse5c` and `http://tinyurl.com/ybzkfevz`). The empirical motivation comes from several sources, in particular from the findings of Pollack.

   Dark genetic code would be realized in terms of dark proton sequences at flux tubes- dark nuclei. The model predicts dark counterparts of DNA, mRNA, tRNA, and AA as dark proton sequences which codons identifiable as dark proton triplets. Bio-chemistry would emerge as a shadow of the much simpler dynamics of dark matter at flux tubes and genetic code would be induced by dark code code.

2. Second model of genetic code emerged accidentally from a geometric model of music harmony [L6, L24] (see `http://tinyurl.com/yad4tqwl` and `http://tinyurl.com/yd8d8x6j`) involving icosahedral (12 vertices-12-note scale and 20 faces-number of AAs) and tetrahedral geometries leading to the proposal that DNA codons and possibly also AAs correspond to 3-chords defining the harmony and obtained as unions of 20+20+20 3-chords associated with icosahedral 20-chord harmonies with symmetries Z_6, Z_4, Z_2 plus tetrahedral 4-chord harmony. There is large number of these harmonies bringing in additional degrees of freedom.

   Remark: This model has obviously analogies with the notion of wave genome introduced by Peter Gariaev [I20, I21, I31].

   Since music both expresses and creates emotions, the proposal is that these harmonies assigning additional hidden degrees of freedom to the MBs of dark variants of DNA, RNA, etc... serve as correlates of emotions also at the molecular level. This emotional context could also give rise to context dependence of the code if several harmonies are realizable chemically. Taking seriously TGD inspired theory of consciousness [L19] (see `http://tinyurl.com/ycxm2tpd`) and model of emotions [L22] (see `http://tinyurl.com/ydhxen4g`), one might say that the details of the code might depend slightly on the "emotional" state of DNA, RNA, and possibly other molecules.

TGD based mechanism for emotional imprinting

One must not forget that as a passionate researcher Emoto probably had very intimate relationship with water! As we all have with one particular water volume, which we call our body! I can intend raising my hand and it raises. Also my emotions are expressed in this personal bag of water containing also some fraction of biomolecules. I doubt that even the most fanatic PS would not try to tell me that I am performing a sleight of hand as I do this. But they should do this in order to take their materialistic logic to its bitter end.

One can perhaps say that Emoto extended his body by fusing with the MB of water, which in turn controls the ordinary part of water just like it controls our own body. The reports of experiences about extension of body are not unheard in the spiritual practices. Not even in everyday life. If you touch ground with a stick, you experience the touch as if the stick were part of your body. Could the stick really become part of your body in some sense?

What could be the precise mechanism for emotional imprinting (as analog of intentional imprinting that Tiller talks about [J40])?

1. The basic vision is that living matter is a quantum critical system making it extremely sensitive to perturbations (actually TGD Universe is quantum critical in well-defined sense [L27] (see `http://tinyurl.com/yakzlllk`). This makes biological system an ideal sensor and motor instrument. In particular, intentions can affect body water at quantum criticality optimally. At quantum criticality phases with several values of Planck constant $h_{eff}/h = n$ are present and correspond to dark matter which is the key player in TGD inspired model

of living systems. As already noticed, the dark portion of water would be maximal at physiological temperature.

2. In the system studied by Emoto the subject person and water must form an entangled quantum critical system. Water - or rather, the MB of water - must have part of it in $h_{eff}/h = n$ dark phase becoming in certain sense part of subject person. Magnetic flux tubes connecting subject person to a sample of water (or of rice and water) and carrying dark matter would serve as correlates of attention.

   What might be called loving attention would provide metabolic energy to the target and might be essential element in generating the dark phase giving rise to the beautiful crystal patterns. $h_{eff}/h = n$ can be seen as kind of universal IQ: the more the system contains subsystems with large n, the higher its ability to generate conscious information, negentropy, is.

   Therefore choosing randomly a subject person who just says a word with positive or negative meaning but without emotion might not be enough to reproduce Emotos findings. It is also quite possible that the outcome of the experiment is a realization of subject person's intention/desire to have the desired effect. This would not however reduce the profound implications of the findings of Emoto if they are true.

3. Thanks to the presence of dark portion of water, super-cooled water is quantum critical system in TGD Universe. In supercooling the temperature can become considerably lower than in the usual freezing and means that also the dark portion of water stays dark. This dark portion would react to the intentions of subject person. The crystal structures would serve as kind of photograph is of the representations of mental images of the system subject person + dark portion of water.

   Remark: Water normally freezes at 273.15 K (0 °C), but it can be supercooled at standard pressure down to its crystal homogeneous nucleation at almost 224.8 K.

What about the effects of music and even visual pictures on water? Also these effects are in principle possible and would rely on universal representation of emotions in living matter at molecular and maybe even at higher levels. Since music represents and creates emotions, the natural assumption is that the collection of allowed 3-chords express emotions both at the molecular level and at the level of MB.

1. The resonant interaction by 3-chords made of photons is possible between any pair formed by taking given member to be either DNA, RNA, tRNA or its dark variant. Dark counterparts of AAs would couple resonantly to the frequencies defined as sums of the frequencies of 3-chords. These dark variants of bio-molecules are present also in water if TGD based explanation of Pollack effect is correct. One actually ends up to a model for prebiotic evolution involving dark nuclei made from dark proton sequences in an essential manner [L20, L24](see `http://tinyurl.com/yalny39x` and `http://tinyurl.com/yd5t82gq`).

2. The frequencies of visible light are rather high for the ordinary value of Planck constant. The original motivation for the hierarchy of Planck constants was the finding that ELF em fields have quantal effects on living matter [J16]. This led to a proposal in which bio-photons at visible and UV frequencies are dark photons at ELF frequencies transformed to ordinary photons [K61]. Also the reverse transformation taking ordinary photons to dark photons is possible so that dark matter - dark variants of AAs responding resonantly to single frequency - at the flux tubes can "see".

3. The effect of words expressing positive emotions would initiate metabolism based on fermentation. The spoken words must serve as encouraging of dis-encouraging control signal just as music of light. The meaning of the words should be same for the subject person and the system rice + water. This can be the case if the systems entangle to single system via flux tube bridges.

   This relates interestingly to the theory of Russian biologist Peter Gariaev based on the assumption that genes define a language in rather concrete sense [I41, I30, I27]. I have developed these ideas from TGD point of view in [L24] (see `http://tinyurl.com/yd5t82gq`): dark variants of genes identified as dark proton sequences - essentially dark variants of nuclei - define a universal language.

4. In the model the 3-chords in question are made of light. In the case of music as we understand it they would be made of sound. In living matter sounds can be transformed to em oscillations by piezo-electric effect. The resulting em oscillations would be accompanied by both ordinary and dark photons, and both the 3-chords and melody of the music would couple to dark dark proton triplets at flux tubes serving as counterparts of DNA, RNA, tRNA, and AAs. If the same mechanism is involved with Emoto's experiments, the sounds should transform to light or they should induce at flux tubes vibrations - dark phonons - at the same frequencies that realize the representation of biomolecules and their dark variants as 3-chords.

   Remark: In TGD Universe physical state as a collection of particles is replaced with a network of flux tubes having particles at its nodes [L12] (see `http://tinyurl.com/y9kwnqfa`). Therefore sound as vibrations of the length of flux tube accompanied by fermionic string connecting pair of nodes becomes fundamental excitation rather than something emerging only at condensed matter physics.

Ugly crystals are assigned with negative emotions and emotions are assigned with harmonies. Harmonies - also those, which are sad (consider only passions of Bach) - are however usually thought of as something beautiful. Can negative emotions really correspond to any bio-harmonies characterized by symmetries. In a discussion with Sini Kunnas I realized that also the notion of disharmony could make sense. There are indeed 6 Hamiltonian cycles without any symmetries [A2, A3, A1]. I neglected them in the model of harmony because they would represent which one might call disharmony. Could one of the contributing 3 Hamiltonian cycles in bio-harmony correspond to this kind of dis-harmony and bring in 20 3-chords without any symmetries? If so the relationship between geometry and aesthetics would become very concrete. The alternative view would be that there are several harmonies realized simultaneously and thi creates disharmony.

6.9 Connection With Mono-Atomic Elements, Cold Fusion, And Sono-luminescence?

Anomalies are treasures for a theoretician and during years I have been using quite a bundle of reported anomalies challenging the standard physics as a test bed for the TGD vision about physics. The so called mono-atomic elements, cold fusion, and sonofusion represent examples of this kind of anomalies not taken seriously by most standard physicists. In the following the possibility that dark matter as large $\hbar$ phase could allow to understand these anomalies.

Of course, I hear the angry voice of the skeptic reader blaming me for a complete lack of source criticism and the skeptic reader is right. I however want to tell him that I am not a soldier in troops of either skeptics or new-agers. My attitude is "let us for a moment assume that these findings are real..." and look for the consequences in this particular theoretical framework.

6.9.1 Mono-Atomic Elements As Dark Matter And High T_c Super-Conductors?

The ideas related to many-sheeted space-time began to develop for a decade ago. The stimulation came from a contact by Barry Carter who told me about so called mono-atomic elements, typically transition metals (precious metals), including Gold. According to the reports these elements, which are also called ORMEs ("orbitally rearranged monoatomic elements") or ORMUS, have following properties.

1. ORMEs were discovered and patented by David [H7] [H7] are peculiar elements belonging to platinum group (platinum, palladium, rhodium, iridium, ruthenium and osmium) and to transition elements (gold, silver, copper, cobalt and nickel).

2. Instead of behaving as metals with valence bonds, ORMEs have ceramic like behavior. Their density is claimed to be much lower than the density of the metallic form.

3. They are chemically inert and poor conductors of heat and electricity. The chemical inertness of these elements have made their chemical identification very difficult.

4. One signature is the infra red line with energy of order .05 eV. There is no text book explanation for this behavior. Hudson also reports that these elements became visible in emission spectroscopy in which elements are posed in strong electric field after time which was 6 times longer than usually.

The pioneering observations of David Hudson [H7] - if taken seriously - suggest an interpretation as an exotic super-conductor at room temperature having extremely low critical magnetic fields of order of magnetic field of Earth, which of course is in conflict with the standard wisdom about super-conductivity. After a decade and with an impulse coming from a different contact related to ORMEs, I decided to take a fresh look on Hudson's description for how he discovered ORMEs [H7] with dark matter in my mind. From experience I can tell that the model to be proposed is probably not the final one but it is certainly the simplest one.

There are of course endless variety of models one can imagine and one must somehow constrain the choices. The key constraints used are following.

1. Only valence electrons determining the chemical properties appear in dark state and the model must be consistent with the general model of the enhanced conductivity of DNA assumed to be caused by large $\hbar$ valence electrons with $r = \hbar/\hbar_0 = n$, $n = 5,6$ assignable with aromatic rings. $r = 6$ for valence electrons would explain the report of Hudson about anomalous emission spectroscopy.

2. This model cannot explain all data. If ORMEs are assumed to represent very simple form of living matter also the presence electrons having $\hbar/\hbar_0 = 2^{k11}$, $k = 1$, can be considered and would be associated with high T_c super-conductors whose model predicts structures with thickness of cell membrane. This would explain the claims about very low critical magnetic fields destroying the claimed superconductivity.

Below I reproduce Hudson's own description here in a somewhat shortened form and emphasize that must not forget professional skepticism concerning the claimed findings.

Basic findings of Hudson

Hudson was recovering gold and silver from old mining sources. Hudson had learned that something strange was going on with his samples. In molten lead the gold and silver recovered but when "I held the lead down, I had nothing". Hudson tells that mining community refers to this as "ghost-gold", a non-assayable, non-identifiable form of gold.

Then Hudson decided to study the strange samples using emission spectroscopy. The sample is put between carbon electrodes and arc between them ionizes elements in the sample so that they radiate at specific frequencies serving as their signatures. The analysis lasts 10-15 seconds since for longer times lower electrode is burned away. The sample was identified as Iron, Silicon, and Aluminium. Hudson spent years to eliminate Fe, Si, and Al. Also other methods such as Cummings Microscopy, Diffraction Microscopy, and Fluorescent Microscopy were applied and the final conclusion was that there was nothing left in the sample in spectroscopic sense.

After this Hudson returned to emission spectroscopy but lengthened the time of exposure to electric field by surrounding the lower Carbon electrode with Argon gas so that it could not burn. This allowed to reach exposure times up to 300 s. The sample was silent up to 90 s after which emission lines of Palladium (Pd) appeared; after 110 seconds Platinum (Pt); at 130 seconds Ruthenium (Ru); at about 140-150 seconds Rhodium; at 190 seconds Iridium; and at 220 seconds Osmium appeared. This is known as fractional vaporization.

Hudson reports the boiling temperatures for the metals in the sample having in mind the idea that the emission begins when the temperature of the sample reaches boiling temperature inspired by the observation that elements become visible in the order which is same as that for boiling temperatures.

The boiling temperatures for the elements appearing in the sample are given by **Table 6.2**.

Hudson experimented also with commercially available samples of precious metals and found that the lines appear within 15 seconds, then follows a silence until lines re-appear after 90 seconds.

Element	Ca	Fe	Si	Al	Pd	Rh
$T_B/^oC$	1420	1535	2355	2327	>2200	2500
Element	Ru	Pt	Ir	Os	Ag	Au
$T_B/^oC$	4150	4300	> 4800	> 5300	1950	2600

Table 6.2: Boiling temperatures of elements appearing in the samples of Hudson.

Note that the ratio of these time scales is 6. The presence of some exotic form of these metals suggests itself: Hudson talks about mono-atomic elements.

Hudson studied specifically what he calls mono-atomic gold and claims that it does not possess metallic properties. Hudson reports that the weight of mono-atomic gold, which appears as a white powder, is 4/9 of the weight of metallic gold. Mono-atomic gold is claimed to behave like super-conductor.

Hudson does not give a convincing justification for why his elements should be mono-atomic so that in following this attribute will be used just because it represents established convention. Hudson also claims that the nuclei of mono-atomic elements are in a high spin state. I do not understand the motivations for this statement.

Remark: More than decade after writing this text (I am writing this 2018) I realized that Hudson's claim about high spin nuclei could make sense in TGD framework. If some valence nucleons inside nucleus, say neutrons in the halo, are dark - just as valence electrons in the model for the findings of Hudson - in the sense of having non-standard value $h_{eff}/h_0 = n$ of Planck constant, the unit for the quantization of angular momentum increases for them. The most plausible identification of the ordinary Planck constant is as $h = 6h_0$ [L13, L21] so that the unit of angular momentum would become $(n/6)\hbar/2$ for these exotic nuclei, and one could understand the large values of nuclear angular momenta.

Claims of Hudson about ORMEs as super conductors

The claims of Hudson that ORMES are super conductors [H7] are in conflict with the conventional wisdom about super conductors.

1. The first claim is that ORMEs are super conductors with gap energy about $E_g = .05$ eV and identifies photons with this energy resulting from the formation of Cooper pairs. This energy happens to correspond one of the absorption lines in high T_c superconductors.

2. ORMEs are claimed to be super conductors of type II with critical fields H_{c1} and H_{c2} of order of Earth's magnetic field having the nominal value $.5 \times 10^{-4}$ Tesla [H7]. The estimates for the critical parameters for the ordinary super conductors suggests for electronic super conductors critical fields, which are about .1 Tesla and thus by a factor $\sim 2^{12}$ larger than the critical fields claimed by Hudson.

3. It is claimed that ORME particles can levitate even in Earth's magnetic field. The latter claim looks at first completely nonsensical. The point is that the force giving rise to the levitation is roughly the gradient of the would-be magnetic energy in the volume of levitating super conductor. The gradient of average magnetic field of Earth is of order B/R, R the radius of Earth and thus extremely small so that genuine levitation cannot be in question.

Minimal model

Consider now a possible TGD inspired model for these findings assuming for definiteness that the basic Hudson's claims are literally true.

1. In what sense mono-atomic elements could be dark matter?

The simplest option suggested by the applicability of emission spectroscopy and chemical inertness is that mono-atomic elements correspond to ordinary atoms for which valence electrons are dark electrons with large value of $r = \hbar/\hbar_0$. Suppose that the emission spectroscopy measures the energies of dark photons from the transitions of dark electrons transforming to ordinary photons before the detection by de-coherence increasing the frequency by r. The size of dark electrons and temporal duration of basic processes would be zoomed up by r.

Since the time scale after which emission begins is scaled up by a factor 6, there is a temptation to conclude that $r = 6$ holds true. Note that $n = 6$ corresponds to Fermat polygon and is thus preferred number theoretically in TGD based model for preferred values of $\hbar$ [K81]. The simplest possibility is that the group G_b is trivial group and $G_a = A_6$ or D_6 so that ring like structures containing six dark atoms are suggestive.

This brings in mind the model explaining the anomalous conductivity of DNA by large $\hbar$ valence electrons of aromatic rings of DNA. The zooming up of spatial sizes might make possible exotic effects and perhaps even a formation of atomic Bose-Einstein condensates of Cooper pairs. Note however that in case of DNA $r = 6$ not gives only rise to conductivity but not super-conductivity and that $r = 6$ cannot explain the claimed very low critical magnetic field destroying the super-conductivity.

2. Loss of weight

The claimed loss of weight by a factor $p \simeq 4/9$ is a very significant hint if taken seriously. The proposed model implies that the density of the partially dark phase is different from that of the ordinary phase but is not quantitative enough to predict the value of p. The most plausible reason for the loss of weight would be the reduction of density induced by the replacement of ordinary chemistry with $r = 6$ chemistry for which the Compton length of valence electrons would increase by this factor.

3. Is super-conductivity possible?

The overlap criterion is favorable for super-conductivity since electron Compton lengths would be scaled up by factor $n_a = 6, n_b = 1$. For $r = \hbar/\hbar_0 = n_a = 6$ Fermi energy would be scaled up by $n_a^2 = 36$ and if the same occurs for the gap energy, T_c would increase by a factor 36 from that predicted by the standard BCS theory. Scaled up conventional super-conductor having $T_c \sim 10$ K would be in question (conventional super-conductors have critical temperatures below 20 K). 20 K upper bound for the critical temperature of these superconductors would allow 660 K critical temperature for their dark variants!

For large enough values of r the formation of Cooper pairs could be favored by the thermal instability of valence electrons. The binding energies would behave as $E = r^2 Z_{eff}^2 E_0/n^2$, where Z_{eff} is the screened nuclear charge seen by valence electrons, n the principal quantum number for the valence electron, and E_0 the ground state energy of hydrogen atom. This gives binding energy smaller than thermal energy at room temperature for $r > (Z_{eff}/n)\sqrt{2E_0/3T_{room}} \simeq 17.4 \times (Z_{eff}/n)$. For $n = 5$ and $Z_{eff} < 1.7$ this would give thermal instability for $r = 6$.

Interestingly, the reported .05 eV infrared line corresponds to the energy assignable to cell membrane voltage at criticality against nerve pulse generation, which suggests a possible connection with high T_c superconductors for which also this line appears and is identified in terms of Josephson energy. .05 eV line appears also in high T_c superconductors. This interpretation does not exclude the interpretation as gap energy. The gap energy of the corresponding BCS super-conductor would be scaled down by $1/r^2$ and would correspond to 14 K temperature for $r = 6$.

Also high T_c super-conductivity could involve the transformation of nuclei at the stripes containing the holes to dark matter and the formation of Cooper pairs could be due to the thermal instability of valence electrons of Cu atoms (having $n = 4$). The rough extrapolation for the critical temperature for cuprate superconductor would be $T_c(Cu) = (n_{Cu}/n_{Rh})^2 T_c(Rh) = (25/36)T_c(Rh)$. For $T_c(Rh) = 300$ K this would give $T_c(Cu) = 192$ K: according to Wikipedia cuprate perovskite has the highest known critical temperature which is 138 K. Note that quantum criticality suggests the possibility of several values of (n_a, n_b) so that several kinds of super-conductivities might be present.

ORMEs as partially dark matter, high T_c super conductors, and high T_c super-fluids

The appearance of .05 eV photon line suggest that same phenomena could be associated with ORMEs and high T_c super-conductors. The strongest conclusion would be that ORMEs are T_c

super-conductors and that the only difference is that Cu having single valence electron is replaced by a heavier atom with single valence electron. In the following I shall discuss this option rather independently from the minimal model.

1. ORME super-conductivity as quantum critical high T_c superconductivity

ORMEs are claimed to be high T_c superconductors and the identification as quantum critical superconductors seems to make sense.

1. According to the model of high T_c superconductors as quantum critical systems, the properties of Cooper pairs should be more or less universal so that the observed absorption lines discussed in the section about high T_c superconductors should characterize also ORMEs. Indeed, the reported 50 meV photon line corresponds to a poorly understood absorption line in the case of high T_c cuprate super conductors having in TGD framework an interpretation as a transition in which exotic Cooper pair is excited to a higher energy state. Also Copper is a transition metal and is one of the most important trace elements in living systems [D2]. Thus the Cooper pairs could be identical in both cases. ORMEs are claimed to be superconductors of type II and quantum critical superconductors are predicted to be of type II under rather general conditions.

2. The claimed extremely low value of H_c is also consistent with the high T_c superconductivity. The supra currents in the interior of flux tubes of radius of order $L_w = .4$ μm are BCS type supra currents with large $\hbar$ so that T_c is by a factor 2^{14} ($127 - 113 = 14$ is inspired by the Mersenne hypothesis for the preferred p-adic length scales) higher than expected and H_c is reduced by a factor 2^{-10}. This indeed predicts the claimed order of magnitude for the critical magnetic field.

3. The problem is that $r = 2^{14}$ is considerably higher that $r = 6$ suggested by the minimum model explaining the emission spectroscopic results of Hudson. Of course, several values of $\hbar$ are possible so that internal consistency would be achieved if ORMEs are regarded as a very simple form of living matter with relatively small value of r and giving up the claim about the low value of critical magnetic field.

4. The electronic configurations of Cu and Gold are chemically similar. Gold has electronic configuration $[Xe, 4f^{14}5d^{10}]6s$ with one valence electron in s state whereas Copper corresponds to $3d^{10}4s$ ground state configuration with one valence electron. This encourages to think that the doping by holes needed to achieve superconductivity induces the dropping of these electrons to $k = 151$ space-time sheets and gives rise to exotic Cooper pairs.

   In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

   Also this model assumes the phase transition of some fraction of Cu nuclei to large $\hbar$ phase and that exotic Cooper pairs appear at the boundary of ordinary and large $\hbar$ phase.

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

2. "Levitation" and loss of weight

The model of high T_c superconductivity predicts that some fraction of Cu atoms drops to the flux tube with radius $L_w = .4$ μm and behaves as a dark matter. This is expected to occur also in the case of other transition metals such as Gold. The atomic nuclei at this space-time sheet have high charges and make phase transition to large $\hbar$ phase and form Bose-Einstein condensate and superfluid behavior results. Electrons in turn form large $\hbar$ variant of BCS type superconductor. These flux tubes are predicted to be negatively charged because of the Bose-Einstein condensate of exotic Cooper pairs at the boundaries of the flux tubes having thickness $L(151)$. The average charge density equals to the doping fraction times the density of Copper atoms.

The first explanation would be in terms of super-fluid behavior completely analogous to the ability of ordinary superfluids to defy gravity. Second explanation is based on the electric field of Earth which causes an upwards directed force on negatively charged BE condensate of exotic Cooper pairs and this force could explain both the apparent levitation and partial loss of weight. The criterion for levitation is $F_e = 2eE/x \geq F_{gr} = Am_pg$, where $g \simeq 10$ m^2/s is gravitational acceleration at the surface of Earth, A is the atomic weight and m_p proton mass, E the strength of electric field, and x is the number of atoms at the space-time sheet of a given Cooper pair. The condition gives $E \geq 5 \times 10{-}10Ax$ V/m to be compared with the strength $E = 10^2 - 10^4$ V/m of the Earths electric field.

An objection against the explanation for the effective loss of weight is that it depends on the strength of electric field which varies in a wide range whereas Hudson claims that the reduction factor is constant and equal to 4/9. A more mundane explanation would be in terms of a lower density of dark Gold. This explanation is quite plausible since there is no atomic lattice structure since nuclei and electrons form their own large $\hbar$ phases.

4. The effects on biological systems

Some monoatomic elements such as White Gold are claimed to have beneficial effects on living systems [H7]. 5 per cent of brain tissue of pig by dry matter weight is claimed to be Rhodium and Iridium. Cancer cells are claimed to be transformed to healthy ones in presence of ORMEs. The model for high T_c super conductivity predicts that the flux tubes along which interior and boundary supra currents flow has same structure as neuronal axons. Even the basic length scales are very precisely the same. On basis of above considerations ORMEs are reasonable candidates for high T_c superconductors and perhaps even super fluids.

The common mechanism for high T_c, ORME- and bio- super-conductivities could explain the biological effects of ORMEs.

1. In unhealthy state superconductivity might fail at the level of cell membrane, at the level of DNA or in some longer length scales and would mean that cancer cells are not anymore able to communicate. A possible reason for a lost super conductivity or anomalously weak super conductivity is that the fraction of ORME atoms is for some reason too small in unhealthy tissue.

2. The presence of ORMEs could enhance the electronic bio- superconductivity which for some reason is not fully intact. For instance, if the lipid layers of cell membrane are, not only wormhole-, but also electronic super conductors and cancer involves the loss of electronic super-conductivity then the effect of ORMEs would be to increase the number density of Cooper pairs and make the cell membrane super conductor again. Similar mechanism might work at DNA level if DNA: s are super conductors in “active” state.

5. Is ORME super-conductivity associated with the magnetic flux tubes of dark magnetic field $B_d = 0.2$ Gauss?

The general model for the ionic super-conductivity in living matter, which has developed gradually during the last few years and will be discussed in detail later, was originally based on the assumption that super-conducting particles reside at the super-conducting magnetic flux tubes of Earth's magnetic field with the nominal value $B_E = .5$ Gauss. It became later clear that the explanation of ELF em fields on vertebrate brain requires $B_d = .2$ Gauss rather than $B_E = .5$ Gauss [K15]. The interpretation was as dark magnetic field $B_d = .2$ Gauss. The model of EEG led also to the hypothesis that Mersenne primes and their Gaussian counterparts define preferred p-adic length scales and their dark counterparts. This hypothesis replaced the earlier $r = 2^{11k}$ hypothesis.

For $r = 2^{127-113=14}$ the predicted radius $L_w = .4\ \mu$m is consistent with the radius of neuronal axons. If one assumes that the radii of flux tubes are given by this length scale irrespective of the value of r, one must replace the quantization condition for the magnetic flux with a more general condition in which the magnetic flux is compensated by the contribution of the supra current flowing around the flux tube: $\oint (p - eA) \cdot dl = n\hbar$ and assume $n = 0$. 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.

The most natural interpretation would be that these flux tubes topologically condense at the flux tubes of B_E. Both bosonic ions and the Cooper pairs of electrons or of fermionic ions can act as charge carriers so that actually an entire zoo of super-conductors is predicted. There is even some support for the view that even molecules and macromolecules can drop to the magnetic flux tubes [K22].

Nuclear physics anomalies and ORMEs

At the homepage of Joe Champion [H19] information about claimed nuclear physics anomalies can be found.

1. The first anomaly is the claimed low temperature cold fusion. For instance, Champion claims that Mercury (Z=80), decays by emission of proton and neutrons to Gold with Z=79 in the electrochemical arrangement described in [H19].

2. Champion mentions also the anomalous production of Cadmium isotopes electrochemically in presence of Palladium reported by Tadahiko Mizuno.

The simplest explanation of the anomalies would be based on genuine nuclear reactions. The interaction of dark nuclei with ordinary nuclei at the boundary between the two phases would make possible genuine nuclear transmutations since the Coulomb wall hindering usually cold fusion and nuclear transmutations would be absent (Trojan horse mechanism). Both cold fusion and reported nuclear transmutations in living matter could rely on this mechanism as suggested in [K94, L2, K79], [L2].

Possible implications

The existence of exotic atoms could have far reaching consequences for the understanding of bio-systems. If Hudson's claims about super-conductor like behavior are correct, the formation of exotic atoms in bio-systems could provide the needed mechanism of electronic super-conductivity. One could even argue that the formation of exotic atoms is the magic step transforming chemical evolution to biological evolution.

Equally exciting are the technological prospects. If the concept works it could be possible to manufacture exotic atoms and build room temperature super conductors and perhaps even artificial life some day. It is very probable that the process of dropping electron to the larger space-time sheet requires energy and external energy feed is necessary for the creation of artificial life. Otherwise the Earth and other planets probably have developed silicon based life for long time ago. Ca, K and Na ions have central position in the electrochemistry of cell membranes. They could actually correspond to exotic ions obtained by dropping some valence electrons from $k = 137$ atomic space-time sheet to larger space-time sheets. For instance, the $k = 149$ space-time sheet of lipid layers could be in question.

The status of ORMEs is far from certain and their explanation in terms of exotic atomic concept need not be correct. The fact is however that TGD predicts exotic atoms: if they are not observed TGD approach faces the challenge of finding a good explanation for their non-observability.

Interestingly, Palladium is one of the "mono-atomic" elements used also in cold fusion experiments as a target material [C9, C26]. This inspires the question whether mono-atomic phase is one of the prerequisites for cold fusion.

6.9.2 Basic Ideas About Cold Fusion

The basic prediction of TGD is a hierarchy of fractally scaled variants of QCD like theories and that color dynamics is fundamental even for our sensory qualia (visual colors identified as increments of color quantum numbers in quantum jump). The model for ORMEs suggest that exotic protons obey QCD like theory in the size scale of atom. If this identification is correct, QCD like dynamics might be studied some day experimentally in atomic or even macroscopic length scales of order cell size and there would be no need for ultra expensive accelerators!

What makes possible cold fusion?

I have proposed that cold fusion might be based on Trojan horse mechanism in which incoming and target nuclei feed their em gauge fluxes to different space-time sheets so that electromagnetic Coulomb wall disappears [K94]. If part of Palladium nuclei are "partially dark", this is achieved. Another mechanism could be the de-localization of protons to a larger volume than nuclear volume induced by the increase of h_{eff} meaning that reaction environment would differ dramatically from that appearing in the usual nuclear reactions and the standard objections against cold fusion would not apply anymore [K94]: this de-localization could correspond to the darkness of electromagnetic and perhaps also electroweak field bodies of protons.

A third proposal is perhaps the most elegant and relies on the nuclear string model [L2] predicting a large number of exotic nuclei obtained by allowing the color bonds connecting nucleons to have all possible em charges $1, 0, 1$. Many ordinary heavy nuclei would be exotic in the sense that some protons would correspond to protons plus negatively charged color bonds. The exchange of an exotic weak boson between D and Pd nuclei transforming D nuclei to exotic neutral D nuclei would occur. The range of the exotic weak interaction correspond to atomic length scale meaning that it behaves as massless particle below this length scale. For instance, W boson could be $r = 2^{24}$ dark variant of $k = 113$ weak boson for which the dark variant of p-adic scale would correspond to the atomic scale $k = 137$ but also other options are possible.

How standard objections against cold fusion can be circumvented?

The following arguments against cold fusion are from an excellent review article by Storms [C10].

1. Coulomb wall requires an application of higher energy. Now electromagnetic Coulomb wall disappears in both models.
2. If a nuclear reaction should occur, the immediate release of energy can not be communicated to the lattice in the time available. In the recent case the time scale is however multiplied by the factor $r = n_a$ and the situation obviously changes. For $n_a = 2^{24}$ the time scale corresponding to MeV energy becomes that corresponding to keV energy which is atomic time scale.
3. When such an energy is released under normal conditions, energetic particles are emitted along with various kinds of radiation, only a few of which are seen by various CANR (Chemically Assisted Nuclear Reactions) studies. In addition, gamma emission must accompany helium, and production of neutrons and tritium, in equal amounts, must result from any fusion reaction. None of these conditions is observed during the claimed CANR effect, no matter how carefully or how often they have been sought. The large value of $\hbar(M^4)$ implying large Compton lengths for protons making possible geometric coupling of gamma rays to condensed matter would imply that gamma rays do not leave the system. If only protons form the quantum coherent state then fusion reactions do not involve the protons of the catode at all and production of ^3He and thus of neutrons in the fusion of D and exotic D.
4. The claimed nuclear transmutation reactions (reported to occur also in living matter [C6]) are very difficult to understand in standard nuclear physics framework.
   (a) The model of [K94] allows them since protons of different nuclei can re-arrange in many different ways when the dark matter state decays back to normal.
   (b) Nuclear string model [L2] allows transmutations too. For instance, neutral exotic tritium produced in the reactions can fuse with Pd and other nuclei.
5. Many attempts to calculate fusion rates based on conventional models fail to support the claimed rates within PdD (Palladium-Deuterium). The atoms are simply too far apart. This objections also fails for obvious reasons.

Mechanisms of cold fusion

In TGD framework exotic nuclei are needed to explain the selection rules which do not conform with standard nuclear physics. There are several options for what exotic nuclei could be.

1. Nuclei might be partially dark with some nucleons in dark state with Compton length of order atomic length scale.
2. Nuclei can also be exotic in the sense that some neutral color bonds have transformed to charged ones by exchange of dark W bosons effectively massless below atomic length scale. This could transform D nuclei to neutral ones and eliminate Coulomb wall. The presence of two oppositely charged bonds by (possibly dark) W exchange could give rise to a nucleus with same em charge as the original but different mass: presumably mass difference would be of order keV.
3. Also the emitted em radiation - say gamma rays - and particles - say protons or neutrons - could be dark and could remain undetected using standard means.

From this it is clear that it easy to invent models consistent with observations: careful consideration of data might however allow to fix the model to a high degree. One can try to deduce a more detailed model for cold fusion from observations, which are discussed systematically in [C10] and in the references discussed therein.

1. A critical phenomenon is in question. The average D/Pd ratio must be in the interval $(.85, .90)$. The current must be over-critical and must flow a time longer than a critical time. The effect occurs in a small fraction of samples. D at the surface of the catode is found to be important and activity tends to concentrate in patches. The generation of fractures leads to the loss of the anomalous energy production. Even the shaking of the sample can have the same effect. The addition of even a small amount of H_2O to the electrolyte (protons to the catode) stops the anomalous energy production.
   (a) These findings are consistent the view that patches correspond to a macroscopic quantum phase involving de-localized nuclear protons. The added ordinary protons and fractures could serve as a seed for a phase transition leading to the ordinary phase [K94].
   (b) An alternative interpretation is in terms of the formation of neutral exotic D and exotic Pd via exchange of exotic, possibly dark, W bosons massless below atomic length scale [L2].
2. When D_2O is used as an electrolyte, the process occurs when PdD acts as a catode but does not seem to occur when it is used as anode. This suggests that the basic reaction is between the ordinary deuterium $D = pn$ of electrolyte with the exotic nucleus of the catode. Denote by $\hat{p}$ the exotic proton and by $\hat{D} = n\hat{p}$ exotic deuterium at the catode.

   For ordinary nuclei fusions to tritium and ^3He occur with approximately identical rates. The first reaction produces neutron and ^3He via $D + D \rightarrow n +^3 He$, whereas second reaction produces proton and tritium by $3H$ via $D + D \rightarrow p +^3 H$. The prediction is that one neutron per each tritium nucleus should be produced. Tritium can be observed by its beta decay to ^3He and neutron flux is several orders of magnitude smaller than tritium flux as found for instance by Tadahiko Mizuno and his collaborators (Mizuno describes the experimental process leading to this discovery in his book [C16]). Hence the reaction producing ^3He cannot occur significantly in cold fusion which means a conflict with the basic predictions of the standard nuclear physics.
   (a) The explanation discussed in [K94] does not involve exotic nuclei with charged color bonds. The assumption is that the proton in the target deuterium $\hat{D}$ is in the exotic state with large Compton length and the production of ^3He occurs very slowly since $\hat{p}$ and p correspond to different space-time sheets. Since neutrons and the proton of the D from the electrolyte are in the ordinary state, Coulomb barrier is absent and tritium production can occur. The mechanism also explains why the cold fusion producing ^3He and neutrons does not occur using water instead of heavy water.

(b) Nuclear string model [L2] model with charged color bonds predicts that only neutral exotic tritium is produced considerably when incoming deuterium interacts with neutral exotic deuterium in the target. This requires that in target D nuclei exchange large $\hbar$ W boson with electron or Pd or other D nucleus. In the latter case the outcome is two exotic nuclei looking chemically like di-neutron and ^3He.

3. The production of ^4He has been reported although the characteristic gamma rays have not been detected.

   (a) ^4He can be produced in reactions such as $D + \hat{D} \rightarrow^4 He$ or its exotic counterpart in the model of [K94].
   (b) Nuclear string model [K94] does not allow direct production of ^4He in D-D collisions.

4. Also more complex reactions between D and Pd for which protons are in exotic state, can occur. These can lead to the reactions transforming the nuclear charge of Pd and thus to nuclear transmutations.

   Both models allow nuclear transmutations. In nuclear string model [K94] the resulting exotic tritium can fuse with Pd and other nuclei and produce nuclear transmutations.

   The reported occurrence of nuclear transmutation such as $^{23}Na+^{16}O \rightarrow^{39} K$ in living matter [C6] allowing growing cells to regenerate elements K, Mg, Ca, or Fe, could be understood in nuclear string model if also neutral exotic charge states are possible for nuclei in living matter. The experimental signature for the exotic ions would be cyclotron energy spectrum containing besides the standard lines also lines with ions with anomalous mass number. This could be seen as a splitting of lines. For instance, exotic variants of ions such Na^+, K^+, Cl^-, Ca^{++} with anomalous mass numbers should exist. It would be easy to mis-interpret the situation unless the actual strength of the magnetic field is not checked.

5. Gamma rays, which should be produced in most nuclear reactions such as ^4He production to guarantee momentum conservation are not observed.

   (a) The explanation of the model of [K94] is that the recoil momentum goes to the macroscopic quantum phase and eventually heats the electrolyte system. This provides obviously the mechanism by which the liberated nuclear energy is transferred to the electrolyte difficult to imagine in standard nuclear physics framework. The emitted gamma rays could be also dark and observed only if they transform to ordinary ones.
   (b) In nuclear string model [L2] ^4He is not produced at all.

6. Both models explain why neutrons are not produced in amounts consistent with the anomalous energy production. The addition of water to the electrolyte is however reported to induce neutron bursts.

   (a) In the model of [K94] (no charged color bonds) a possible mechanism is the production of neutrons in the phase transition $\hat{p} \rightarrow p$. $\hat{D} \rightarrow p + n$ could occur as the proton contracts back to the ordinary size in such a manner that it misses the neutron. This however requires energy of 2.23 MeV if the rest masses of $\hat{D}$ and D are same. Also $\hat{D} + \hat{D} \rightarrow n +^3 He$ could be induced by the phase transition to ordinary matter when $\hat{p}$ transformed to p does not combine with its previous neutron partner to form D but recombines with $\hat{D}$ to form $^3\hat{He} \rightarrow^3 He$ so that a free neutron is left.
   (b) Nuclear string model [L2] would suggest that the collisions of protons of water with exotic neutral D with negatively charged color bond produce neutron and ordinary D. This requires the transformation of negatively charged color bond between p and n of target D to a neutral color bond between incoming p and neutron of target.

A cautious conclusion is that nuclear string model with exotic color bonds and dark weak bosons is the more natural option. Also dark protons suggested strongly by the model for the dark portion of water can be considered but partial darkness of nuclei is perhaps an artificial idea. Note that all nuclei might appear as dark variants with size scale of molecules and analogous to folded proteins. This intriguing similarity creates the question whether the physics of linear biomolecules mimics nuclear physics and whether dark nuclei are involved with this mimicry natural in the fractal Universe of TGD.

6.9.3 Does Rossi's Reactor Give Rise To Cold Fusion?

Lubos Motl has been raging several times about the cold fusion gadget of Andrea Rossi and I decided to write the following response as he returned to the topic again (see `http://tinyurl.com/ot5kfok`). The claim of Rossi and physicist Fogardi [C22] is that the cold fusion reaction of H and Ni producing Cu takes place in the presence of some "additives" (Palladium catalyst as in may cold fusion experiments gathering at its surface Ni?).

Objections claiming that the evaporation of water does not actually take place

Lubos Motl of course "knows" before hand that the gadget cannot work: Coulomb barrier. Since Lubos Motl is true believer in naïve text book wisdom, he simply refuses to consider the possibility that the physics that we learned during student days might not be quite right. Personally I do not believe or disbelieve cold fusion: I just take it seriously as any person calling himself scientist should do. I have been developing for more than 15 years ideas about possible explanation of cold fusion in TGD framework. The most convincing idea is that large value of Planck constant associated with nuclei could be involved scaling up the range of weak interactions from 10^{-17} meters to atomic size scale and also scaling up the size of nucleus to atomic size scale so that nucleus and even quarks would like constant charge densities instead of point like charge. Therefore Coulomb potential would be smoothed and the wall would become much lower [K94, L2].

One must say in honor of Lubos Motl that at this time he had detailed arguments about what goes wrong with the reactor of Rossi: this is in complete contrast with the usual arguments of skeptics which as a rule purposefully avoid saying anything about the actual content and concentrate on ridiculing the target. The reason is of course that standard skeptic is just a soldier who has got the list of targets to be destroyed and as a good soldier does his best to achieve the goal. Thinking is not what a good soldier is expected to do since the professors in the consultive board take care of this and give orders to those doing the dirty job.

As a theoretician I have learned the standard arguments used to debunk TGD: logic is circular, text is mere world salad, everything is just cheap numerology, too many self references, colleagues have not recognized my work, the work has not been published in respected journals, and so on. The additional killer arguments state that I have used certain words which are taboos and already for this reason am a complete crackpot. Examples of bad words are "water memory", "homeopathy", "cold fusion", "crop circles", "quantum biology", "quantum consciousness". There is of course no mention about the fact that I have always emphasized that I am skeptic, not a believer or disbeliever, and only make the question "What if...." and try to answer it in TGD framework. Intellectual honesty does not belong to the virtues of skeptics who are for modern science what jesuits were for the catholic church. Indeed, as Loyola said: the purpose sanctifies the deeds.

Lubos Motl has real arguments but they suffer from the strong negative emotional background coloring so that one cannot be trust the rationality of the reasoning. The core of the arguments of Lubos Motl is following.

1. The water inside reactor is heated to a temperature of 100.1 C. This is slightly above 100 C defining the nominal value of the boiling point temperature at normal pressure. The problem is that if the pressure is somewhat higher, the boiling point increases and the it could happen that the no evaporation of the water takes place. If this is the case, the whole energy fed into the reactor could go to the heating of the water. The input power is indeed somewhat higher than the power needed to heat the water to this temperature without boiling so that this possibility must be taken seriously and the question is whether the water is indeed evaporated.

   Comments:

   (a) This looks really dangerous. Rossi uses water only as a passive agent gathering the energy assumed to be produced in the fusion of hydrogen and nickel to copper. This would allow to assume that the water fed in is at lower temperature and also the water at outlet is below boiling boiling. Just by measuring the temperature at the outlet one can check whether the outgoing water has temperature higher than it would be if all input energy goes to its heating.

(b) This is only one particular demonstration and it might be that there are other demonstrations in which the situation is this. As a matter fact, from an excellent video interview of Nobelist Brian Josephson (see `http://tinyurl.com/ya2n6mbd`) one learns that there are also demonstrations in which water is only heated so that the argument of Lubos Motl does not bite here. The gadget of Rossi is already used to heat university building. The reason why the evaporation is probably that this provides an effective manner to collect the produced energy. Also by reading the Nyteknik report (see `http://tinyurl.com/ohal8cd`) [C22] one learns that the energy production is directly measured rather than being based on the assumption that evaporation occurs.

2. Is the water evaporated or not? This is the question posed by Lubos Motl. The demonstration shows explicitly that there is a flow of vapor from the outlet. As Rossi explains there is some condensation. Lubos Motl claims that the flow of about 2 liters of vapor per second resulting from the evaporation 2 ml of water per second should produce much more dramatic visual effect. More vapor and with a faster flow velocity. Lubos Motl claims that water just drops from the tube and part of it spontaneously evaporates. This is what Lubos Motl wants to see and I have no doubt that he is seeing it. Strong belief can move mountains! Or at least can make possible the impression that they are moving!

   Comments:

   (a) I do not see what Lubos Motl sees but I am not able to tell how many liters of vapor per second comes out. Therefore the visual demonstration as such is not enough.

   (b) I wonder why Rossi has not added flow meter measuring the amount of vapor going through the tube. Second possibility is to allow the vapor condense back to water in the tube by using heat exchanger. This would allow to calculate the energy gain without making the assumption that all that comes out is vapor. It might be that in some experiments this is done.

3. But why would Rossi use this kind of questionable arrangement susceptible to accusations about fraud? Why not use lower temperature in which evaporation does not take place (Josephson reports that this has been done in some demonstrations)? The presence of dark matter phase is essential in TGD based model for cold fusion by proton absorption, and TGD vision about the generation of dark matter allows to image a possible good reason for working near thermodynamical criticality.

   The phases with large value of Planck constant are associated with quantum criticality involving long range quantum fluctuations, and large scale quantum coherence is assignable to a large value of h_{eff}. To generate dark matter one must create quantum criticality. If thermodynamical criticality is accompanied by quantum criticality at the deeper level, cold fusion would be most effective near thermodynamical criticality. In the similar manner, the doping ratio of Palladium by deuterium in $p+D$ cold fusion must be critical.

   A possible concrete model relies on the generation of large h_{eff} variants of weak bosons effectively massless below the dark weak scale, which relates to the weak scale by a factor h_{eff}/h or $(h_{eff}/h)^{1/2}$ (depending on whether the p-adic length scale is proportional to h_{eff} as suggested by the definition of Compton length or to $(h_{eff}/h)^{1/2}$ as suggested by p-adic mass calculations). In any case case, the weak scale would be scaled down from about 10^{-17} meters to atomic length scale 10^{-10} meters. This would make weak interactions as strong as em interaction below dark weak scale and proton could exchange dark W boson with target nucleus transforming therefore to neutron experiencing no Coulomb wall. Dark weak boson would be absorbed by color bond between nuclei of nuclear string [L2].

To sum up, Lubos Motl in his eagerness to debunk forgets that he is concentrating on single demonstration and forgetting other demonstrations altogether and also the published report [C22] to which his argument do not apply. I remain however skeptic (I mean real skeptic, the skepticism of Lubos Motl and -sad to say- of quite too many skeptics- has nothing to do with a real skeptic attitude). Rossi should give information about the details of his invention and quantitative tests really measuring the heat produced should be carried out and published. Presumably the financial aspects related to the invention explain the secrecy in a situation in which patenting is difficult.

Objections from nuclear physics

The reading of Rossi's paper and Wikipedia article led me to consider in more detail also various nuclear physics based objections (see `http://tinyurl.com/yd8wka4w`) against Rossi's reactor [C4]. Coulomb barrier, the lack of gamma rays, the lack of explanation for the origin of the extra energy, the lack of the expected radioactivity after fusing a proton with ^{58}Ni (production of neutrino and positron in beta decay of ^{59}Cu), the unexplained occurrence of 11 per cent iron in the spent fuel, the 10 per cent copper in the spent fuel strangely having the same isotopic ratios as natural copper, and the lack of any unstable copper isotopes in the spent fuel as if the reactor only produced stable isotopes.

1. Could natural isotope ratios be determined by cold fusion?

The presence of Cu in natural isotope ratios and the absence of unstable copper isotopes of course raise the question whether the copper is just added there. Also the presence of iron is strange. Could one have an alternative explanation for these strange co-incidences?

1. Whether unstable isotopes of Cu are present or not, depends on how fast ^{A}Cu, $A<63$ decays by neutron emission: this decay is expected to be fast since it proceeds by strong interactions. I do not know enough about the detailed decay rates to be able to say anything about this.

2. Why the isotope ratios would be the same as for naturally occurring copper isotopes? The simplest explanation would be that the fusion cascades of two stable Ni isotopes determine the ratio of naturally occurring Cu isotopes so that cold fusion would be responsible for their production. As a matter fact, TGD based model combined with what is claimed about bio-fusion led to the proposal that stable isotopes are produced in interstellar space by cold fusion and that this process might even dominate over the production in stellar interiors. This wold solve among other things also the well-known Lithium problem. The implications of the ability to produce technologically important elements artificially at low temperatures are obvious.

   If the reaction rate does not depend on isotope of Ni, the ratio ^{63}Cu/ ^{65}Cu= 69.1/30.9=2.23 should be equal to ^{62}Ni/^{64}Ni= 3.66/1.16=3.15. This is not the case if the isotope ratios are natural.

3. The presence of only stable isotopes is a further serious objection. Why the unstable isotopes would not be created in the process. Ni has several stable isotopes with mass numbers 58, 60, 61, 62, 64 with abundances 67.8, 26.23, 1.25, 3.66, 1.16 per cent. The stable isotopes of Cu have mass numbers 63,65. Isotopes with mass number 59, 61, 62, 63(stable), 65 (stable) should be created. ^{59}Cu is very shortlived. ^{61}Cu and ^{62}Cu have half-lifes of 3.33 h and 9.80 min. Their absence could be understood if the isotope ratios are determined after long enough time, say next day.

2. Could standard nuclear physics view about cold fusion allow to overcome the objections?

Consider now whether one could answer the objections in standard nuclear physics framework as a model for cold fusion processes.

1. By inspecting stable nuclides (see `http://tinyurl.com/2etfs4m`) one learns that there are two fusion cascades. In the first cascade the isotopes of copper would be produced in a cascade starting from with $^{58}Ni+n\rightarrow^{59}Cu$ and stopping at ^{63}Cu. All isotopes ^{A}Cu, $A\in\{55,62\}$ are unstable with lifetime shorter than one day. The second fusion cascade begins from ^{63}Ni and stops at ^{65}Cu.

2. The first cascade involves five cold fusions and 4 weak decays of Cu. Second cascade involves two cold fusions and one weak decay of Cu. The time taken by the cascade would be same

if there is single slow step involved having same duration. The only candidates for the slow step would be the fusion of the stable Ni isotope with the neutron or the fusion producing the stable Cu isotope. If the fusion time is long and same irrespective of the neutron number of the stable isotope, one could understand the result. Of course, this kind of co-incidence does not look plausible.

3. ^{A-5}Fe could be produced via alpha decay $^{A}Cu \rightarrow^{A-4} Co+\alpha$ followed by $^{A-4}Co \rightarrow^{A-5} Fe+p$.

3. Could TGD view about cold fusion allow to overcome the objections?

The claimed absence of positrons from beta decays and the absence of gamma rays are strong objections against the assumption that standard nuclear physics is enough. In TGD framework it is possible to ask whether the postulated fusion cascades really occur and whether instead of it weak interactions in dark phase of nuclear matter with range of order atomic length scale are responsible for the process because weak bosons would be effectively massless below atomic length scale. For TGD inspired model of cold fusion see `http://tinyurl.com/y73ydac9` and `hhttp://tinyurl.com/zofj62f` [K94, L2].

1. The nuclear string model assumes that nucleons for nuclear strings with nucleons connected with color bonds having quark and antiquark at their ends. Color bonds could be also charged and this predicts new kind of internal structure for nuclei. Suppose that the space-time sheets mediating weak interactions between the color bonds and nucleons correspond to so large value of Planck constant that weak interaction length scale is scaled up to atomic length scale. The generalization of this hypothesis combined with the p-adic length scale hypothesis is actually standard piece of TGD inspired quantum biology (`http://tinyurl.com/y9mmqzk2`) [K79].

2. The energy scale of the excitations of color bond excitations of the exotic nuclei would be measured in keVs. One could even consider the possibility that the energy liberated in cold fusion would correspond to this energy scale. In particular, the photons emitted would be in keV range corresponding to wavelength of order atomic length sale rather than in MeV range. This would resolve gamma ray objection.

3. Could the fusion process $^{58}Ni + n$ actually lead to a generation of Ni nucleus ^{59}Ni with one additional positively charged color bond? Could the fusion cascade only generate exotic Ni nuclei with charged color bonds, which would transform to stable Cu by internal dark W boson exchange transferring the positive charge of color bond to neutron and thus transforming it to neutron? This would not produce any positrons. This cascade might dominate over the one suggested by standard nuclear physics since the rates for beta decays could be much slower than the rate for direct generation of Ni isotopes with positively charged color bonds.

4. In this case also the direct alpha decay of Ni with charged color bond to Fe with charged color bond decaying to ordinary Fe by positron emission can be imagined besides the proposed mechanism producing Fe.

5. If one assumes that this process is responsible for producing the natural isotope ratios, one could overcome the basic objections against Rossi's reactor.

The presence of em radiation in keV range would be a testable basic signature of the new nuclear physics as also effects of X-ray irradiation on measured nuclear decay and reaction rates due to the fact that color bonds are excited. As a matter fact, it is known that X-ray bursts from Sun in keV range has effects on the measured nuclear decay rates and I have proposed that the proposed exotic nuclear physics in keV range is responsible for the effect. Quite generally, the excitations of color bonds would couple nuclear physics with atomic physics and I have proposed that the anomalies of water could involve classical Z^0 force in atomic length scales. Also the low compressibility of condensed matter phase could involve classical Z^0 force. The possible connections with sono-luminescence and claimed sonofusion are also obvious (`http://tinyurl.com/ycofa7jx`) [K80].

More recent results concerning heat production in Rossi's reactor

According to the article "Indication of anomalous heat energy production in a reactor device containing hydrogen loaded nickel powder" [H15] (`http://tinyurl.com/l22dxgk`) cold fusion has been demonstrated quite convincingly so that "indication" in the title can be take as a humorous understatement.

The studied system is the E-Cat HT of Rossi containing Ni power plus unknown catalyst under hydrogen pressure. The durations of test runs were about 100 hours. Heat cameras were used to measure the temperature at the upper surface of the cylinder. The lower bound for the heat power estimated theoretically from the temperature distribution using estimates for radiation power, very small conduction power through the contacts with environment, and from estimate convection power through the surrounding air. In one of the runs the input power was 360 W and output power 2034 W giving $COP \simeq 5.6$. The run took 96 hours and the weight of Ni cylinder was.236 kg. On basis of this the heat energy per weight is higher than.68 MJ/kg which is higher than for any conventional energy source. This is a lower bound since only the heat energy produced during the test run is included.

To my opinion, it seems safe to conclude that low energy nuclear reactions can be regarded as an established fact and the commercialization is indeed in full swing. It is a pity that at the same time academic theoretical physics after the results from LHC has reached dead end basically due to the sticking to the reductionistic dogma, which does not allow any new physics above elementary particle length scale - and if we believe string theorists- above Planck length length scale.

6.9.4 Sono-Luminescence, Classical Z^0 Force, And Hydrodynamic Hierarchy Of P-Adic Length Scales

Sono-luminescence [D27], [D27] is a peculiar phenomenon, which might provide an application for the hydrodynamical hierarchy. The radiation pressure of a resonant sound field in a liquid can trap a small gas bubble at a velocity node. At a sufficiently high sound intensity the pulsations of the bubble are large enough to prevent its contents from dissolving in the surrounding liquid. For an air bubble in water, a still further increase in intensity causes the phenomenon of sono-luminescence above certain threshold for the sound intensity. What happens is that the minimum and maximum radii of the bubble decrease at the threshold and picosecond flash of broad band light extending well into ultraviolet is emitted. Rather remarkably, the emitted frequencies are emitted simultaneously during very short time shorter than 50 picoseconds, which suggests that the mechanism involves formation of coherent states of photons. The transition is very sensitive to external parameters such as temperature and sound field amplitude.

A plausible explanation for the sono-luminescence is in terms of the heating caused by shock waves launched from the boundary of the adiabatically contracting bubble [D27], [D27] . The temperature jump across a strong shock is proportional to the square of Mach number and increases with decreasing bubble radius. After the reflection from the minimum radius $R_s(min)$ the outgoing shock moves into the gas previously heated by the incoming shock and the increase of the temperature after focusing is approximately given by $T/T_0 = M^4$, where M is Mach number at focusing and $T_0 \sim 300\ K$ is the temperature of the ambient liquid. The observed spectrum of sono-luminescence is explained as a brehmstrahlung radiation emitted by plasma at minimum temperature $T \sim 10^5\ K$. There is a fascinating possibility that sono-luminescence relates directly to the classical Z^0 force.

Even standard model reproduces nicely the time development of the bubble and sono-luminescence spectrum and explains sensitivity to the external parameters [D27], [D27]. The problem is to understand how the length scales are generated and explain the jump-wise transition to sono-luminescence and the decrease of the bubble radius at sono-luminescence: ordinary hydrodynamics predicts continuous increase of the bubble radius. The length scales are the ambient radius R_0 (radius of the bubble, when gas is in pressure of 1 atm) and the minimum radius $R_s(min)$ of the shock wave determining the temperature reached in shock wave heating. Zero radius is certainly not reached since shock front is susceptible to instabilities.

p-Adic length scale hypothesis and the length scales of sono-luminescence

Since p-adic length scale hypothesis introduces a hierarchy of hydrodynamics with each hydrodynamics characterized by a p-adic cutoff length scale there are good hopes of achieving a better understanding of these length scales in TGD. The change in bubble size in turn could be understood as a change in the "primary" condensation level of the bubble.

1. The bubble of air is characterized by its primary condensation level k. The minimum size of the bubble at level k must be larger than the electron Compton scale $L_e(k) = \sqrt{5}L(k)$. This suggests that the transition to photo-luminescence corresponds to the change in the primary condensation level of the air bubble. In the absence of photo-luminescence the level can be assumed to be $k = 163$ with $L_e(163) \sim .76\ \mu m$ in accordance with the fact that the minimum bubble radius is above $L_e(163)$. After the transition the primary condensation level of the air bubble one would have $k = 157$ with $L_e(157) \sim .07\ \mu m$. In the transition the minimum radius of the bubble decreases below $L_e(163)$ but should not decrease below $L_e(157)$: this hypothesis is consistent with the experimental data [D27], [D27].

2. The particles of hydrodynamics at level k have minimum size $L(k_{prev})$. For $k = 163$ one has $k_{prev} = 157$ and for $k = 157$ $k_{prev} = 151$ with $L_e(151) \sim 11.8\ nm$. It is natural to assume that the minimum size of the particle at level k gives also the minimum radius for the spherical shock wave since hydrodynamic approximation fails below this length scale. This means that the minimum radius of the shock wave decreases from $R_s(min, 163) = L_e(157)$ to $R_s(min, 157) = L_e(151)$ in the transition to sono-luminescence. The resulting minimum radius is 11 nm and much smaller than the radius .1 μ m needed to explain the observed radiation if it is emitted by plasma.

   A quantitative estimate goes along lines described in [D27], [D27].

1. The radius of the spherical shock is given by

$$R_s = At^{\alpha} , \tag{6.9.1}$$

   where t is the time to the moment of focusing and α depends on the equation of state (for water one has $\alpha \sim .7$).

2. The collapse rate of the adiabatically compressing bubble obeys

$$\frac{dR}{dt} = c_0\left(\frac{2}{3\gamma}\frac{\rho_0}{\rho}\left(\frac{R_m}{R_0}\right)^3\right)^{1/2} , \tag{6.9.2}$$

   where c_0 is the sound velocity in gas, γ is the heat capacity ratio and ρ_0/ρ is the ratio of densities of the ambient gas and the liquid.

3. Assuming that the shock is moving with velocity c_0 of sound in gas, when the radius of the bubble is equal to the ambient radius R_0 one obtains from previous equations for the Mach number M and for the radius of the shock wave

$$\begin{aligned} M &= \frac{\frac{dR_s}{dt}}{c_0} = (t_0/t)^{\alpha-1} , \\ R_s &= R_0(t/t_0)^{\alpha} , \\ t_0 &= \frac{\alpha R_0}{c_0} . \end{aligned} \tag{6.9.3}$$

   where t_0 is the time that elapses between the moment, when the bubble radius is R_0 and the instant, when the shock would focus to zero radius in the ideal case. For $R_0 = L_e(167)$ (order of magnitude is this) and for $R_s(min) = L_e(151)$ one obtains $R_0/R_s(min) = 256$ and $M \simeq 10.8$ at the minimum shock radius.

4. The increase of the temperature immediately after the focusing is approximately given by

$$\frac{T}{T_0} \simeq M^4 = (\frac{R_0}{R_s})^{\frac{4(1-\alpha)}{\alpha}} \simeq 1.3 \cdot 10^4 \ . \tag{6.9.4}$$

For $T_0 = 300\ K$ this gives $T \simeq 4 \cdot 10^6\ K$: the temperature is far below the temperature needed for fusion.

In principle the further increase of the temperature can lead to further transitions. The next transition would correspond to the transition $k = 157 \rightarrow k = 151$ with the minimum size of particle changing as $L_e(k_{prev}) \rightarrow L_e(149)$. The next transition corresponds to the transition to $k = 149$ and $L_e(k_{prev}) \rightarrow L_e(141)$. The values of the temperatures reached depend on the ratio of the ambient size R_0 of the bubble and the minimum radius of the shock wave. The fact that R_0 is expected to be of the order of $L_e(k_{next})$ suggests that the temperatures achieved are not sufficiently high for nuclear fusion to take place.

Could sonoluminescence involve the formation of a phase near vacuum extremals?

In TGD inspired model of cell membrane [K41] a key role is played by almost vacuum extremals for which the induced Kähler field is very small. Vacuum extremals are accompanied by a strong classical Z^0 field proportional to classical electromagnetic field and given by $Z^0 = -2\gamma/p$, $p = sin^2(\theta_W)$. One could also imagine that em field is vanishing in which case Z^0 field is proportional to Kähler field and also strong because of $Z^0 = 6J/p$, $p = sin^2(\theta_W)$ proportionality. In this case also classical color fields are present. It is however not clear whether these fields can be realized as preferred extremals of Kähler action.

The classical Z^0 field should have a source and the vacuum polarization in the sense that flux tubes are generated with many fermion state and its conjugate at its opposite ends would generate it. The Compton scale of weak bosons must correspond to $L_e(157)$ so that either dark variants of ordinary weak bosons or their light variants would be in question. Both would be effectively massless below $L_e(157)$. The simplest situation corresponds to many-neutrino state for vacuum extremals but also many quark states are possible when em field for the flux tube vanishes.

The length scales involved correspond to Gaussian Mersennes $M_{G,k} = (1+i)^k - 1$ and together with $k = 151$ and $k = 167$ define biologically important length scales [K41]. The p-adically scaled up variants and dark variants of of QCD and weak physics have been conjectured to play key role in biology between length scales 10 nm (cell membrane thickness) and 2.5 μm (the size scale of nucleus). This motivates the question whether a nearly vacuum extremal phase (as far as induced gauge fields are considered) accompanies the transition changing the p-adic length scale associated with the bubble from $k = 163$ to $k = 157$. The acceleration in the strong Z^0 field associated with the flux tubes could generate the visible light as brehmstrahlung radiation, perhaps also Z^0 and W bremstrahlung could be generated and would decay to photons and charged particles and generate a plasma in this manner. If the weak scale is given by $k_W = 157$, the mass scale of weak bosons is $2^{-31} \simeq 10^{-9}/2$ times smaller than that of ordinary weak bosons (about 50 eV which corresponds to a temperature of 5×10^5 K). A further transition to $k = 151$ would correspond to gauge boson mass scale 400 eV and temperature or order 4×10^6 K.

Could phase transitions increasing Planck constant and p-adic prime accompany sono-luminescence

In sonoluminescence external sound source induces oscillation of the radius of a bubble of water containing noble gas atoms. The unexpected observation is generation of radiation even at gamma ray energies and it is proposed that nuclear fusion might take place.

A possible new element in the model is h_{eff} increasing phase transition of the space-time sheet containing the water vapour and other atoms to dark phase during the expansion phase and reduction back to the ordinary value during implosion period now forced by the sound wave. If implosion actually takes place spontaneously then the energy of sound wave could be liberated as luminescence. If also dark hydrogen atoms are generated, dark protons could be able to circumvent the Coulomb wall so that low energy nuclear reactions could occur. On the other hand, if the phase transition reducing the Planck constant and increasing p-adic length scale takes place for the water space-time sheet in such a way that the two scale changes compensate each other (this requires $h_{eff} = 2^k h$ and $p \rightarrow 2^{2k} p$ (this in excellent approximation), zero point kinetic energy (ZPKE) is liberated and could heat the bubble and induce high energy radiation and perhaps even the proposed ordinary fusion. Cold fusion however seems more elegant alternative. The fact that neutron yield has not been observed in sonoluminescence suggests that ordinary hot fusion is not involved.

I have earlier considered the possibility that classical long ranged Z^0 fields predicted by TGD might be involved and give rise to a new interaction possibly related to sonoluminescence. I have proposed that classical Z^0 fields could play a role in the physics of cell membrane. The speculative proposal is that cell membrane could be in two possible states: the first ("ordinary") state would correspond to far from vacuum extremal for which electric field dominates. Second state would be near to vacuum extremal: in this case classical Z^0 field would dominate and give rise to rather radical modification of the model for cell membrane since Z^0 membrane potential would replace the ordinary one. Neurons serving as sensory receptors might correspond to this phase.

This model remains very speculative as also the possible role of classical Z^0 fields in sono-fusion. Note however that the phase transition increasing h_{eff} implies a dilution to vapour like phase ("electrically expanded water")and means that the state is near vacuum. By quantum classical correspondence classical Z^0 fields might become important. In the case of cell membrane Z^0 Coulomb energy defined by Z^0 potential is much stronger than its electronic counterpart and corresponds to voltage of order few eV and therefore to visible photon energies roughly 50 times higher than the energies assignable to the ordinary membrane potential of about.06 eV. One can wonder whether similar effect could appear also in electrolysis where also strong local electric fields appear.

6.10 The TGD Variant Of The Model Of Widom And Larsen For Cold Fusion

Widom and Larsen (for articles see the Widom Larsen LENR Theory Portal [C3] (see `http://tinyurl.com/boq2u2z`) have proposed a theory of cold fusion (LENR) (see `http://tinyurl.com/y8ejwxom`) [C2], which claims to predict correctly the various isotope ratios observed in cold fusion and accompanying nuclear transmutations. The ability to predict correctly the isotope ratios suggests that the model is on the right track. A further finding is that the predicted isotope ratios correspond to those appearing in Nature which suggests that LENR is perhaps more important than hot fusion in solar interior as far as nuclear abundances are considered. TGD leads to the same proposal and Lithium anomaly could be understood as one implication of LENR [L2]. The basic step of the reaction would rely on weak interactions: the proton of hydrogen atom would transform to neutron by capturing the electron and therefore would overcome the Coulomb barrier.

6.10.1 Challenges Of The Model

The model has to meet several challenges.

1. The electron capture reaction $p + e \rightarrow n + \nu$ is not possible for ordinary atom since the mass difference of neutron is 1.3 MeV and larger than electron mass.5 MeV (electron has too small kinetic energy). The proposal is that strong electric fields at the catalyst surface imply renormalization effects for the plasmon phase at the surface of the catalyst increasing electron mass so that it has width of few MeVs [C35]. Physically this would mean that strong em radiation helps to overcome the kinematical threshold for the reaction. This assumption [C25]: the claim is that the mass renormalization is much smaller than claimed by Widom and Larsen.

2. Second problem is that weak interactions are indeed very weak. The rate is proportional

to $1/m_W^4$, $m_W \sim 100$ GeV whereas for the exchange of photon with energy E it would be proportional to $1/E^4$. For $E \sim 1$ keV the ratio of the rates would be of the order of 10^{-48}!

This problem could be circumvented if the transition from proton to neutron occurs coherently for large enough surface patch. This would give rate proportional to N^2, where N is the number electrons involved. Another mechanism hoped to help to get high enough reaction rate is based on the assumption that the neutron created by the capture process has ultra-low momentum. This is the case if the mass renormalization of electron is such that the energies of the neutrons produced in the reaction are just above the kinematical threshold. Note however that this reduces the electron capture cross section. The argument is that the absorption rate for neutron by target nucleus is by very general arguments proportional to $1/v_n$, v_n the velocity of neutron. Together these two mechanisms are hoped to give high enough rate for cold fusion.

3. The model must also explain why gamma radiation is not observed and why neutrons are produced much less than expected. Concerning gamma rays one must assume that the heavy electrons of the plasmon phase assigned to the surface of the catalyst absorb the gamma rays and re-emit them as infrared light emitted to environment as heat. Ordinary electrons cannot absorb gamma rays but heavy electrons can [C34], and the claim is that they do transform gamma rays to infrared photons. If the neutrons created in LENR have ultra-low energies their capture cross sections are enormous and the claim is that they do not get out of the system.

The assumption that electron mass is renormalized so that the capture reaction can occur but occurs only very near threshold so that the resulting neutrons are ultraslow has been criticized [C25].

6.10.2 TGD Variant Of The Model

TGD allows to consider two basic approaches to the LENR.

1. **Option I** involves only dark nucleons and dark quarks. In this case, one can imagine that the large Compton length of dark proton - at least of order atomic scale - implies that it overlaps target nucleus, which can see the negatively charged d quark of the proton so that instead of Coulomb wall one has Coulomb well.

2. **Option II** involves involves both dark weak bosons and possibly also dark nucleons and dark electrons. The TGD inspired model for living matter - in particular, the model for cell membrane involving also Z^0 membrane potential in the case of sensory receptor neurons [K79] - favors the model involving both dark weak bosons, nucleons, and even electrons. Chiral selection for biomolecules is extremely difficult to understand in standard model but could be understood in terms of weak length scale of order atomic length scale at least: below this scale dark weak bosons would be effectively massless and weak interactions would be as strong as em interactions. The model for electrolysis based on plasmoids identified as primitive life forms supports also this option. The presence of dark electrons is suggested by Tesla's cold currents and by the model of cell membrane.

   This option is fixed quantitatively by the condition that the Compton length of dark weak bosons is of the order of atomic size scale at least. The ratio of the corresponding p-adic size scales is of order 10^7 and therefore one has $h_{eff} \sim 10^{14}$. The condition that $h_{eff}/h = 2^k$ guarantees that the phase transition reducing h_{eff} to h and increasing p-adic prime p by about 2^k and p-adic length scale by $2^{k/2}$ does not change the size scale of the space-time sheet and liberates cyclotron magnetic energy $E_n(1-2^{-k}) \simeq E_n$.

Consider next **Option II** by requiring that the Coulomb wall is overcome via the transformation of proton to neutron. This would guarantee correct isotope ratios for nuclear transmutations. There are two options to consider depending on whether a) the W boson is exchanged between proton nucleus (this option is not possible in standard model) or b) between electron and proton (the model of Widom and Larsen relying on the critical massivation of electron).

1. **Option II.1**. Proton transforms to neutron by exchanging W boson with the target nucleus.

   (a) In this case kinematics poses no obvious constraints on the process. There are two options depending on whether the neutron of the target nucleus or quark in the neutral color bond receives the W boson.

   (b) If electron and proton are dark with $h_{eff}/h = n = 2^k$ in the range $[10^{12}, 10^{14}]$ the situation can change since W boson has its usual mass from the point of view of electron and proton. $\hbar^4/m_W^4$ factor in differential cross section for 2-to-2 scattering by W exchange is scaled up by n^4 (see the appendix of [B11] so that effectively m_W would be of order 10 keV for ordinary $\hbar$.

   (c) One can argue that in the volume defined by proton Compton length $\lambda_p \simeq 2^{-11}\lambda_e \in [1.2, 12]$ nm one has a superposition of amplitudes for the absorption of dark proton by nucleus. If there are N nuclei in this volume, the rate is proportional to N^2. One can expect at most $N \in [10^3, 10^6]$ target nuclei in this volume. This would give a factor in the range $10^9 - 10^{12}$.

2. **Option II.2**: Electron capture by proton is the Widom-Larsen candidate for the reaction in question. As noticed, this process cannot occur unless one assumes that the mass of electron is renormalized to have a value in a range of few MeV. If dark electrons are heavier than ordinary, the process could be mediated by W boson exchange and if the electron and proton have their normal sizes the process occurs with same rate as em processes.

   If electron and proton are dark with $h_{eff}/h = n \in [10^{12}, 10^{14}]$ the situation can change since W boson has its usual mass from the point of view of electron and proton. 2-to-2 cross section is proportional to $\hbar^4$ and is scaled up by n^4. One the other hand, the naïve expectation is that $|\Psi(0)|^2 \propto m_e^3/h_{eff}^3 \propto 1/n^{-3}$ for electron is scaled by n^{-3} so that the rate is increased by a factor of order $n \in [10^{12}, 10^{14}]$ (electron Compton length is of order cell size scale! instead of Angstrom) from its ordinary value. This is not enough.

   On the other hand, one can argue in the volume defined by proton Compton size one has a superposition of amplitudes for the absorption of electron. If there are N dark electrons in this volume, the rate is proportional to N^2. One can expect at most 10^6 dark electrons in the volume of scale 10 nm so that this could give a factor 10^{12}. This would give amplification factor 10^{26} to the weak rate so that it would be only by two orders of magnitude smaller than the rate for massless weak bosons.

There are also other strange features to be understood.

1. The absence of gamma radiation could be due to the fact that the produced gamma rays are dark. For $h_{eff}/h \in [10^{12}, 10^{14}]$ the energy frequency of 1 MeV dark gamma ray would correspond to that of photon with energy of [1, .1] μeV and thus to radio wave photon with wavelength of order 1 m and frequency of order 3×10^8 Hz. In Widom-Larsen model the photons would be infrared photons. The decay of the dark gamma ray to a bunch of ordinary radio wave photons should be observed as radio noise. Note that Gariaev has observed transformation of laser light scattered from DNA to radio wave photons with frequencies down to 1 kHz at least.

2. The absence of the neutrons could be understood if they are dark and simply do not interact with visible matter before phase transition to ordinary neutrons. One can imagine an alternative interpretation allowing the interaction and assuming that nuclei are dark in the reaction volume. The large Compton wavelength implies that dark neutrons are absorbed by dark nuclei coherently in a volume of order 1.2-12 nm so that an additional amplification factor $N^2 \in [10^9, 10^{12}]$ would be obtained. The absorption cross section for neutrons should be proportional to $\hbar^2$ giving a huge amplification factor in the range $[10^{24}, 10^{48}]$. Effectively this corresponds to the assumption of Widom and Larsen stating that neutrons have ultra-low momentum.

The natural question is why h_{eff} us such that the resulting scale as photon wavelength corresponds to energy in scale 10-100 keV. The explanation could relate to the predicted exotic nuclei obtained by replacing some neutral color bonds connecting nucleons with charged ones and exchange of weak boson would affect this replacement. Could the weak physics associated with $h_{eff} \in [10^{12}, 10^{14}]$ be associated with dark color bonds? The reported annual variations of the nuclear reaction rates correlating with the distance of Earth from Sun suggest that these variations are induced by solar X rays [C14].

6.11 Dark Atomic Physics

Dark matter might be relevant also for atomic physics and in the sequel some speculations along these lines are represented. Previous considerations assumed that only field bodies can be dark and this is assumed also now. The notion of dark atom depends strongly on the precise meaning of the generalized embedding space and I have considered several options.

1. The first option was based on the singular coverings $CD \times CP_2 \rightarrow CD/G_a \times CP_2/G_b$. This approach has a concrete connection to the quantization and the selection of quantization axes correlates closely with the identification of groups G_a and G_b. The questionable assumption is that elementary particle like partonic 2-surfaces remain invariant under the cyclic groups $G_a \times G_b$.

2. The next proposal was that both factor spaces and coverings of H are possible. For this option the notion of covering is somewhat unsatisfactory because it lacks concreteness. Singular factor of CD and CP_2 spaces make possible all rational values of Planck constant and one loses the vision about evolution as drift to the sectors of embedding space characterized by increasing value of Planck constant.

3. The last proposal is based on the realization that basic quantum TGD could well explain the hierarchy of Planck constants in terms of singular covering spaces emerging naturally when the time derivatives of the embedding space coordinates are many-valued functions of the canonical momentum densities. In this framework singular factors spaces are not possible and the formula $r \equiv \hbar/\hbar_0 = n_a n_b$ emerges naturally as well as charge fractionization. One also ends up to a unique recipe for how to obtain binding energies in this kind of situation and the results are consistent with the earlier formulas deduced on purely formal arguments. Groups G_a and G_b do not directly correspond to subgroups of isometry groups but the fractionization of quantum numbers implied by the scaling of Planck constant implies that wave functions for the selected quantization axes behave as if the maximal cyclic subgroups of G_a and G_b had a geometric meaning.

For covering space option fermion number is fractionized. The group algebra of $G_a \times G_b$ defines $n_a n_b$ single particle wave functions in the covering. The simplest option is that total fermion number is integer valued so that the many-sheeted structure is analogous to a full Fermi sphere containing $n_a n_b$ fermions with fractional fermion number $1/n_a n_b$. A more general option allows states with fractional total fermion number varying from from $1/n_a n_b$ to 1. One could generalize the condition about integer fermion number so that it holds for the entire quantum state involving several covering regions and the condition would correspond to the $G_a \times G_b$ singletness of the physical states.

6.11.1 Dark Atoms And Dark Cyclotron States

The development of the notion of dark atom involves many side tracks which make me blush. The first naïve guess was that dark atom would be obtained by simply replacing Planck constant with its scaled counterpart in the basic formulas and interpreting the results geometrically. After some obligatory twists and turns it became clear that this assumption is indeed the most plausible one. The main source of confusion has been the lack of precise view about what the hierarchy of Planck constants means at the level of embedding space at space-time.

The rules are very simple when one takes the singular coverings assigned to the many-valuedness of the time-derivatives of embedding space coordinates as functions of canonical momentum densities as a starting point.

1. The mass and charge of electron are fractionized as is also the reduced mass in Schrödinger equation. This implies the replacements $e \rightarrow e/r$, $m \rightarrow m/r$, and $\hbar \rightarrow r\hbar_0$, $r = n_a n_b$, in the general formula for the binding energy assigned with single sheet of the covering. If maximal number $n_a n_b$ are present corresponding to a full "Fermi sphere", the total binding energy is r times the binding energy associated with single sheet.

2. In the case of hydrogen atom the proportionality $E \propto m/\hbar^2$ implies that the binding energy for single sheet of the covering scales as $E \rightarrow E/(n_a n_b)^3$ and maximal binding energy scales as $E \rightarrow E/(n_a n_b)^2$. This conforms with the naïve guess. For high values of the nuclear charge Z it can happen that the binding energy is larger than the rest mass and fractionization might take place when binding energy is above critical fraction of the rest mass.

3. In the case of cyclotron energies one must must decide what happens to the magnetic flux. Magnetic flux quantization states that the flux is proportional to $\hbar$ for each sheet separately. Hence one has $\Phi \rightarrow r\Phi$ for each sheet and the total flux scales as r^2. Since the dimensions of the flux quantum are scaled up by r the natural scaling of the size of flux quantum is by r^2. Therefore the quantization of the magnetic flux requires the scaling $B \rightarrow B/r$. The cyclotron energy for single sheet satisfies $E \propto \hbar qB/m$ and since both mass m and charge q become fractional, the energy E for single sheet remains invariant whereas total cyclotron energy is scaled up by r in accordance with the original guess and the assumption used in applications.

4. Dark cyclotron states are expected to be stable up to temperatures which are r times higher than for ordinary cyclotron states. The states of dark hydrogen atoms and its generalizations are expected to be stable at temperatures scaled down by $1/r^2$ in the first approximation.

5. Similar arguments allow to deduce the values of binding energies in the general case once the formula of the binding energy given by standard quantum theory is known.

The most general option option allows fractional atoms with proton and electron numbers varying from $1/r$ to 1. One can imagine also the possibility of fractional molecules. The analogs of chemical bonds between fractional hydrogen atoms with $N-k$ and k fractional electrons and protons can be considered and would give rise to a full shell of fractional electrons possessing an exceptional stability. These states would have proton and electron numbers equal to one.

Catalytic sites are one possible candidate for fractal electrons and catalyst activity might be perhaps understood as a strong tendency of fractal electron and its conjugate to fuse to form an ordinary electron.

6.11.2 Could Q-Laguerre Equation Relate To The Claimed Fractionation Of The Principal Quantum Number For Hydrogen Atom?

The so called hydrino atom concept of Randell Mills [D41] represents one of the notions related to free energy research not taken seriously by the community of university physicists. What is claimed that hydrogen atom can exists as scaled down variants for which binding energies are much higher than usually due to the large Coulomb energy. The claim is that the quantum number n having integer values $n = 0, 1, 2, 3..$ and characterizing partially the energy levels of the hydrogen atom can have also inverse integer values $n = 1/2, 1/3, ...$ The claim of Mills is that the laboratory BlackLight Inc. led by him can produce a plasma state in which transitions to these exotic bound states can occur and liberate as a by-product usable energy.

The National Aeronautic and Space Administration has dispatched mechanical engineering professor Anthony Marchese from Rowan University to BlackLight's labs in Cranbury, NJ, to investigate whether energy plasmas-hot, charged gases- produced by Mills might be harnessed for a new generation of rockets. Marchese reported back to his sponsor, the NASA Institute for Advanced Concepts, that indeed the plasma was so far unexplainably energetic. An article about the findings of Mills and collaborators have been accepted for publication in Journal of Applied Physics so that there are reasons to take seriously the experimental findings of Mills and collaborators even if one does not take seriously the theoretical explanations.

The fractionized principal quantum number n claimed by Mills [D41] is reported to have at least the values $n = 1/k$, $k = 2, 3, 4, 5, 6, 7, 10$. First explanation would be in terms of Plack constant having also values smaller than $\hbar_0$ possible if singular factor spaces of causal diamond CD and CP_2 are allowed. q-Deformations of ordinary quantum mechanics are suggested strongly by the hierarchy of Jones inclusion associated with the hyper-finite factor of type II_1 about which WCW spinors are a basic example. This motivates the attempt to understand the claimed fractionization in terms of q-analog of hydrogen atom. The safest interpretation for them would be as states which can exist in ordinary embedding space (and also in other branches)

The Laguerre polynomials appearing in the solution of Schrödinger equation for hydrogen atom possess quantum variant, so called q-Laguerre polynomials [A8], and one might hope that they would allow to realize this semiclassical picture at the level of solutions of appropriately modified Schrödinger equation and perhaps also resolve the difficulty associated with $n = 1/2$. Unfortunately, the polynomials discussed in [A8] correspond to $0 < q \leq 1$ rather than complex values of $q = exp(i\pi/m)$ on circle and the extrapolation of the formulas for energy eigenvalues gives complex energies.

q-Laquerre equation for $q = exp(i\pi/m)$

The most obvious modification of the Laguerre equation for S-wave sates (which are the most interesting by semiclassical argument) in the complex case is based on the replacement

$$\begin{aligned} \partial_x &\rightarrow \frac{1}{2}(\partial_x^{q)} + \partial_x^{\overline{q})}) \\ \partial_x^{q)} f &= \frac{f(qx) - f(x)}{(q-1)x} \ , \\ q &= exp(i\pi/m) \end{aligned} \tag{6.11.1}$$

to guarantee hermiticity. When applied to the Laguerre equation

$$x\frac{d^2L_n}{dx^2} + (1-x)\frac{dL_n}{dx} = nL_n \ , \tag{6.11.2}$$

and expanding L_n into Taylor series

$$L_n(x) = \sum_{n\geq 0} l_n x^n \ , \tag{6.11.3}$$

one obtains difference equation

$$\begin{aligned} a_{n+1}l_{n+1} &+ b_n l_n = 0 \ , \\ a_{n+1} &= \frac{1}{4R_1^2}\left[R_{2n+1} - R_{2n} + 2R_{n+1}R_1 + 3R_1)\right] + \frac{1}{2R_1}\left[R_{n+1} + R_1\right] \\ b_n &= \frac{R_n}{2R_1} - n^{q)} + \frac{1}{2} \ , \\ R_n &= 2cos\left[(n-1)\pi/m\right] - 2cos\left[n\pi/m\right] \ . \end{aligned} \tag{6.11.4}$$

Here $n^{q)}$ is the fractionized principal quantum number determining the energy of the q-hydrogen atom. One cannot pose the difference equation on l_0 since this together with the absence of negative powers of x would imply the vanishing of the entire solution. This is natural since for first order difference equations lowest term in the series should be chosen freely.

Polynomial solutions of q-Laquerre equation

The condition that the solution reduces to a polynomial reads as

$$b_n = 0 \tag{6.11.5}$$

and gives

$$n^{q)} = \frac{1}{2} + \frac{R_n}{2R_1} \ , \tag{6.11.6}$$

For $n = 1$ one has $n^{q)} = 1$ so that the ground state energy is not affected. At the limit $N \to \infty$ one obtains $n^{q)} \to n$ so that spectrum reduces to that for hydrogen atom. The periodicity $R_{n+2Nk} = R_n$ reflects the corresponding periodicity of the difference equation which suggests that only the values $n \leq 2m - 1$ belong to the spectrum. Spectrum is actually symmetric with respect to the middle point $[N/2]$ which suggests that only $n < [m/2]$ corresponds to the physical spectrum. An analogous phenomenon occurs for representations of quantum groups [K69]. When m increases the spectrum approaches integer valued spectrum and one has $n > 1$ so that no fractionization in the desired sense occurs for polynomial solutions.

Non-polynomial solutions of q-Laquerre equation

One might hope that non-polynomial solutions associated with some fractional values of $n^{q)}$ near to those claimed by Mills might be possible. Since the coefficients a_n and b_n are periodic, one can express the solution ansatz as

$$\begin{aligned}
L_n(x) &= P_a^{2m)}(x)\sum_k a^k x^{2mk} = P_a^{2m)}(x)\frac{1}{1-ax^{2m}} \ , \\
P_a^{2m)}(x) &= \sum_{k=0}^{2m-1} l_k x^k \ , \\
a &= \frac{l_{2m}}{l_0} \ ,
\end{aligned} \tag{6.11.7}$$

This solution behaves as $1/x$ asymptotically but has pole at $x_\infty = (1/a)^{1/2m}$ for $a > 0$.

The expression for $l_{2m}/l_0 = a$ is

$$a = \prod_{k=1}^{2m} \frac{b_{2m-k}}{a_{2m-k+1}} \ . \tag{6.11.8}$$

This can be written more explicitly as

$$\begin{aligned}
a &= (2R_1)^{2m}\prod_{k=1}^{2m} X_k \ , \\
X_k &= \frac{R_{2m-k} + (-2n^{q)}+1)R_1}{R_{4m-2k+1} - R_{4m-2k} + 4R_{2m-k+1}R_1 + 2R_1^2 + 3R_1} \ , \\
R_n &= 2cos\left[(n-1)\pi/m\right] - 2cos\left[n\pi/m\right] \ .
\end{aligned} \tag{6.11.9}$$

This formula is a specialization of a more general formula for $n = 2m$ and resulting ratios l_n/l_0 can be used to construct $P_a^{2m)}$ with normalization $P_a^{2m)}(0) = 1$.

Results of numerical calculations

Numerical calculations demonstrate following.

1. For odd values of m one has $a < 0$ so that a a continuous spectrum of energies seems to result without any further conditions.

2. For even values of m a has a positive sign so that a pole results.

m	$1/n^{q)}_{\simeq}$	$1/n^{q)}$	m	$1/n^{q)}_{\simeq}$	$1/n^{q)}$
18	**3**	2.7568	30	8	7.5762
20	**4**	3.6748	**32**	**8**	8.3086
22	5	4.5103	**34**	**9**	9.0342
24	**5**	5.3062	**36**	**10**	9.7529
26	**6**	6.0781	38	10	10.4668
28	**7**	6.8330			

Table 6.3: Table gives the approximations $1/n^{q})_{\simeq} = 1/k$ and corresponding exact values $1/n^{q})$ in the range $k = 3, ..., 10$ for which $P_a^{2m)}(x_\infty)$ is nearest to zero. The corresponding values of $m = 2k$ vary in the range, $k = 18, ..., 38$. For odd values of m the value of the parameter a is negative so that there is no pole. Boldface marks for the best approximation by $1/n^{q)}_{\simeq} = k$.

For even value of m it could happen that the polynomial $P_a^{2m)}(x)$ has a compensating zero at x_∞ so that the solution would become square integrable. The condition for reads explicitly

$$P_a^{2m)}\left((\frac{1}{a})^{\frac{1}{2m}}\right) = 0 \ . \tag{6.11.10}$$

If $P_a^{2m)}(x)$ has zeros there are hopes of finding energy eigen values satisfying the required conditions. Laguerre polynomials and also q-Laguerre polynomials must posses maximal number of real zeros by their orthogonality implied by the hermiticity of the difference equation defining them. This suggests that also $P_a^{2m)}(x)$ possesses them if a does not deviate too much from zero. Numerical calculations demonstrate that this is the case for $n^{q)} < 1$.

For ordinary Laguerre polynomials the naïve estimate for the position of the most distant zero in the units used is larger than n but not too much so. The naïve expectation is that L_{2m} has largest zero somewhat above $x = 2m$ and that same holds true a small deformation of L_{2m} considered now since the value of the parameter a is indeed very small for $n^{q)} < 1$. The ratio $x_\infty/2m$ is below .2 for $m \leq 10$ so that this argument gives good hopes about zeros of desired kind.

One can check directly whether x_∞ is near to zero for the experimentally suggested candidates for $n^{q)}$. **Table 6.3** summarizes the results of numerical calculations.

1. **Table 6.3** gives the exact eigenvalues $1/n_{q)}$ with a 4-decimal accuracy and corresponding approximations $1/n^{q)}_{\simeq} = k$ for $k = 3, ..., 10$. For a given value of m only single eigenvalue $n^{q)} < 1$ exists. If the observed anomalous spectral lines correspond to single electron transitions, the values of m for them must be different. The value of m for which $n^{q)} \simeq 1/k$ approximation is optimal is given with boldface. The value of k increases as m increases. The lowest value of m allowing the desired kind of zero of $P^{2m)}$ is $m = 18$ and for $k \in \{3, 10\}$ the allowed values are in range $18, .., 38$.

2. $n^{q)} = 1/2$ does not appear as an approximate eigenvalue so that for even values of m quantum calculation produces same disappointing result as the classical argument. Below it will be however found that $n^{q)} = 1/2$ is a universal eigenvalue for odd values of m.

How to obtain $n^{q)} = 1/2$ state?

For odd values of m the quantization recipe fails and physical intuition tells that there must be some manner to carry out quantization also now. The following observations give a hunch about the desired condition.

1. For the representations of quantum groups only the first m spins are realized [K69]. This suggests that there should exist a symmetry relating the coefficients l_n and l_{n+m} and implying $n^{q)} = 1/2$ for odd values of m. This symmetry would remove also the double degeneracy associated with the almost integer eigenvalues of $n^{q)}$. Also other fractional states are expected on basis of physical intuition.

2. For $n^{q)} = 1/2$ the recursion formula for the coefficients l_n involves only the coefficients R_m.
3. The coefficients R_k have symmetries $R_k = R_{k+2m}$ and $R_{k+m} = -R_m$.

There is indeed this kind of symmetry. From the formula

$$\begin{aligned}\frac{l_n}{l_0} &= (2R_1)^n \prod_{k=1}^{n} X_k \ , \\ X_k &= \frac{R_{n-k} + (-2n^{q)} + 1)R_1}{[R_{2n-2k+1} - R_{n-2k} + 4R_{n-k+1}R_1 + 2R_1^2 + 3R_1}\end{aligned} \quad (6.11.11)$$

one finds that for $n^{q)} = 1/2$ the formula giving l_{n+m} in terms of l_n changes sign when n increases by one unit

$$\begin{aligned}A_{n+1} &= (-1)^m A_n \ , \\ A_n &= \prod_{k=1}^{m} \frac{b_{n+m-k}}{a_{n+m-k+1}} = \prod_{k=1}^{m}(2R_1)^m \prod_{k=1}^{m} X_{k+n} \ .\end{aligned} \quad (6.11.12)$$

The change of sign is essentially due to the symmetries $a_{n+m} = -a_n$ and $b_{n+m} = b_n$. This means that the action of translations on A_n in the space of indices n are represented by group Z_2.

This symmetry implies $a = l_{2m}/l_0 = -(l_m)(l_0)^2$ so that for $n^{q)} = 1/2$ the polynomial in question has a special form

$$\begin{aligned}P_a^{2m)} &= P_a^{m)}(1 - Ax^m) \ , \\ A &= A_0 \ .\end{aligned} \quad (6.11.13)$$

The relationship $a = -A^2$ implies that the solution reduces to a form containing the product of m^{th} (rather than $(2m)^{th}$) order polynomial with a geometric series in x^m (rather than x^{2m}):

$$L_{1/2}(x) = \frac{P_a^{m)}(x)}{1 + Ax^m} \ . \quad (6.11.14)$$

Hence the n first terms indeed determine the solution completely. For even values of m one obtains similar result for $n^{q)} = 1/2$ but now A is negative so that the solution is excluded. This result also motivates the hypothesis that for the counterparts of ordinary solutions of Laguerre equation sum (even m) or difference (odd m) of solutions corresponding to n and $2m - n$ must be formed to remove the non-physical degeneracy.

This argument does not exclude the possibility that there are also other fractional values of n allowing this kind of symmetry. The condition for symmetry would read as

$$\begin{aligned}\prod_{k=1}^{m}(R_k + \epsilon R_1) &= \prod_{k=1}^{m}(R_k - \epsilon R_1) \ , \\ \epsilon &= (2n^{q)} - 1 \ .\end{aligned} \quad (6.11.15)$$

The condition states that the odd part of the polynomial in question vanishes. Both ϵ and $-\epsilon$ solutions so that $n^{q)}$ and $1 - n^{q)}$ are solutions. If one requires that the condition holds true for all values of m then the comparison of constant terms in these polynomials allows to conclude that $\epsilon = 0$ is the only universal solution. Since ϵ is free parameter, it is clear that the m: th order polynomial in question has at most m solutions which could correspond to other fractionized eigenvalues expected to be present on basis of physical intuition.

This picture generalizes also to the case of even n so that also now solutions of the form of Eq. 6.11.14 are possible. In this case the condition is

$$\prod_{k=1}^{m}(R_k+\epsilon R_1) = -\prod_{k=1}^{m}(R_k-\epsilon R_1) \ . \qquad (6.11.16)$$

Obviously $\epsilon = 0$ and thus $n = 1/2$ fails to be a solution to the eigenvalue equation in this case. Also now one has the spectral symmetry $n_\pm = 1/2 \pm \epsilon$.

The symmetry $R_n = (-1)^m R_{n+m-1} = (-1)^m R_{n-m-1} = (-1)^m R_{m-n+1}$ can be applied to show that the polynomials associated with ϵ and $-\epsilon$ contain both the terms $R_n - \epsilon$ and $R_n + \epsilon$ as factors except for odd m for $n = (m+1)/2$. Hence the values of n can be written for even values of m as

$$n^{q)}(n) = \frac{1}{2} \pm \frac{R_n}{2R_1} \ , \ n = 1, ..., \frac{m}{2} \ , \qquad (6.11.17)$$

and for odd values of m as

$$\begin{aligned} n^{q)}_\pm(n) &= \frac{1}{2} \pm \frac{R_n}{2R_1} \ , \ n = 1, ..., \frac{m+1}{2} - 1 \ , \\ n^{q)} &= 1/2 \ . \end{aligned} \qquad (6.11.18)$$

Plus sign obviously corresponds to the solutions which reduce to polynomials and to $n^{q)} \simeq n$ for large m. The explicit expression for $n^{q)}$ reads as

$$n^{q)}_\pm(n) = \frac{1}{2} \pm \frac{(sin^2(\pi(n-1)/2m) - sin^2(\pi n/2m))}{2sin^2(\pi/2m)} \ . \qquad (6.11.19)$$

At the limit of large m one has

$$n^{q)}_+(n) \simeq n \ , \ n^{q)}_-(n) \simeq 1-n \ . \qquad (6.11.20)$$

so that the fractionization $n \simeq 1/k$ claimed by Mills is not obtained at this limit. The minimum for $|n^{q)}|$ satisfies $|n^{q)}| < 1$ and its smallest value $|n^{q)}| = .7071$ corresponds to $m = 4$. Thus these zeros cannot correspond to $n^{q)} \simeq 1/k$ yielded by the numerical computation for even values of m based on the requirement that the zero of $P^{2m)}$ cancels the pole of the geometric series.

Some comments

Some closing comments are in order.

1. An open question is whether there are also zeros $|n^{q)}| > 1$ satisfying $P^{2m)}_a((1/a)^{1/2m}) = 0$ for even values of m.

2. The treatment above is not completely general since only s-waves are discussed. The generalization is however a rather trivial replacement $(1-x)d/dx \rightarrow (l+1-x)d/dx$ in the Laguerre equation to get associated Laguerre equation. This modifies only the formula for a_{n+1} in the recursion for l_n so that expression for $n^{q)}$, which depends on b_n: s only, is not affected. Also the product of numerators in the formula for the parameter $a = l_{2m}/l_0$ remains invariant so that the general spectrum has the spectral symmetry $n^{q)} \rightarrow 1 - n^{q)}$. The only change to the spectrum occurs for even values of m and is due to the dependence of $x_\infty = (1/a)^{1/2m}$ on l and can be understood in the semiclassical picture. It might happen that the value of l is modified to its q counterpart corresponding to q-Legendre functions.

3. The model could partially explain the findings of Mills and $n^{q)} \simeq 1/k$ for $k > 2$ also fixes the value of corresponding m to a very high degree so that one would have direct experimental contact with generalized embedding space, spectrum of Planck constants, and dark matter. The fact that the fractionization is only approximately correct suggests that the states in question could be possible for all sectors of embedding space appear as intermediate states into sectors in which the spectrum of hydrogen atom is scaled by $n_b/n_a = k = 2, 3, ...$

4. The obvious question is whether q-counterparts of angular momentum eigenstates ($idf_m/d\phi = mf_m$) are needed and whether they make sense. The basic idea of construction is that the phase transition changing $\hbar$ does not involve any other modifications except fractionization of angular momentum eigenvalues and momentum eigenvalues having purely geometric origin. One can however ask whether it is possible to identify q-plane waves as ordinary plane waves. Using the definition $L_z = 1/2(\partial_u^q + \partial_{\overline{u}}^{\overline{q}})$, $u = exp(i\phi)$, one obtains $f_n = exp(in\phi)$ and eigenvalues as $n^{q)} = R_n/R_1 \rightarrow n$ for $m \rightarrow \infty$. Similar construction applies in the case of momentum components.

6.11.3 Shy Positrons

The latest weird looking effect in atomic physics is the observation that positrium atoms consisting of positron and electron scatter particles almost as if they were lonely electrons [C24, C12]. The effect has been christened cloaking effect for positron.

The following arguments represent the first attempts to understand the cloaking of positron in terms of these notions.

1. Let us start with the erratic argument since it comes first in mind. If positron and electron correspond to different space-time sheets and if the scattered particles are at the space-time sheet of electron then they do not see positron's Coulombic field at all. The objection is obvious. If positron interacts with the electron with its full electromagnetic charge to form a bound state, the corresponding electric flux at electron's space-time sheet is expected to combine with the electric flux of electron so that positronium would look like neutral particle after all. Does the electric flux of positron return back to the space-time sheet of positronium at some distance larger than the radius of atom? Why should it do this? No obvious answer.

2. Assume that positron dark but still interacts classically with electron via Coulomb potential. In TGD Universe darkness means that positron has large $\hbar$ and Compton size much larger than positronic wormhole throat (actually wormhole contact but this is a minor complication) would have more or less constant wave function in the volume of this larger space-time sheet characterized by zoomed up Compton length of electron. The scattering particle would see point-like electron plus background charge diffused in a much larger volume. If the value of $\hbar$ is large enough, the effect of this constant charge density to the scattering is small and only electron would be seen.

3. As a matter fact, I have proposed this kind of mechanism to explain how the Coulomb wall, which is the basic argument against cold fusion could be overcome by the incoming deuteron nucleus [L2], [L2]. Some fraction of deuteron nuclei in the palladium target would be dark and have large size just as positron in the above example. It is also possible that only the protons of these nuclei are dark. I have also proposed that dark protons explain the effective chemical formula $H_{1.5}O$ of water in scattering by neutrons and electrons in atto-second time scale [L2], [L2]. The connection with cloaked positrons is highly suggestive.

4. Also one of TGD inspired proposals for the absence of antimatter is that antiparticles reside at different space-time sheets as dark matter and are apparently absent [K92]. Cloaking positrons (shy as also their discoverer Dirac!) might provide an experimental supports for these ideas.

The recent view about the detailed structure of elementary particles forces to consider the above proposal in more detail.

1. According to this view all particles are weak string like objects having wormhole contacts at its ends and magnetically charged wormhole throats (four altogether) at the ends of the string like objects with length given by the weak length cale connected by a magnetic flux tube at both space-time sheets. Topological condensation means that these structures in turn are glued to larger space-time sheets and this generates one or more wormhole contacts for which also particle interpretation is highly suggestive and could serve as space-time correlate for interactions described in terms of particle exchanges. As far electrodynamics is considered, the second ends of weak strings containing neutrino pairs are effectively non-existing. In the case of fermions also only the second wormhole throat carrying the fermion number is effectively present so that for practical purposes weak string is only responsible for the massivation of the fermions. In the case of photons both wormhole throats carry fermion number.

2. An interesting question is whether the formation of bound states of two charged particles at the same space-time sheet could involve magnetic flux tubes connecting magnetically charged wormhole throats associated with the two particles. If so, Kähler magnetic monopoles would be part of even atomic and molecular physics. I have proposed already earlier that gravitational interaction in astrophysical scales involves magnetic flux tubes. These flux tubes would have o interpretation as analogs of say photons responsible for bound state energy. In principle it is indeed possible that the energies of the two wormhole throats are of opposite sign for topological sum contact so that the net energy of the wormhole contact pair responsible for the interaction could be negative.

3. Also the interaction of positron and electron would be based on topological condensation at the same space-time sheet and the formation of wormhole contacts mediating the interaction. Also now bound states could be glued together by magnetically charged wormhole contacts. In the case of dark positron, the details of the interaction are rather intricate since dark positron would correspond to a multi-sheeted structure analogous to Riemann surface with different sheets identified in terms of the roots of the equation relating generalized velocities defined by the time derivatives of the embedding space coordinates to corresponding canonical momentum densities.

Chapter 7

Dark Forces and Living Matter

7.1 Introduction

The unavoidable presence of classical long ranged weak (and also color) gauge fields in TGD Universe has been a continual source of worries for more than two decades. The basic question has been whether electro-weak charges of elementary particles are screened in electro-weak length scale or not. The TGD based view about dark matter assumes that weak charges are indeed screened for ordinary matter in electro-weak length scale but that dark electro-weak bosons correspond to much longer symmetry breaking length scale.

The large value of $\hbar$ in dark matter phase implies that Compton lengths and -times are scaled up. In particular, the sizes of nucleons and nuclei become of order atom size so that dark nuclear physics would have direct relevance for condensed matter physics. It becomes impossible to make a reductionistic separation between nuclear physics and condensed matter physics and chemistry anymore. This view forces a profound re-consideration of the earlier ideas in nuclear and condensed physics context. It however seems that most of the earlier ideas related to the classical Z^0 force and inspired by anomaly considerations survive in a modified form.

The weak form of electric-magnetic duality led to the identification of the long sought for mechanism causing the weak screening in electroweak scales. The basic implication of the duality is that Kähler electric charges of wormhole throats representing particles are proportional to Kähler magnetic charges so that the CP_2 projections of the wormhole throats are homologically non-trivial. The Kähler magnetic charges do not create long range monopole fields if they are neutralized by wormhole throats carrying opposite monopole charges and weak isospin neutralizing the axial isospin of the particle's wormhole throat. One could speak of confinement of weak isospin. The weak field bodies of elementary fermions would be replaced with string like objects with a length of order W boson Compton length. Electro-magnetic flux would be feeded to electromagnetic field body where it would be feeded to larger space-time sheets. Similar mechanism could apply in the case of color quantum numbers. Weak charges would be therefore screened for ordinary matter in electro-weak length scale but dark electro-weak bosons correspond to much longer symmetry breaking length scale for weak field body. Large values of Planck constant would make it possible to zoop up elementary particles and study their internal structure without any need for gigantic accelerators.

One can still worry about large parity breaking effects - say in nuclear physics- since the couplings of spinors to classical weak fields are there. Around 2012 it became clear that the condition that induced spinor fields have well defined em charge localizes their modes in the generic case to 2-surfaces carrying vanishing induced W gauge fields. It is quite possible that this localization is consistent with Kähler-Dirac equation only in ther Minkowskian regions were the effective metric defined by Kähler-Dirac gamma matrices can be effectively 2-dimensional.

On can pose the additional condition that also classical Z^0 field vanishes - at least above weak scale. Fundamental fermions would experience only em field so that the worries related to large parity breaking effects would disappear. The proportionality of weak scale to $h_{eff} = n \times h$ however predicts that weak fields are effectively massless belong scaled up weak scale. Therefore worries about large parity breaking effects in ordinary nuclear physics can be forgotten.

In its original form this chapter was an attempt to concretize and develop ideas related to dark matter by using some experimental inputs with emphasis on the predicted interaction between the new nuclear physics and condensed matter. As the vision about dark matter became more coherent and the nuclear string model developed in its recent form, it became necessary to update the chapter and throw away the obsolete material. I dare hope that the recent representation is more focused than the earlier one.

7.1.1 Evidence For Long Range Weak Forces And New Nuclear Physics

There is a lot of experimental evidence for long range electro-weak forces, dark matter, and exotic nuclear physics giving valuable guidelines in the attempts to build a coherent theoretical scenario.

Cold fusion

Cold fusion [C10] is a phenomenon involving new nuclear physics and the known selection rules give strong constraints when one tries to understand the character of dark nuclear matter. The simplest model for cold fusion found hitherto is based on the nuclear string model [L2]. [L2] and will be taken as the basis of the considerations of this chapter. Also comparisons with the earlier variant of model of cold fusion [K94] will be made in the section about cold fusion.

Large parity breaking effects

Large parity breaking effects in living matter indicate the presence of long ranged weak forces, and the reported nuclear transmutations in living matter [C7, C33] suggest that new nuclear physics plays a role also now. For instance, the Gaussian Mersennes $(1+i)^k-1$ for $k = 113, 151, 157163, 167$ could correspond to weak length scales and four biologically important length scales in the range 10 nm-25 μm, which seem to relate directly to the coiling hierarchy of DNA double strands.

Anomalies of the physics of water

The physics of water involves a large number of anomalies and life depends in an essential way on them. As many as 41 anomalies are discussed in the excellent web page "Water Structure and Behavior" of M. Chaplin [D64]. The fact that the physics of heavy water differs much more from that of ordinary water as one might expect on basis of different masses of water molecules suggests that dark nuclear physics is involved.

1. The finding that one hydrogen atom per two water molecules remain effectively invisible in neutron and electron interactions in atto-second time scale [D64, D61] suggests that water is partially dark. These findings have been questioned in [D72] and thought to be erroneous in [D43]. If the findings are real, dark matter phase made of super-nuclei consisting of protons connected by dark color bonds could explain them as perhaps also the clustering of water molecules predicting magic numbers of water molecules in clusters. If so, dark nuclear physics could be an essential part of condensed matter physics and biochemistry. For instance, the condensate of dark protons might be essential for understanding the properties of bio-molecules and even the physical origin of van der Waals radius of atom in van der Waals equation of state.

2. The observation that the binding energy of dark color bond for $n = 2^{11} = 1/v_0$ of the scaling of $\hbar$ corresponds to the bond energy.5 eV of hydrogen bond raises the fascinating possibility that hydrogen bonds is accompanied by a color bond between proton and oxygen nucleus. Also more general chemical bonds might be accompanied by color bonds so that dark color physics might be an essential part of molecular physics. Color bonds might be also responsible for the formation of liquid phase and thus solid state. Dark weak bonds between nuclei could be involved and might be responsible for the repulsive core of van der Waals force and be part of molecular physics too. There is evidence for two kinds of hydrogen bonds [D62] : a possible identification is in terms of p-adic scaling of hydrogen bonds by a factor 2. This kind of doubling is predicted by nuclear string model [L2], [L2].

3. Years after writing this piece of text emerged the idea that covalent bonds of biopolymers might be accompanied by color bonds carrying the metabolic energy liberated in the decay of these polymers [K23]. Polymer like sequences of "half-dark" water molecules with one dark proton with dark protons connected by color bonds to form dark nucleus could have emerged as prebiotic counterparts of biomolecules and carry metabolic energy in color bonds and realize genetic code [K19, L2]. They could accompany ordinary bio-bolymers in water environment and color bonds could carry the metabolic energy. There are of course many other options, and one must have open mind since the belief that biochemistry is understood reduces to high extent to the belief in the reductionistic dogma.

4. Tetrahedral water clusters consisting of 14 water molecules would contain 8 dark protons which corresponds to a magic number for a dark nucleus consisting of protons. Icosahedral water clusters in turn consist of 20 tetrahedral clusters. This raises the question whether fractally scaled up super-nuclei could be in question. If one accepts the vision about dark matter hierarchy based in Jones inclusions to be discussed briefly later, tetrahedral and icosahedral structures of water could correspond directly to the unique genuinely 3-dimensional $G_a = E_6$ and E_8 coverings of CP_2 with $n_a = 3$ and $n_a = 5$ assignable to dark electrons. Icosahedral structures are also very abundant in living matter, mention only viruses.

Other anomalies

There are also other anomalies which might relate to the hierarchy of Planck constants and also to dark weak forces.

1. Exotic chemistries

Exotic chemistries [D71] in which clusters of atoms of given given type mimic the chemistry of another element. These systems behave as if nuclei would form a jellium (constant charge density) defining a harmonic oscillator potential for electrons. Magic numbers correspond to full electron shells analogous to noble gas elements. It is difficult to understand why the constant charge density approximation works so well. If nuclear protons are in large $\hbar(M^4)$ phase with Fermat integer $n_F = 3 \times 2^{11}$, the electromagnetic sizes of nuclei would be about 2.4 Angstroms and the approximation would be natural.

As a matter, fact nuclear string model predicts that the nuclei can have as many as $3A$ exotic charge states obtained by giving neutral color bond charge ± 1: this would give rise to quite different kind of alchemy [L2]. [L2] revealing itself in cold fusion.

2. Free energy anomalies

The anomalies reported by free energy researchers such as over unity energy production in devices involving repeated formation and dissociation of H_2 molecules based on the original discovery of Nobelist Irwing Langmuir [D53] (see for instance [H12]) suggest that part of H atoms might end up to dark matter phase liberating additional energy. The "mono-atomic" elements of Hudson suggest also dark nuclear physics [H7]. There is even evidence for macroscopic transitions to dark phase [H23, H13, H11].

3. Tritium beta decay anomaly and findings of Shnoll

Tritium beta decay anomaly [C15, C21, C28, C23] suggests exotic nuclear physics related to weak interactions. The evidence for the variation of the rates of nuclear and chemical processes correlating with astrophysical periods [E3] , [E3] could be understood in terms of weak fields created by dark matter and affect by astrophysical phenomena.

7.1.2 Dark Rules

I have done a considerable amount of trials and errors in order to identify the basic rules allowing to understand what it means to be dark matter is and what happens in the phase transition to dark matter. It is good to try to summarize the basic rules of p-adic and dark physics allowing to avoid obvious contradictions.

The notion of field body

The notion of "field body" implied by topological field quantization is essential. There would be em, $Z0$, W, gluonic, and gravitonic field bodies, each characterized by its one prime. The motivation for considering the possibility of separate field bodies seriously is that the notion of induced gauge field means that all induced gauge fields are expressible in terms of four CP_2 coordinates so that only single component of a gauge potential allows a representation as and independent field quantity. Perhaps also separate magnetic and electric field bodies for each interaction and identifiable as flux quanta must be considered. This kind of separation requires that the fermionic content of the flux quantum (say fermion and anti-fermion at the ends of color flux tube) is such that it conforms with the quantum numbers of the corresponding boson.

What is interesting that the conceptual separation of interactions to various types would have a direct correlate at the level of space-time topology. From a different perspective inspired by the general vision that many-sheeted space-time provides symbolic representations of quantum physics, the very fact that we make this conceptual separation of fundamental interactions could reflect the topological separation at space-time level.

The p-adic mass calculations for quarks encourage to think that the p-adic length scale characterizing the mass of particle is associated with its electromagnetic body and in the case of neutrinos with its Z^0 field body. Z^0 field body can contribute also to the mass of charged particles but the contribution would be small. It is also possible that these field bodies are purely magnetic for color and weak interactions. Color flux tubes would have exotic fermion and anti-fermion at their ends and define colored variants of pions. This would apply not only in the case of nuclear strings but also to molecules and larger structures so that scaled variants of elementary particles and standard model would appear in all length scales as indeed implied by the fact that classical electro-weak and color fields are unavoidable in TGD framework.

One can also go further and distinguish between magnetic field body of free particle for which flux quanta start and return to the particle and "relative field" bodies associated with pairs of particles. Very complex structures emerge and should be essential for the understanding the space-time correlates of various interactions. In a well-defined sense they would define space-time correlate for the conceptual analysis of the interactions into separate parts. In order to minimize confusion it should be emphasized that the notion of field body used in this chapter relates to those space-time correlates of interactions, which are more or less *static* and related to the formation of *bound states.*

What dark variant of elementary particle means

It is not at all clear what the notion of dark variant of elementary particle or of larger structures could mean.

1. *Are only field bodies dark?*

One variety of dark particle is obtained by making some of the field bodies dark by increasing the value of Planck constant. This hypothesis could be replaced with the stronger assumption that elementary particles are maximally quantum critical systems so that they are same irrespective of the value of the Planck constant. Elementary particles would be represented by partonic 2-surfaces, which belong to the universal orbifold singularities remaining invariant by all groups $G_a \times G_b$ for a given choice of quantization axes. If $G_a \times G_b$ is assumed to leave invariant the choice of the quantization axes, it must be of the form $Z_{n_a} \times Z_{n_b} \subset SO(3) \times SU(3)$. Partonic 2-surface would belong to $M^2 \times CP_2/U(1) \times U(1)$, where M^2 is spanned by the quantization axis of angular momentum and the time axis defining the rest system.

A different way to say this is that the CP_2 type extremal representing particle would suffer multiple topological condensation on its field bodies so that there would be no separate "particle space-time sheet".

Darkness would be restricted to particle interactions if it is assigned with topological field quanta mediating interactions. The value of the Planck constant would be assigned to a particular interaction between systems rather than system itself. This conforms with the original finding that gravitational Planck constant satisfies $\hbar_{gr} = GM_1M_2/v_0$, $v_0 \simeq 2^{-11}$. Since each interaction can give rise to a hierarchy dark phases, a rich variety of partially dark phases is predicted. The standard assumption that dark matter is visible only via gravitational interactions would mean that gravitational field body would not be dark for this particular dark matter. Note however that gravitational Planck constant h_{fr} having gigantic values could have different origin as Planck constant h_{eff} emerging from considerations related to biology: this is discussed in [K91].

Complex combinations of dark field bodies become possible and the dream is that one could understand various phases of matter in terms of these combinations. All phase transitions, including the familiar liquid-gas and solid-liquid phase transitions, could have a unified description in terms of dark phase transition for an appropriate field body. At mathematical level Jones inclusions would provide this description.

The book metaphor for the interactions at space-time level is very useful in this framework. Elementary particles correspond to ordinary value of Planck constant analogous to the ordinary sheets of a book and the field bodies mediating their interactions are the same space-time sheet or at dark sheets of the book.

2. Can also elementary particles be dark?

Also dark elementary particles themselves rather than only the flux quanta could correspond to dark space-time sheet defining multiple coverings of $H/G_a \times G_b$. This would mean giving up the maximal quantum criticality hypothesis in the case of elementary particles. These sheets would be exact copies of each other. If single sheet of the covering contains topologically condensed space-time sheet, also other sheets contain its exact copy.

The question is whether these copies of space-time sheet defining classical identical systems can carry different fermionic quantum numbers or only identical fermionic quantum numbers so that the dark particle would be exotic many-fermion system allowing an apparent violation of statistics (N fermions in the same state).

Even if one allows varying number of fermions in the same state with respect to a basic copy of sheet, one ends up with the notion of N-atom in which nuclei would be ordinary but electrons would reside at the sheets of the covering. The question is whether symbolic representations essential for understanding of living matter could emerge already at molecular level via the formation of N-atoms.

Criterion for the transition to dark phase

The criterion $\alpha Q_1 Q_2 > 1$ for the transition to dark matter phase relates always to the interaction between two systems and the interpretation is that when the field strength characterizing the interaction becomes too strong, the interaction is mediated by dark space-time sheets which define $n = n(G_a) \times n(G_b)$-fold covering of $M^4 \times CP_2/G_a \times G_b$. The sharing of flux between different space-time sheets reduces the field strength associated with single sheet below the critical value.

Mersenne hypothesis

The generalization of the embedding space means a book like structure for which the pages are products of singular coverings or factor spaces of CD (causal diamond defined as intersection of future and past directed light-cones) and of CP_2 [K81]. This predicts that Planck constants are rationals and that given value of Planck constant corresponds to an infinite number of different pages of the Big Book, which might be seen as a drawback. If only singular covering spaces are allowed the values of Planck constant are products of integers and given value of Planck constant corresponds to a finite number of pages given by the number of decompositions of the integer to two different integers.

TGD inspired quantum biology and number theoretical considerations suggest preferred values for $r = \hbar/\hbar_0$. For the most general option the values of $\hbar$ are products and ratios of two integers n_a and n_b. Ruler and compass integers defined by the products of distinct Fermat primes and power of two are number theoretically favored values for these integers because the phases $exp(i2\pi/n_i)$, $i \in \{a, b\}$, in this case are number theoretically very simple and should have emerged first in the number theoretical evolution via algebraic extensions of p-adics and of rationals. p-Adic length scale hypothesis favors powers of two as values of r.

One can however ask whether a more precise characterization of preferred Mersennes could exist and whether there could exists a stronger correlation between hierarchies of p-adic length scales and Planck constants. Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1+i)k-1$, $k \in \{113, 151, 157, 163, 167, 239, 241..\}$ are expected to be physically highly interesting and up to $k = 127$ indeed correspond to elementary particles. The number theoretical miracle is that all the four scaled up electron Compton lengths with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm). The question has been whether these define scaled up copies of electro-weak and QCD type physics with ordinary value of $\hbar$. The proposal that this is the case and that these physics are in a well-defined sense induced by the dark scaled up variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$.

What induction means is that dark variant of exotic nuclear physics induces exotic physics with ordinary value of Planck constant in the new scale in a resonant manner: dark gauge bosons transform to their ordinary variants with the same Compton length. This transformation is natural since in length scales below the Compton length the gauge bosons behave as massless and free particles. As a consequence, lighter variants of weak bosons emerge and QCD confinement scale becomes longer.

This proposal will be referred to as Mersenne hypothesis. It leads to strong predictions about EEG [K15] since it predicts a spectrum of preferred Josephson frequencies for a given value of membrane potential and also assigns to a given value of $\hbar$ a fixed size scale having interpretation as the size scale of the body part or magnetic body. Also a vision about evolution of life emerges. Mersenne hypothesis is especially interesting as far as new physics in condensed matter length scales is considered: this includes exotic scaled up variants of the ordinary nuclear physics and their dark variants. Even dark nucleons are possible and this gives justification for the model of dark nucleons predicting the counterparts of DNA, RNA, tRNA, and amino-acids as well as realization of vertebrate genetic code [K104].

These exotic nuclear physics with ordinary value of Planck constant could correspond to ground states that are almost vacuum extremals corresponding to homologically trivial geodesic sphere of CP_2 near criticality to a phase transition changing Planck constant. Ordinary nuclear physics would correspond to homologically non-trivial geodesic sphere and far from vacuum extremal property. For vacuum extremals of this kind classical Z^0 field proportional to electromagnetic field is present and this modifies dramatically the view about cell membrane as Josephson junction. The model for cell membrane as almost vacuum extremal indeed led to a quantitative breakthrough in TGD inspired model of EEG and is therefore something to be taken seriously. The safest option concerning empirical facts is that the copies of electro-weak and color physics with ordinary value of Planck constant are possible only for almost vacuum extremals - that is at criticality against phase transition changing Planck constant.

7.1.3 Weak Form Of Electric Magnetic Duality, Screening Of Weak Charges, And Color Confinement?

TGD predicts the presence of long range classical weak fields and color fields and one should understand classically why quarks and leptons do not couple to these fields above weak boson length scale. Why the quarks inside ordinary nuclei do not generate long range weak fields and do not couple to them? Obviously the weak charges of quarks must be screened so that only electromagnetic charge remains. The extreme non-linearity of field equations in principle allows non-vanishing vacuum charge densities making possible this kind of screening. I have not been able to develop any detailed model for this.

A rather attractive looking explanation came with the discovery of electric-magnetic duality leading to a considerable progress in the understanding of basic quantum TGD. The basic implication of the duality is that Kähler electric charges of wormhole throats representing particles are proportional to Kähler magnetic charges so that the CP_2 projections of the wormhole throats are homologically non-trivial. The Kähler magnetic charges do not create long range monopole fields if they are neutralized by wormhole throats carrying opposite monopole charges and weak isospin neutralizing the axial isospin of the particle's wormhole throat. One could speak of confinement of weak isospin. The weak field bodies of elementary fermions would be replaced with string like objects with a length of order W boson Compton length. Electro-magnetic flux would be feeded to electromagnetic field body where it would be feeded to larger space-time sheets. Similar mechanism could apply in the case of color quantum numbers.

One of the basic questions closely related to the weak screening have been whether it is s possible to have a weak analog of the ordinary atom - say neutrino atom. Formally one can of course construct this kind of model and I have indeed doe this. The recent wiew about the screening of weak forces does not however allow neutrino atoms since the weak gauge fluxes flow along flux tubes and are screened by opposite charges at their end rather than being spherically symmetric Coulomb fields. Elementary particles themselves can be regarded as string like objects neutralized above weak boson Compton length. The size of the magnetic flux tubes however scales as $\sqrt{\hbar}$ so that large values of $\hbar$ it is in principle possible to zoom up the elementary particles and see what their interior looks like. This applies to both weak and color forces and might some day make possible study of elementary particles without gigantic accelerators.

7.1.4 Dark Weak Forces And Almost Vacuum Extremals

TGD suggests strongly the presence of long range weak force and the large parity breaking in living matter realized as chiral selection provides support for it. One would however like some more concrete quantitative evidence for the conjecture that the classical weak forces are indeed there. This kind of evidence comes from the model of cell membrane based on the hypothesis that cell membrane correspond to almost vacuum extremal.

1. Induced Kähler form vanishes for vacuum extremals. The condition for vanishing implies that classical Z^0 and electromagnetic fields are proportional to each other so that induced spinor field couples to both these fields. The assumption is that the quarks of nuclei and possibly also neutrinos correspond to a large value of Planck constant and therefore couple to the classical Z^0 field. Atomic electrons would not have these couplings. This modifies dramatically the model for the cell membrane as a Josephson junction and raises the scale of Josephson energies from IR range just above thermal threshold to visible and ultraviolet. The amazing finding is that the Josephson energies for biologically important ions correspond to the energies assigned to the peak frequencies in the biological activity spectrum of photoreceptors in retina suggesting. This suggests that almost vacuum extremals and thus also classical Z^0 fields could be in a central role in the understanding of the functioning of the cell membrane and of sensory qualia. This would also explain the large parity breaking effects in living matter.

   One can construct also a generalization of Josephson junction as transmembrane protein such that Josephson energy is generalized to include also the difference of cyclotron energies over the membrane. This allows to understand the role of protons in metabolism and large value about.5 eV of metabolic energy quantum roughtly 10 times larger that Josephson energy for cell membrane in terms of "square root of thermodynamics" replacing the ordinary thermodynamical model of cell membrane. In this case classical Z^0 force is not necessary. It is of course possible that cell membrane proteins can be in two phases: without or with classical Z^0 fields at string world sheets of dark fermions.

2. A further conjecture is that EEG and its predicted fractally scaled variants which same energies in visible and UV range but different scales of Josephson frequencies correspond to Josephson photons with various values of Planck constant. The decay of dark ELF photons with energies of visible photons would give rise to bunches of ordinary ELF photons. Biophotons in turn could correspond to ordinary visible photons resulting in the phase transition of these photons to photons with ordinary value of Planck constant. This leads to a very detailed view about the role of dark electromagnetic radiation in biomatter and also to a model for how sensory qualia are realized [K16, K41, K15].

What darkness means in the case of nuclei is that the "weak" field bodies of quarks are dark so that the size scale assignable to them is of order cell size. This does not affect their electromagnetic field bodies so that it is possible to speak about ions in the ordinary sense of the word. If the size scale of a given part of field body corresponds to the Compton length proportional proportional to the p-adic length scale scaled up by $\sqrt{\hbar}$ then cell membrane thickness as a Compton scale for the field body of weak bosons means rather large value of $\hbar \sim 2^{151-89} = 2^{62}\hbar_0$. This would scale down 10^{14} Hz frequency of visible photons to about 10^{-4} Hz.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L5].

7.2 Weak Form Electric-Magnetic Duality And Its Implications

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 world of classical worlds. 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. What this means will be discussed in the sequel.

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: this could become manifest at LHC energies.

4. The weak form electric-magnetic duality together with Beltrami flow property of Kähler leads to the reduction of Kähler action to Chern-Simons action so that TGD reduces to almost topological QFT and that Kähler function is explicitly calculable. This has enormous impact concerning practical calculability of the theory.

5. One ends up also to a general solution ansatz for field equations from the condition that the theory reduces to almost topological QFT. The solution ansatz is inspired by the idea that all isometry currents are proportional to Kähler current which is integrable in the sense that the flow parameter associated with its flow lines defines a global coordinate. The proposed solution ansatz would describe a hydrodynamical flow with the property that isometry charges are conserved along the flow lines (Beltrami flow). A general ansatz satisfying the integrability conditions is found.

   The strongest form of the solution ansatz states that various classical and quantum currents flow along flow lines of the Beltrami flow defined by Kähler current (Kähler magnetic field associated with Chern-Simons action). Intuitively this picture is attractive. A more general ansatz would allow several Beltrami flows meaning multi-hydrodynamics. The integrability conditions boil down to two scalar functions: the first one satisfies massless d'Alembert equation in the induced metric and the gradients of the scalar functions are orthogonal. The interpretation in terms of momentum and polarization directions is natural.

7.2.1 Could A Weak Form Of Electric-Magnetic Duality Hold True?

Holography means that the initial data at the partonic 2-surfaces should fix the WCW metric. A weak form of this condition allows only the partonic 2-surfaces defined by the wormhole throats at which the signature of the induced metric changes. A stronger condition allows all partonic 2-surfaces in the slicing of space-time sheet to partonic 2-surfaces and string world sheets. Number theoretical vision suggests that hyper-quaternionicity *resp.* co-hyperquaternionicity constraint could be enough to fix the initial values of time derivatives of the embedding space coordinates in the space-time regions with Minkowskian *resp.* Euclidian signature of the induced metric. This is a condition on modified gamma matrices and hyper-quaternionicity states that they span a hyper-quaternionic sub-space.

Definition of the weak form of electric-magnetic duality

One can also consider alternative conditions possibly equivalent with this condition. The argument goes as follows.

1. The expression of the matrix elements of the metric and Kähler form of WCW in terms of the Kähler fluxes weighted by Hamiltonians of $\delta M^4_\pm$ at the partonic 2-surface X^2 looks very attractive. These expressions however carry no information about the 4-D tangent space of the partonic 2-surfaces so that the theory would reduce to a genuinely 2-dimensional theory, which cannot hold true. One would like to code to the WCW metric also information about the electric part of the induced Kähler form assignable to the complement of the tangent space of $X^2 \subset X^4$.

2. Electric-magnetic duality of the theory looks a highly attractive symmetry. The trivial manner to get electric magnetic duality at the level of the full theory would be via the identification of the flux Hamiltonians as sums of of the magnetic and electric fluxes. The presence of the induced metric is however troublesome since the presence of the induced metric means that the simple transformation properties of flux Hamiltonians under symplectic transformations -in particular color rotations- are lost.

3. A less trivial formulation of electric-magnetic duality would be as an initial condition which eliminates the induced metric from the electric flux. In the Euclidian version of 4-D YM theory this duality allows to solve field equations exactly in terms of instantons. This approach involves also quaternions. These arguments suggest that the duality in some form might work. The full electric magnetic duality is certainly too strong and implies that space-time surface at the partonic 2-surface corresponds to piece of CP_2 type vacuum extremal and can hold only in the deep interior of the region with Euclidian signature. In the region surrounding wormhole throat at both sides the condition must be replaced with a weaker condition.

4. To formulate a weaker form of the condition let us introduce coordinates (x^0, x^3, x^1, x^2) such (x^1, x^2) define coordinates for the partonic 2-surface and (x^0, x^3) define coordinates labeling partonic 2-surfaces in the slicing of the space-time surface by partonic 2-surfaces and string world sheets making sense in the regions of space-time sheet with Minkowskian signature. The assumption about the slicing allows to preserve general coordinate invariance. The weakest condition is that the generalized Kähler electric fluxes are apart from constant proportional to Kähler magnetic fluxes. This requires the condition

$$J^{03}\sqrt{g_4} = KJ_{12} . \tag{7.2.1}$$

A more general form of this duality is suggested by the considerations of [K20] reducing the hierarchy of Planck constants to basic quantum TGD and also reducing Kähler function for preferred extremals to Chern-Simons terms [B1] at the boundaries of CD and at light-like wormhole throats. This form is following

$$J^{n\beta}\sqrt{g_4} = K\epsilon \times \epsilon^{n\beta\gamma\delta}J_{\gamma\delta}\sqrt{g_4} \ . \tag{7.2.2}$$

Here the index n refers to a normal coordinate for the space-like 3-surface at either boundary of CD or for light-like wormhole throat. ϵ is a sign factor which is opposite for the two ends of CD. It could be also opposite of opposite at the opposite sides of the wormhole throat. Note that the dependence on induced metric disappears at the right hand side and this condition eliminates the potentials singularity due to the reduction of the rank of the induced metric at wormhole throat.

5. Information about the tangent space of the space-time surface can be coded to the WCW metric with loosing the nice transformation properties of the magnetic flux Hamiltonians if Kähler electric fluxes or sum of magnetic flux and electric flux satisfying this condition are used and K is symplectic invariant. Using the sum

$$J_e + J_m = (1+K)J_{12} \ , \tag{7.2.3}$$

where J denotes the Kähler magnetic flux, , makes it possible to have a non-trivial WCW metric even for $K = 0$, which could correspond to the ends of a cosmic string like solution carrying only Kähler magnetic fields. This condition suggests that it can depend only on Kähler magnetic flux and other symplectic invariants. Whether local symplectic coordinate invariants are possible at all is far from obvious, If the slicing itself is symplectic invariant then K could be a non-constant function of X^2 depending on string world sheet coordinates. The light-like radial coordinate of the light-cone boundary indeed defines a symplectically invariant slicing and this slicing could be shifted along the time axis defined by the tips of CD.

Electric-magnetic duality physically

What could the weak duality condition mean physically? For instance, what constraints are obtained if one assumes that the quantization of electro-weak charges reduces to this condition at classical level?

1. The first thing to notice is that the flux of J over the partonic 2-surface is analogous to magnetic flux

$$Q_m = \frac{e}{\hbar}\oint BdS = n \ .$$

n is non-vanishing only if the surface is homologically non-trivial and gives the homology charge of the partonic 2-surface.

2. The expressions of classical electromagnetic and Z^0 fields in terms of Kähler form [L1] , [L1] read as

$$\begin{aligned}\gamma &= \frac{eF_{em}}{\hbar} = 3J - sin^2(\theta_W)R_{03} \ , \\ Z^0 &= \frac{g_ZF_Z}{\hbar} = 2R_{03} \ .\end{aligned} \tag{7.2.4}$$

Here R_{03} is one of the components of the curvature tensor in vielbein representation and F_{em} and F_Z correspond to the standard field tensors. From this expression one can deduce

$$J = \frac{e}{3\hbar}F_{em} + sin^2(\theta_W)\frac{g_Z}{6\hbar}F_Z \ . \quad (7.2.5)$$

3. The weak duality condition when integrated over X^2 implies

$$\begin{aligned} \frac{e^2}{3\hbar}Q_{em} + \frac{g_Z^2 p}{6}Q_{Z,V} &= K\oint J = Kn \ , \\ Q_{Z,V} &= \frac{I_V^3}{2} - Q_{em} \ , \ \ p = sin^2(\theta_W) \ . \end{aligned} \quad (7.2.6)$$

Here the vectorial part of the Z^0 charge rather than as full Z^0 charge $Q_Z = I_L^3 + sin^2(\theta_W)Q_{em}$ appears. The reason is that only the vectorial isospin is same for left and right handed components of fermion which are in general mixed for the massive states.

The coefficients are dimensionless and expressible in terms of the gauge coupling strengths and using $\hbar = r\hbar_0$ one can write

$$\begin{aligned} \alpha_{em}Q_{em} &+ p\frac{\alpha_Z}{2}Q_{Z,V} = \frac{3}{4\pi}\times rnK \ , \\ \alpha_{em} &= \frac{e^2}{4\pi\hbar_0} \ , \ \ \alpha_Z = \frac{g_Z^2}{4\pi\hbar_0} = \frac{\alpha_{em}}{p(1-p)} \ . \end{aligned} \quad (7.2.7)$$

4. There is a great temptation to assume that the values of Q_{em} and Q_Z correspond to their quantized values and therefore depend on the quantum state assigned to the partonic 2-surface. The linear coupling of the Kähler-Dirac operator to conserved charges implies correlation between the geometry of space-time sheet and quantum numbers assigned to the partonic 2-surface. The assumption of standard quantized values for Q_{em} and Q_Z would be also seen as the identification of the fine structure constants α_{em} and α_Z. This however requires weak isospin invariance.

The value of K from classical quantization of Kähler electric charge

The value of K can be deduced by requiring classical quantization of Kähler electric charge.

1. The condition that the flux of $F^{03} = (\hbar/g_K)J^{03}$ defining the counterpart of Kähler electric field equals to the Kähler charge g_K would give the condition $K = g_K^2/\hbar$, where g_K is Kähler coupling constant which should invariant under coupling constant evolution by quantum criticality. Within experimental uncertainties one has $\alpha_K = g_K^2/4\pi\hbar_0 = \alpha_{em} \simeq 1/137$, where α_{em} is finite structure constant in electron length scale and $\hbar_0$ is the standard value of Planck constant.

2. The quantization of Planck constants makes the condition highly non-trivial. The most general quantization of r is as rationals but there are good arguments favoring the quantization as integers corresponding to the allowance of only singular coverings of CD andn CP_2. The point is that in this case a given value of Planck constant corresponds to a finite number pages of the "Big Book". The quantization of the Planck constant implies a further quantization of K and would suggest that K scales as $1/r$ unless the spectrum of values of Q_{em} and Q_Z allowed by the quantization condition scales as r. This is quite possible and the interpretation would be that each of the r sheets of the covering carries (possibly same) elementary charge. Kind of discrete variant of a full Fermi sphere would be in question. The interpretation in terms of anyonic phases [K89] supports this interpretation.

3. The identification of J as a counterpart of $eB/\hbar$ means that Kähler action and thus also Kähler function is proportional to $1/\alpha_K$ and therefore to $\hbar$. This implies that for large values of $\hbar$ Kähler coupling strength $g_K^2/4\pi$ becomes very small and large fluctuations are suppressed in the functional integral. The basic motivation for introducing the hierarchy of Planck constants was indeed that the scaling $\alpha \rightarrow \alpha/r$ allows to achieve the convergence of perturbation theory: Nature itself would solve the problems of the theoretician. This of course does not mean that the physical states would remain as such and the replacement of single particles with anyonic states in order to satisfy the condition for K would realize this concretely.

4. The condition $K = g_K^2/\hbar$ implies that the Kähler magnetic charge is always accompanied by Kähler electric charge. A more general condition would read as

$$K = n \times \frac{g_K^2}{\hbar}, n \in Z \ . \tag{7.2.8}$$

This would apply in the case of cosmic strings and would allow vanishing Kähler charge possible when the partonic 2-surface has opposite fermion and anti-fermion numbers (for both leptons and quarks) so that Kähler electric charge should vanish. For instance, for neutrinos the vanishing of electric charge strongly suggests $n = 0$ besides the condition that abelian Z^0 flux contributing to em charge vanishes.

It took a year to realize that this value of K is natural at the Minkowskian side of the wormhole throat. At the Euclidian side much more natural condition is

$$K = \frac{1}{hbar} \ . \tag{7.2.9}$$

In fact, the self-duality of CP_2 Kähler form favours this boundary condition at the Euclidian side of the wormhole throat. Also the fact that one cannot distinguish between electric and magnetic charges in Euclidian region since all charges are magnetic can be used to argue in favor of this form. The same constraint arises from the condition that the action for CP_2 type vacuum extremal has the value required by the argument leading to a prediction for gravitational constant in terms of the square of CP_2 radius and α_K the effective replacement $g_K^2 \rightarrow 1$ would spoil the argument.

The boundary condition $J_E = J_B$ for the electric and magnetic parts of Kählwer form at the Euclidian side of the wormhole throat inspires the question whether all Euclidian regions could be self-dual so that the density of Kähler action would be just the instanton density. Self-duality follows if the deformation of the metric induced by the deformation of the canonically imbedded CP_2 is such that in CP_2 coordinates for the Euclidian region the tensor $(g^{\alpha\beta}g^{\mu\nu} - g^{\alpha\nu}g^{\mu\beta})/\sqrt{g}$ remains invariant. This is certainly the case for CP_2 type vacuum extremals since by the light-likeness of M^4 projection the metric remains invariant. Also conformal scalings of the induced metric would satisfy this condition. Conformal scaling is not consistent with the degeneracy of the 4-metric at the wormhole.

Reduction of the quantization of Kähler electric charge to that of electromagnetic charge

The best manner to learn more is to challenge the form of the weak electric-magnetic duality based on the induced Kähler form.

1. Physically it would seem more sensible to pose the duality on electromagnetic charge rather than Kähler charge. This would replace induced Kähler form with electromagnetic field, which is a linear combination of induced Kahler field and classical Z^0 field

$$\begin{aligned} \gamma &= 3J - sin^2\theta_W R_{12} \ , \\ Z^0 &= 2R_{03} \ . \end{aligned} \tag{7.2.10}$$

Here $Z_0 = 2R_{03}$ is the appropriate component of CP_2 curvature form [L1]. For a vanishing Weinberg angle the condition reduces to that for Kähler form.

2. For the Euclidian space-time regions having interpretation as lines of generalized Feynman diagrams Weinberg angle should be non-vanishing. In Minkowskian regions Weinberg angle could however vanish. If so, the condition guaranteeing that electromagnetic charge of the partonic 2-surfaces equals to the above condition stating that the em charge assignable to the fermion content of the partonic 2-surfaces reduces to the classical Kähler electric flux at the Minkowskian side of the wormhole throat. One can argue that Weinberg angle must increase smoothly from a vanishing value at both sides of wormhole throat to its value in the deep interior of the Euclidian region.

3. The vanishing of the Weinberg angle in Minkowskian regions conforms with the physical intuition. Above elementary particle length scales one sees only the classical electric field reducing to the induced Kähler form and classical Z^0 fields and color gauge fields are effectively absent. Only in phases with a large value of Planck constant classical Z^0 field and other classical weak fields and color gauge field could make themselves visible. Cell membrane could be one such system [K41]. This conforms with the general picture about color confinement and weak massivation.

The GRT limit of TGD suggests a further reason for why Weinberg angle should vanish in Minkowskian regions.

1. The value of the Kähler coupling strength mut be very near to the value of the fine structure constant in electron length scale and these constants can be assumed to be equal.

2. GRT limit of TGD with space-time surfaces replaced with abstract 4-geometries would naturally correspond to Einstein-Maxwell theory with cosmological constant which is non-vanishing only in Euclidian regions of space-time so that both Reissner-Nordström metric and CP_2 are allowed as simplest possible solutions of field equations [K103]. The extremely small value of the observed cosmological constant needed in GRT type cosmology could be equal to the large cosmological constant associated with CP_2 metric multiplied with the 3-volume fraction of Euclidian regions.

3. Also at GRT limit quantum theory would reduce to almost topological QFT since Einstein-Maxwell action reduces to 3-D term by field equations implying the vanishing of the Maxwell current and of the curvature scalar in Minkowskian regions and curvature scalar + cosmological constant term in Euclidian regions. The weak form of electric-magnetic duality would guarantee also now the preferred extremal property and prevent the reduction to a mere topological QFT.

4. GRT limit would make sense only for a vanishing Weinberg angle in Minkowskian regions. A non-vanishing Weinberg angle would make sense in the deep interior of the Euclidian regions where the approximation as a small deformation of CP_2 makes sense.

The weak form of electric-magnetic duality has surprisingly strong implications for the basic view about quantum TGD as following considerations show.

7.2.2 Magnetic Confinement, The Short Range Of Weak Forces, And Color Confinement

The weak form of electric-magnetic duality has surprisingly strong implications if one combines it with some very general empirical facts such as the non-existence of magnetic monopole fields in macroscopic length scales.

How can one avoid macroscopic magnetic monopole fields?

Monopole fields are experimentally absent in length scales above order weak boson length scale and one should have a mechanism neutralizing the monopole charge. How electroweak interactions become short ranged in TGD framework is still a poorly understood problem. What suggests itself is the neutralization of the weak isospin above the intermediate gauge boson Compton length by neutral Higgs bosons. Could the two neutralization mechanisms be combined to single one?

1. In the case of fermions and their super partners the opposite magnetic monopole would be a wormhole throat. If the magnetically charged wormhole contact is electromagnetically neutral but has vectorial weak isospin neutralizing the weak vectorial isospin of the fermion only the electromagnetic charge of the fermion is visible on longer length scales. The distance of this wormhole throat from the fermionic one should be of the order weak boson Compton length. An interpretation as a bound state of fermion and a wormhole throat state with the quantum numbers of a neutral Higgs boson would therefore make sense. The neutralizing throat would have quantum numbers of $X_{-1/2} = \nu_L\overline{\nu}_R$ or $X_{1/2} = \overline{\nu}_L\nu_R$. $\nu_L\overline{\nu}_R$ would not be neutral Higgs boson (which should correspond to a wormhole contact) but a super-partner of left-handed neutrino obtained by adding a right handed neutrino. This mechanism would apply separately to the fermionic and anti-fermionic throats of the gauge bosons and corresponding space-time sheets and leave only electromagnetic interaction as a long ranged interaction.

2. One can of course wonder what is the situation situation for the bosonic wormhole throats feeding gauge fluxes between space-time sheets. It would seem that these wormhole throats must always appear as pairs such that for the second member of the pair monopole charges and I_V^3 cancel each other at both space-time sheets involved so that one obtains at both space-time sheets magnetic dipoles of size of weak boson Compton length. The proposed magnetic character of fundamental particles should become visible at TeV energies so that LHC might have surprises in store!

Well-definedness of electromagnetic charge implies stringiness

Well-definedness of electromagnetic charged at string world sheets carrying spinor modes is very natural constraint and not trivially satisfied because classical W boson fields are present. As a matter fact, all weak fields should be effectively absent above weak scale. How this is possible classical weak fields identified as induced gauge fields are certainly present.

The condition that em charge is well defined for spinor modes implies that the space-time region in which spinor mode is non-vanishing has 2-D CP_2 projection such that the induced W boson fields are vanishing. The vanishing of classical Z^0 field can be poses as additional condition - at least in scales above weak scale. In the generic case this requires that the spinor mode is restricted to 2-D surface: string world sheet or possibly also partonic 2-surface. This implies that TGD reduces to string model in fermionic sector. Even for preferred extremals with 2-D projecting the modes are expected to allow restriction to 2-surfaces. This localization is possible only for Kähler-Dirac action.

A word of warning is however in order. The GRT limit or rather limit of TGD as Einstein Yang-Mills theory replaces the sheets of many-sheeted space-time with Minkowski space with effective metric obtained by summing to Minkowski metric the deviations of the induced metrics of space-time sheets from Minkowski metric. For gauge potentials a similar identification applies. YM-Einstein equations coupled with matter and with non-vanishing cosmological constant are expected on basis of Poincare invariance. One cannot exclude the possibility that the sums of weak gauge potentials from different space-time sheet tend to vanish above weak scale and that well-definedness of em charge at classical level follows from the effective absence of classical weak gauge fields.

Magnetic confinement and color confinement

Magnetic confinement generalizes also to the case of color interactions. One can consider also the situation in which the magnetic charges of quarks (more generally, of color excited leptons and quarks) do not vanish and they form color and magnetic singles in the hadronic length scale. This would mean that magnetic charges of the state $q_{\pm 1/2} - X_{\mp 1/2}$ representing the physical quark would not vanish and magnetic confinement would accompany also color confinement. This would explain why free quarks are not observed. To how degree then quark confinement corresponds to magnetic confinement is an interesting question.

For quark and antiquark of meson the magnetic charges of quark and antiquark would be opposite and meson would correspond to a Kähler magnetic flux so that a stringy view about meson emerges. For valence quarks of baryon the vanishing of the net magnetic charge takes place provided that the magnetic net charges are $(\pm 2, \mp 1, \mp 1)$. This brings in mind the spectrum of color hyper charges coming as $(\pm 2, \mp 1, \mp 1)/3$ and one can indeed ask whether color hypercharge correlates with the Kähler magnetic charge. The geometric picture would be three strings connected to single vertex. Amusingly, the idea that color hypercharge could be proportional to color hyper charge popped up during the first year of TGD when I had not yet discovered CP_2 and believed on $M^4 \times S^2$.

p-Adic length scale hypothesis and hierarchy of Planck constants defining a hierarchy of dark variants of particles suggest the existence of scaled up copies of QCD type physics and weak physics. For p-adically scaled up variants the mass scales would be scaled by a power of $\sqrt{2}$ in the most general case. The dark variants of the particle would have the same mass as the original one. In particular, Mersenne primes $M_k = 2^k - 1$ and Gaussian Mersennes $M_{G,k} = (1+i)^k - 1$ has been proposed to define zoomed copies of these physics. At the level of magnetic confinement this would mean hierarchy of length scales for the magnetic confinement.

One particular proposal is that the Mersenne prime M_{89} should define a scaled up variant of the ordinary hadron physics with mass scaled up roughly by a factor $2^{(107-89)/2} = 512$. The size scale of color confinement for this physics would be same as the weal length scale. It would look more natural that the weak confinement for the quarks of M_{89} physics takes place in some shorter scale and M_{61} is the first Mersenne prime to be considered. The mass scale of M_{61} weak bosons would be by a factor $2^{(89-61)/2} = 2^{14}$ higher and about 1.6×10^4 TeV. M_{89} quarks would have virtually no weak interactions but would possess color interactions with weak confinement length scale reflecting themselves as new kind of jets at collisions above TeV energies.

In the biologically especially important length scale range 10 nm -2500 nm there are as many as four scaled up electron Compton lengths $L_e(k) = \sqrt{5}L(k)$: they are associated with Gaussian Mersennes $M_{G,k}$, $k = 151, 157, 163, 167$. This would suggest that the existence of scaled up scales of magnetic-, weak- and color confinement. An especially interesting possibly testable prediction is the existence of magnetic monopole pairs with the size scale in this range. There are recent claims about experimental evidence for magnetic monopole pairs [D44] .

Magnetic confinement and stringy picture in TGD sense

The connection between magnetic confinement and weak confinement is rather natural if one recalls that electric-magnetic duality in super-symmetric quantum field theories means that the descriptions in terms of particles and monopoles are in some sense dual descriptions. Fermions would be replaced by string like objects defined by the magnetic flux tubes and bosons as pairs of wormhole contacts would correspond to pairs of the flux tubes. Therefore the sharp distinction between gravitons and physical particles would disappear.

The reason why gravitons are necessarily stringy objects formed by a pair of wormhole contacts is that one cannot construct spin two objects using only single fermion states at wormhole throats. Of course, also super partners of these states with higher spin obtained by adding fermions and anti-fermions at the wormhole throat but these do not give rise to graviton like states [K82] . The upper and lower wormhole throat pairs would be quantum superpositions of fermion anti-fermion pairs with sum over all fermions. The reason is that otherwise one cannot realize graviton emission in terms of joining of the ends of light-like 3-surfaces together. Also now magnetic monopole charges are necessary but now there is no need to assign the entities $X_\pm$ with gravitons.

Graviton string is characterized by some p-adic length scale and one can argue that below this length scale the charges of the fermions become visible. Mersenne hypothesis suggests that some Mersenne prime is in question. One proposal is that gravitonic size scale is given by electronic Mersenne prime M_{127}. It is however difficult to test whether graviton has a structure visible below this length scale.

What happens to the generalized Feynman diagrams is an interesting question. It is not at all clear how closely they relate to ordinary Feynman diagrams. All depends on what one is ready to assume about what happens in the vertices. One could of course hope that zero energy ontology could allow some very simple description allowing perhaps to get rid of the problematic aspects of Feynman diagrams.

1. Consider first the recent view about generalized Feynman diagrams which relies ZEO. A highly attractive assumption is that the particles appearing at wormhole throats are on mass shell particles. For incoming and outgoing elementary bosons and their super partners they would be positive it resp. negative energy states with parallel on mass shell momenta. For virtual bosons they the wormhole throats would have opposite sign of energy and the sum of on mass shell states would give virtual net momenta. This would make possible twistor description of virtual particles allowing only massless particles (in 4-D sense usually and in 8-D sense in TGD framework). The notion of virtual fermion makes sense only if one assumes in the interaction region a topological condensation creating another wormhole throat having no fermionic quantum numbers.

2. The addition of the particles $X^{\pm}$ replaces generalized Feynman diagrams with the analogs of stringy diagrams with lines replaced by pairs of lines corresponding to fermion and $X_{\pm 1/2}$. The members of these pairs would correspond to 3-D light-like surfaces glued together at the vertices of generalized Feynman diagrams. The analog of 3-vertex would not be splitting of the string to form shorter strings but the replication of the entire string to form two strings with same length or fusion of two strings to single string along all their points rather than along ends to form a longer string. It is not clear whether the duality symmetry of stringy diagrams can hold true for the TGD variants of stringy diagrams.

3. How should one describe the bound state formed by the fermion and $X^{\pm}$? Should one describe the state as superposition of non-parallel on mass shell states so that the composite state would be automatically massive? The description as superposition of on mass shell states does not conform with the idea that bound state formation requires binding energy. In TGD framework the notion of negentropic entanglement has been suggested to make possible the analogs of bound states consisting of on mass shell states so that the binding energy is zero [K28] . If this kind of states are in question the description of virtual states in terms of on mass shell states is not lost. Of course, one cannot exclude the possibility that there is infinite number of this kind of states serving as analogs for the excitations of string like object.

4. What happens to the states formed by fermions and $X_{\pm 1/2}$ in the internal lines of the Feynman diagram? Twistor philosophy suggests that only the higher on mass shell excitations are possible. If this picture is correct, the situation would not change in an essential manner from the earlier one.

The highly non-trivial prediction of the magnetic confinement is that elementary particles should have stringy character in electro-weak length scales and could behaving to become manifest at LHC energies. This adds one further item to the list of non-trivial predictions of TGD about physics at LHC energies [K29] .

7.3 Dark Matter Hierarchy, Genetic Machinery, And The Un-Reasonable Selectivity Of Bio-Catalysis

One of the most fascinating outcomes of ideas related to the dark matter hierarchy is the notion of inherently dark fractional atom (molecule) generalizing the notion of Bose-Einstein condensate to the fermionic case. These notions might provide an elegant manner to understand the mysteries of DNA replication, transcription, and translation, and more generally, the incredible selectivity of bio-catalysis.

As often, the original idea was not quite correct. I spoke about N-atoms rather than fractional atoms. In particular, the mass of N-molecule was N times larger than that of the ordinary molecule apart from corrections from binding energy. The more precise view about dark matter hierarchy led to the realization that fractionization of all quantum numbers occurs. In the most general case one can have fractional particles with particle number $n = k/r$, $k = 1, .., r$, $r = \frac{\hbar}{\hbar_0}$. This leaves the model essentially as such at formal level. The model is however much more realistic than the original one since fractional atoms have mass which is never larger than that of ordinary atom and also conforms with the recent view about the origin of the hierarchy of Planck constants.

7.3.1 Dark Atoms And Dark Cyclotron States

The development of the notion of dark atom involves many side tracks which make me blush. The first naïve guess was that dark atom would be obtained by simply replacing Planck constant with its scaled counterpart in the basic formulas and interpreting the results geometrically. After some obligatory twists and turns it became clear that this assumption is indeed the most plausible one. The main source of confusion has been the lack of precise view about what the hierarchy of Planck constants means at the level of embedding space at space-time.

The rules are very simple when one takes the singular coverings assigned to the many-valuedness of the time-derivatives of embedding space coordinates as functions of canonical momentum densities as a starting point.

1. The mass and charge of electron are fractionized as is also the reduced mass in Schrödinger equation. This implies the replacements $e \to e/r$, $m \to m/r$, and $\hbar \to r\hbar_0$, $r = n_a n_b$, in the general formula for the binding energy assigned with single sheet of the covering. If maximal number $n_a n_b$ are present corresponding to a full "Fermi sphere", the total binding energy is r times the binding energy associated with single sheet.

2. In the case of hydrogen atom the proportionality $E \propto m/\hbar^2$ implies that the binding energy for single sheet of the covering scales as $E \to E/(n_a n_b)^3$ and maximal binding energy scales as $E \to E/(n_a n_b)^2$. This conforms with the naïve guess. For high values of the nuclear charge Z it can happen that the binding energy is larger than the rest mass and fractionization might take place when binding energy is above critical fraction of the rest mass.

3. In the case of cyclotron energies one must must decide what happens to the magnetic flux. Magnetic flux quantization states that the flux is proportional to $\hbar$ for each sheet separately. Hence one has $\Phi \to r\Phi$ for each sheet and the total flux scales as r^2. Since the dimensions of the flux quantum are scaled up by r the natural scaling of the size of flux quantum is by r^2. Therefore the quantization of the magnetic flux requires the scaling $B \to B/r$. The cyclotron energy for single sheet satisfies $E \propto \hbar qB/m$ and since both mass m and charge q become fractional, the energy E for single sheet remains invariant whereas total cyclotron energy is scaled up by r in accordance with the original guess and the assumption used in applications.

4. Dark cyclotron states are expected to be stable up to temperatures which are r times higher than for ordinary cyclotron states. The states of dark hydrogen atoms and its generalizations are expected to be stable at temperatures scaled down by $1/r^2$ in the first approximation.

5. Similar arguments allow to deduce the values of binding energies in the general case once the formula of the binding energy given by standard quantum theory is known.

The most general option option allows fractional atoms with proton and electron numbers varying from $1/r$ to 1. One can imagine also the possibility of fractional molecules. The analogs of chemical bonds between fractional hydrogen atoms with $N-k$ and k fractional electrons and protons can be considered and would give rise to a full shell of fractional electrons possessing an exceptional stability. These states would have proton and electron numbers equal to one.

Catalytic sites are one possible candidate for fractal electrons and catalyst activity might be perhaps understood as a strong tendency of fractal electron and its conjugate to fuse to form an ordinary electron.

Connection with quantum groups?

The phase $q = exp(i2\pi/r)$ brings unavoidably in mind the phases defining quantum groups and playing also a key role in the model of topological quantum computation [K67]. Quantum groups indeed emerge from the spinor structure in the "world of classical worlds" realized as the space of

3-surfaces in $M^4 \times CP_2$ and being closely related to von Neumann algebras known as hyper-finite factors of type II_1 [K106].

Only singular coverings are allowed if the hierarchy of Planck constants and corresponding hierarchy of singular coverings follows from the basic TGD. If the integer n characterizing the quantum phase allows identification with with $r = \hbar/\hbar_0$, living matter could be perhaps understood in terms of quantum deformations of the ordinary matter, which would be characterized by the quantum phases $q = exp(i2\pi/r)$. Hence quantum groups, which have for long time suspected to have significance in elementary particle physics, might relate to the mystery of living matter and predict an entire hierarchy of new forms of matter.

How to distinguish between fractional particles and ordinary particles?

The unavoidable question is whether bio-molecules in vivo could involve actually fractional atoms molecules as their building blocks. This raises a series of related questions.

1. Could it be that we can observe only the fusion of of dark fractional fold molecules to ordinary molecules or its reversal? Is the behavior of matter matter in vivo dictated by the dark matter commentn and of matter in vitro by ordinary matter? Could just the act of observing the matter in vivo in the sense of existing science make it ordinary dead matter?

2. If fractional atoms and molecules correspond to the maximum number of fractional quanta their masses are same as for ordinary atoms and molecules and only the different binding energy photon spectrum distinguishes between them. Situation changes all fractional states are possible and one obtains scaled down spectrum as a unique signature.

3. The fusion of fractional molecules to ordinary molecules in principle allows to conclude that fractional molecule was present. Could this process mean just the replacement of DNA in vivo with DNA in vitro?

7.3.2 Spontaneous Decay And Completion Of Dark Fractional Atoms As A Basic Mechanisms Of Bio-Chemistry?

The replication of DNA has remained for me a deep mystery and I dare to doubt that the reductionistic belief that this miraculous process is well-understood involves self deceptive elements. Of course the problem is much more general: DNA replication is only a single very representative example of the miracles of un-reasonable selectivity of the bio-catalysis. I take this fact as a justification for some free imagination inspired by the notion of dark fractional molecule.

Dark fermionic molecules can replicate via decay and spontaneous completion

Unit particle number for fractional atom or molecule means that the analog of closed electronic shell are in question so that the state is especially stable. Note that the analogy with full Fermi electronic sphere makes also sense. These atoms or molecules could decay to fractional atoms or molecules. with fractional particle numbers k/r and $(r-k)/r$.

Suppose that a fractional molecule with unit particle number decays into k/r-molecule and $(r-k)/r$-molecule. If r is even it is possible to have $k = r - k = r/2$ and the situation is especially symmetric. If fermionic $k/r < 1$ fractional atoms or molecules are present, one can imagine that they tend to be completed to full molecules spontaneously. Thus spontaneous decay and completion would favor the spontaneous replication (or rather fractionization) and dark molecules could be ideal replicators (fractionizators) The idea that the mechanisms of spontaneous decay and completion of dark fractional particles somehow lurk behind DNA replication and various high precision bio-catalytic processes is rather attractive.

Reduction of lock and key mechanism to spontaneous completion

DNA replication and molecular recognition by the lock and key mechanism are the two mysterious processes of molecular biology. As a matter fact, DNA replication reduces to spontaneous opening of DNA double strand and to the lock and key mechanism so that it could be enough to understand the opening of double strand in terms of spontaneous decay and lock and key mechanism in terms of spontaneous completion of fractional particle (-atom or -molecule).

Consider bio-molecules which fit like a lock and key. Suppose that they are accompanied by dark fractional atoms or molecules, to be called dark fractional particles in sequel, such that one has $k_1 + k_2 = r$ so that in the formation of bound state dark molecules combine to form r-molecule analogous to a full fermionic shell or full Fermi sea. This is expected to enhance the stability of this particular molecular complex and prefer it amongst generic combinations.

For instance, this mechanism would make it possible for nucleotide and its conjugate, DNA and mRNA molecule, and tRNA molecule and corresponding amino-acid to recognize each other. Spontaneous completion would allow to realize also the associations characterizing the genetic code as a map from RNAs to subset of RNAs and associations of this subset of RNAs with amino-acids (assuming that genetic code has evolved from RNA $\rightarrow$ RNA code as suggested in this chapter).

As such this mechanism allows a rather limited number of different lock and key combinations unless r is very large. There is however a simple generalization allowing to increase the representative power so that lock and key mechanism becomes analogous to a password used in computers. The molecule playing the role of lock *resp.* molecule would be characterized by a set of n fractional particles with $k_1 \in \{k_{1,1}, ...k_{1,n}\}$ *resp.* $k_2 \in \{k_{2,1} = r - k_{1,1}, ..., k_{2,n} = r - k_{1,n}\}$. The molecules with conjugate names would fit optimally together. Fractional molecules or fractional electrons or atoms appearing as their building blocks would be like letters of a text characterizing the name of the molecule.

The mechanism generalizes also to the case of $n > 2$ reacting molecules. The molecular complex would be defined by a partition of n copies of integer r to a sum of m integers $k_{k,i}$: $\sum_i k_{k,i} = r$.

This mechanism could provide a universal explanation for the miraculous selectivity of catalysts and this selectivity would have practically nothing to do with ordinary chemistry but would correspond to a new level of physics at which symbolic processes and representations based on dark fractional particles emerge.

Connection with the number theoretic model of genetic code?

The emergence of partitions of integers in the labelling of molecules by fractional particles suggests a connection with the number theoretical model of genetic code [K74], where DNA triplets are characterized by integers $n \in \{0, ..., 63\}$ and amino-acids by integers $0, 1$ and 18 primes $p < 64$. For instance, one can imagine that the integer n means that DNA triplet is labelled by n/r-particle. $r = 64$ would be the obvious candidate for r and conjugate DNA triplet would naturally have $n_c = 64 - n$.

The model relies on number-theoretic thermodynamics for the partitions of n to a sum of integers and genetic code is fixed by the minimization of number theoretic entropy which can be also negative and has thus interpretation as information. Perhaps these partitions could correspond to states resulting in some kind of decays of n-fermion to n_k/r-fermions with $\sum_{k=1}^{r} n_k = n$. The n_k/r-fermions should however not correspond to separate particles but something different. A possible interpretation is that partition corresponds to a state in which n_1/r particle is topologically condensed at $n_2/r \geq n_1/r$ particle topologically condensed....at $n_k/r \geq n_{k-1}/r$-particle. This would also automatically define a preferred ordering of the integers n_i in the partition.

An entire ensemble of labels would be present and depending on the situation codon could be labelled not only by n/r-particle but by any partition $n = \sum_{i=1}^{k} n_i$ corresponding to the state resulting in the decay of n/r-particle to k fractional particles.

Reduction of DNA replication to a spontaneous decay of r-particle

DNA replication could be induced by a spontaneous decay of r-particle inducing the instability of the double strand leading to a spontaneous completion of the component strands.

Strand and conjugate strand would be characterized by k_1/r-particle and $(r-k_1)/r$-particle, which combine to form r-particle as the double strand is formed. The opening of the double strand is induced by the decay of r-particle to k_1/r- and $(r - k_1)/r$-particles accompanying strand and its conjugate and after this both strands would complete themselves to double strands by the completion to r-particle.

It would be basically the stability of fractional particle which would make DNA double strand stable. Usually the formation of hydrogen bonds between strands and more generally, between the atoms of stable bio-molecule, is believed to explain the stability. Since the notion of hydrogen bond is somewhat phenomenological, one cannot exclude the possibility that these two mechanisms might be closely related to each other. I have already earlier considered the possibility that hydrogen bond might involve dark protons [K80]: this hypothesis was inspired by the finding that there seems to exist two kinds of hydrogen bonds [D62].

The reader has probably already noticed that the participating fractional molecules in the model of lock and key mechanism are like sexual partners, and if already molecules are conscious entities as TGD inspired theory of consciousness strongly suggests, one might perhaps see the formation of entangled bound states with positive number theoretic entanglement entropy accompanied by molecular experience of one-ness as molecular sex. Even more, the replication of DNA brings in also divorce and process of finding of new companions!

7.3.3 The New View About Hydrogen Bond And Water

Concretization of the above scenario leads to a new view about hydrogen bond and the role of water in bio-catalysis.

What the fractional particles labelling bio-molecules could be?

What the dark fractional particles defining the letters for the names of various bio-molecules could be? Dark fractional hydrogen atoms are the lightest candidates for the names of bio-molecules. The fusion could give rise to the hydrogen atom appearing in hydrogen bond. One could say the fractional hydrogen atoms belong to the molecules between which the hydrogen bond is formed. In absence of bond the fractional atoms would define active catalyst sites. This mechanism would also conform with the belief that hydrogen bonds guarantee the stability of bio-molecules.

This idea is not a mere speculation. The first experimental support for the notion of dark matter [K80] came from the experimental finding that water looks in atto-second time scale from the point of view of neutron diffraction and electron scattering chemically like $H_{1.5}O$: as if one fourth of protons are dark [D64, D61, D72, D43]. Dark protons would be identifiable as fractional protons. Of course, also dark hydrogen atoms can be considered.

One can imagine also a second option. The model for [I3] [K19] leads to a rather concrete view about how magnetic body controls biological body and receives sensory input from it. The model relies on the idea that dark water molecule clusters and perhaps also dark exotically ionized super-nuclei formed as linear closed strings of dark protons [K80] perform this mimicry. Dark proton super-nuclei are ideal for mimicking the cyclotron frequencies of ordinary atoms condensed to dark magnetic flux quanta. Of course, also partially ionized hydrogen fractional ions could perform the cyclotron mimicry of molecules with the same accuracy.

One can consider the possibility fractional molecules/atoms correspond to exotic atoms formed by electrons bound to exotically ionized dark super-nuclei: the sizes of these nuclei are however above atomic size scale so that dark electrons would move in a harmonic oscillator potential rather than Coulombic potential and form states analogous to atomic nuclei. The prediction would be the existence of magic electron numbers [K80]. Amazingly, there is strong experimental evidence for the existence of this kind of many-electron states. Even more, these states are able to mimic the chemistry of ordinary atoms [D71, D38, D30]. The formation of hydrogen bonds between catalyst and substrate could be the correlate for the fusion of fractional hydrogen atoms.

If the fusion process gives rise 1/1-hydrogen, its spontaneous decay to ordinary hydrogen would liberate the difference of binding energies as metabolic energy helping to overcome the energy barrier for the reaction. The liberated energy would be rather large and correspond 3.4 eV UV photon even for $r = 2$ which suggests that it does not relate with standard metabolism. For larger values of r the liberated energy rapidly approaches to the ground state energy of hydrogen. Note that the binding energy of ordinary hydrogen atom in state $n = r$ has in the lowest order approximation same energy as the ground state of dark hydrogen atom for $\hbar/\hbar_0 = r$ so that one can consider the possibility of a resonant coupling of these states.

Fractional protons and electrons have effective charge $\pm ke/r$ so that the binding regions of catalysts and reacting molecules could carry effective fractional surface charge.

This might relate in an interesting manner to the problem of how poly-electrolytes can be stable (I am grateful for Dale Trenary for pointing me the problem and for interesting discussions). For instance, DNA carries a charge of -2 units per nucleotide due to the phosphate backbone. The models trying to explain the stability involve effective binding of counter ions to the polyelectrolyte so that the resulting system has a lower charge density. The simulations of DNA condensation by Stevens [I39] however predict that counter ion charge should satisfy $z > 2$ in the case of DNA. The problem is of course that protons with $z = 1$ are the natural counter ions. The positive surface charge defined by the fractional protons attached to the nucleotides of DNA strand could explain the stability.

The hydrogen atoms in hydrogen bonds as fractional hydrogen atoms and $H_{1.5}O$ formula for water

The simplest assumption is that the hydrogens associated with hydrogen bonds are actually associated with 1/1 type dark hydrogen atoms. This hypothesis has interesting implications and could explain the formula $H_{1.5}O$ for water in atto-second time scales suggested by neutron diffraction and electron scattering [D64, D61, D72, D43].

The formation of hydrogen bond would correspond to a fusion of name and conjugate name between $H_{k/r}$-O-H atom and its conjugate $H_{(r-k)/r}$-O-H atom. The resulting pairs would obey the chemical formula H_3-O_2. Hence the formation of hydrogen bonds would predict the $H_{1.5}O$ formula suggested by neutron diffraction and electron scattering in atto-second time scale. This holds true only if one has complete pairing by hydrogen bonds. A more plausible explanation is that just the presence of fractioanl hydrogens implies the effect. Furthermore, the fraction of dark protons can depend on temperature.

The roles of water and ordered water in catalysis

The new view about hydrogen bond allows to understand the role of water in biology at qualitative level. For instance, one can

1. tentatively identify "ordered water" as a phase in which all $H_{k/r}$ atoms and their conjugates have combined to $H_{1/1}$ atoms,
2. understand why (or perhaps it is better to say "predict that") water containing $H_{k/r}$ atoms acts as a catalytic poison so that the binding sites of catalysts and reactants must be isolated from water unless the water is ordered,
3. justify the belief that gel phase involving ordered water is necessary for biological information processing,
4. understand why hydration causes hydrolysis,
5. understand the instability of DNA against decay to RNA outside nucleus.

A more more detailed sketch looks like following.

1. Suppose that at least part of water molecules appear in form $H_{k/r}$-OH and $H_{(r-k)/r}$-O-H. These molecules and the molecule $H_{1/1}$-OH_2 formed in their fusion has much smaller binding energy than ordinary water molecule and is expected to be unstable against transition to H_3O. This would suggest that the feed of metabolic energy is needed to generate the dark hydrogen atoms.

   Fractional dark water molecules can join pairwise to form H-O-($H_{1/1}$)-O-H$\equiv$ H_3O_2 with $H_{1/1}$-atoms replacing hydrogen in hydrogen bond. Also $H_{k_1/r}$-O-$H_{k_2/r}$ molecules are possible and could form closed strings obeying the chemical formula $O_n(H_{1/1})_n$. Also open strings with H-O: s at ends are possible. This phase of water might allow identificaton as "ordered water" believed to be associated with gel phase and be crucial for quantal information processing inside cell. Liquid crystal phase of water could correspond to a bundle of open vertical segments H-$O_n(H_{1/1})_{n-2}$-H forming a 2-dimensional liquid (vertical freezing).

2. Exotic water molecules could spoil the action of both catalyst and reactant molecules by attaching to the "letters" in the name of catalyst or reactant so that the letters are not visible and catalyst and reactant cannot recognize each other anymore. Hence binding sites of catalyst and reactant must be isolated from water containing fractional water molecules. This is what Sidorova and Rau [I48] suggest on basis of comparison of specific and non-specific catalysts: non-specific catalysts contain water in an isolated binding volume whereas for specific catalysts this volume is empty. An alternative mechanism hindering water molecules to attach to "letters" is that water is "ordered water" with no fractional water molecules present.

3. DNA is known to be stable against decay to RNA via hydration inside the cell but not outside. Hydration could correspond to the joining of fractional water to sites of DNA transforming it to RNA. Inside nucleus this cannot occur if water is in ordered water phase permanently.

How the first self-replicators emerged?

The identification of the first self replicator can be seen as perhaps the most fascinating and challenging problem faced by the pre-biotic model builders. Self replicator is by definition an entity which catalyzes its own replication. The analogy with the self-referential statement appearing in Gödel's theorem obvious.

In TGD framework self replication would reduce to a spontaneous decay of $H_{1/1}$-atom to $H_{k/r}$- and $H_{(r-k)/r}$-atoms and their subsequent completion to $H_{1/1}$-atoms

The picture about emergence of self-replicators would be roughly following.

1. The first self-replicating entities would have been plasmoids [I36] generating $H_{1/1}$ atoms whose presence would have made possible the emergence of the first molecular self replicators. The generation of $H_{1/1}$ atoms requires metabolic energy feed. In the first approximation the decay of $H_{1,1}$ to fractional hydrogen atoms does not liberate nor require energy.

2. $H_{k/r}$ atoms would have replaced some ordinary H-atoms in some negatively charged molecules M_i (perhaps MXTP, $X = A, U, C, G$) leading to a spontaneous emergence of linear negatively charged polymers consisting of M_i. One can imagine a coding in which each X corresponds to fixed value of k or collection of the (2 hydrogen bonds or 3 hydrogen bonds depending on X). This would make the attachment of X and its conjugate to form a hydrogen bond a highly favored process.

3. $H_{k/r}$ atoms would have taken also the role of active binding sites. In ordered water conjugate molecules $M_{c,i}$ having $H_{(r-k)/r}$ atoms as labels would have had high probability to attach to the polymers made of M_i.

4. RNA molecules are good candidates for self-replicators in the presence of ordered water. The phase transition from ordinary to ordered water (which would have developed later to sol-gel phase transition) would have been an essential element of replication.

The role of water in chiral selection

In the latest New Scientist (when I am writing this) there was a news telling that chiral selection occurs in water but not in heavy water [C27]. The L form of amino-acid glutamate is more stable than R in ordinary but not so in heavy water so that water environment must be responsible for the chirality selection of bio-molecules. The proposed explanation for the finding, whose importance cannot be over-estimated, was following.

1. Water molecules have two forms: orto- and para, depending on whether the nuclear spins of protons are parallel or opposite. Deuterium nuclei are spinless so that heavy water has only single form. In thermal equilibrium the fraction of orto water is 3/4 and para water 1/4.

2. Ortho-water is magnetic and if L form of amino-acid is slightly more magnetic than R, chirality selection can be understood as result of the magnetic interaction with water.

One can of course wonder how extremely short ranged weak interactions could produce strong enough effect on the magnetic moment. The situation is not made easier by the fact that magnetic interaction energies are inherently very weak and deep below the thermal threshold.

It is interesting to find whether these findings could be explained by and allow a more detailed formulation of the TGD based model for water based on the notion of fractional hydrogen atom, the new view about hydrogen bond, and the notion of dark protonic strings forming atomic sized super-nuclei carrying exotic weak charges.

1. Dark matter brings in long ranged exotic weak interactions which can produce large parity breaking effects in atomic and even longer length scales. The long ranged parity breaking weak interactions of the dark protonic super nuclei assignable to amino-acids and water could explain the chiral selection.

2. The magnetic interaction energy is scaled up by r, so that magnetic interactions could indeed play a key role. Ordinary classical magnetic fields are in TGD framework always accompanied by Z^0 magnetic fields. If amino-acids possess exotic em charge implying also exotic weak charge, one can understand the chiral breaking as being induced by the Z^0 magnetic interaction of aminocids with the dark magnetic fields generated by water molecules or their clusters possessing a net magnetic moment. In heavy water these fields would be absent so that the experimental findings could be understood.

3. The experimental evidence that water behaves as $H_{1.5}O$ in atto-second time scales means that 1/4: th of protons of water are effectively dark. The notion of fractional hydrogen atom leads to a model of hydrogen bond predicting correctly $H_{1.5}O$ formula and the dropping of 1/4: th of protons at larger possibly dark space-time sheets. The model also predicts that the mass of $H-O-H_r-O-H \equiv 2H_{1.5}O$ hydrogen bonded pairs is very near to the mass of 2 water molecules since there are $r \simeq m_p/m_e$ electrons involved. The paired molecules have three protons and non-vanishing net nuclear spin and thus generate a magnetic field and make hydrogen bonded water a magnetic system. The natural identification would be as dark magnetic field accompanied by Z^0 magnetic field responsible for the chiral selection.

   In the case of $D-O-D_r-O-D$ mass would be by about one proton mass m_p lower than mass of two D_2O molecules so that this D-bonded heavy water would look like $D_{1.25}O$ as far as masses are considered and $D_{1.5}O$ as far neutron diffraction and electron scattering are considered. In this case no magnetic field is generated since the nuclear spin of D vanishes and no chiral breaking results. This picture explains the experimental findings. The model is not equivalent with the proposal of the experimentalists.

4. The model predicts that the protons liberated in the formation of hydrogen bonds drop to larger space-time sheets but does not specify their fate. A strong constraint comes from the requirement that the dropped particles have exotic weak charges acting as sources of the geometrically unavoidable classical Z^0 magnetic field at dark space-time sheets causing the large parity breaking. This constraint is satisfied if the protons form super-nuclei (scaled up variants of nuclei) consisting of protonic strings connected by color bonds involving exotic quark and antiquark at its ends and some of these bonds are charged (of type $u\overline{d}$ or $d\overline{u}$: this could also generate the em charge needed to make the protonic string stable.

7.4 TGD Based Model For Qualia And Sensory Receptors

The identification of quantum number increments in quantum jump for a subsystem representing sub-self 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 [K66]. 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 [J21], and 160 Hz to cerebellar synchrony [J20]. 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 [K41] remain to be disentangled.

3. The understanding of the Negentropy Maximization Principle [K28] 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 (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) become basic aspects of conscious intelligence and are expected to be especially important for understanding the difference between speech and music.

4. One of the basic challenge has been to construct a quantitative model for cell membrane.

   (a) The first model was based on the assumption that long range weak forces however play a key role [K5]. 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 the 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. The essential element is that the energies of the Josephson photons are in visible range. This would explain bio-photons and even why the frequencies assignable to visual receptors. The problem is that Weinberg angle must be assumed to be much smaller in the near vacuum extremal phase than in standard model.

   (b) Second model is based on Gerald Pollack's findings about fourth phase of water and exclusion zones [L8]. These zones inspire a model for pre-biotic cells. The outcome is a modification of the simplest model of Josephson junction. Besides resting potential also the difference between cyclotron energies between the two sides of the membrane plays a key role. This model allows to understand what happens in metabolism in terms of a quantum model replacing the thermodynamical model for cell membrane with its quantal "square root" inspired by Zero Energy Ontology. The model allows also to understand bio-photons as decay products of dark photons.

   (c) The success of the latter model does not of course mean that the weak forces could not be important in cell membrane scale and the realistic model could be a hybrid of these two models. The inclusion of Z^0 contribution to the effective magnetic field could also to the fact that the endogenous magnetic field deduced from Blackman's experiments is $B_{end} = 2B_E/5$ rather than B_E (Earth's magnetic field).

7.4.1 A General Model Of Qualia And Sensory Receptor

The identification of sensory qualia in terms of quantum number increments and geometric qualia representing geometric and kinematic information in terms of moduli of CD, the assignment of sensory qualia with the membrane of sensory receptor, and capacitor model of qualia are basic ideas behind the model. The communication of sensory data to magnetic body using Josephson photons is also a key aspect of the model.

A general model of qualia

It is good to start by summarizing the general vision about sensory qualia and geometric qualia in TGD Universe.

1. The basic assumption is that sensory qualia correspond to increments of various quantum numbers in quantum jump. Standard model quantum numbers- color quantum numbers, electromagnetic charge and weak isospin, and spin are the most obvious candidates. Also cyclotron transitions changing the integer characterizing cyclotron state could corresponds to some kind of quale- perhaps "a feeling of existence". This could make sense for the qualia of the magnetic body.

2. Geometric qualia could correspond to the increments of zero modes characterizing the induced CP_2 Käjhler form of the partonic 2-surface and of the moduli characterizing the causal diamonds serving as geometric correlates of selves. This moduli space involves the position of CD and the relative position of tips as well as position in CP_2 and relative position of two CP_2 points assigned to the future and past boundaries of CD. There are good motivations for proposing that the relative positions are quantized. This gives as a special case the quantization of the scale of CD in powers of two. Position and orientation sense could would represent this kind of qualia. Also kinematical qualia like sensation of acceleration could correspond to geometric qualia in generalized 4-D sense. For instance, the sensation about motion could be coded by Lorentz boots of sub-CD representing mental image about the object.

3. One can in principle distinguish between qualia assignable to the biological body (sensory receptors in particular) and magnetic body. The basic question is whether sensory qualia can be assigned only with the sensory receptors or with sensory pathways or with both. Geometric qualia might be assignable to the magnetic body and could provide third person perspective as a geometric and kinematical map of the body and its state of motion represented using the moduli space assignable to causal diamonds (CD). This map could be provided also by the body in which case the magnetic body would only share various mental images. The simplest starting assumption consistent with neuro-science is that sensory qualia are assigned with the cell membrane of sensory receptor and perhaps also with the neurons receiving data from it carried by Josephson radiation coding for the qualia and possibly partially regenerating them if the receiving neuron has same value of membrane potential as the sensory receptor when active. Note that during nerve pulse also this values of membrane potential is achieved for some time.

Could some sensory qualia correspond to the sensory qualia of the magnetic body?

Concerning the understanding of a detailed model for how sensory qualia are generated, the basic guideline comes from the notion of magnetic body and the idea that sensory data are communicated to the magnetic body as Josephson radiation associated with the cell membrane. This leaves two options: either the primary a sensory qualia are generated at the level of sensory receptor and the resulting mental images negentropically entangle with the "feeling of existence" type mental images at the magnetic body or they can be also generated at the level of the magnetic body by Josephson radiation -possibly as cyclotron transitions. The following arguments are to-be-or-not-to-be questions about whether the primary qualia must reside at the level of sensory receptors.

1. Cyclotron transitions for various cyclotron condensates of bosonic ions or Cooper pairs of fermionic ions or elementary particles are assigned with the motor actions of the magnetic body and Josephson frequencies with the communication of the sensory data. Therefore it would not be natural to assign qualia with cyclotron transitions. One the other hand, in zero energy ontology motor action can be regarded formally as a time reversed sensory perception, which suggests that cyclotron transitions correlated with the "feeling of existence" at magnetic body entangled with the sensory mental images. They could also code for the pitch of sound as will be found but this quale is strictly speaking also a geometric quale in the 4-D framework.

2. If Josephson radiation induces cyclotron transitions, the energy of Josephson radiation must correspond to that of cyclotron transition. This means very strong additional constraint not easy to satisfy except during nerve pulse when frequencies varying from about 10^{14} Hz down to kHz range are emitted the system remains Josephson contact. Cyclotron frequencies are also rather low in general, which requires that the value of $\hbar$ must be large in order to have cyclotron energy above the thermal threshold. This would however conform with the very beautiful dual interpretation of Josephson photons in terms of bio-photons 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 counterparts of weak bosons are involved besides photons. This is quite a strong additional assumption and it will be found that the identification of sensory qualia in terms of quantum numbers of quark pair restricts them to the cell membrane. The coding of qualia by Josephson frequencies is however possible and makes it possible to regenerate them in nervous system. The successful model explaining the peak frequencies of photoreceptors in terms of ionic cyclotron frequencies supports this view and provides a realization for an old idea about spectroscopy of consciousness which I had already been ready to give up.

Capacitor model of sensory qualia

In capacitor model of sensory receptor the increments of quantum numbers are amplified as particles with given quantum numbers flow between the plates of capacitor like system and the second plate defines the sub-self responsible for the mental image. The generation of complementary qualia assignable to the two plates and bringing in mind complementary colors is predicted. The capacitor is at the verge of di-electric breakdown. The interior and exterior of the receptor cell are the most plausible candidates for the capacitor plates with lipid layers defining the analog of di-electric able to changes its properties. Josephson currents generating Josephson radiation could communicate the sensory percept to the magnetic body but would not generate genuine sensory qualia there (the pitch of sound would be interpreted as a geometric quale). The coding is possible if the basic qualia correspond in one-one manner to ionic Josephson currents. There are sensory receptors which themselves do not fire (this is the case for hair cells for hearing and tactile receptor cells) and in this case the neuron next to the receptor in the sensory pathway would take the role of the quantum critical system.

The notion of sensory capacitor can be generalized. In zero energy ontology the plates could be effectively replaced with positive and negative energy parts of zero energy state or with cyclotron Bose-Einstein condensates corresponding to two different energies. Plates could also correspond to a pair of space-time sheets labeled by different p-adic primes and the generation of quale would correspond in this case to a flow of particles between the space-time sheets or magnetic flux tubes connected by contacts defining Josephson junctions.

The TGD inspired model for photoreceptors [K41] relies crucially on the assumption that sensory neurons at least and probably all cell membranes correspond to nearly vacuum extremals with the value of Weinberg angle equal to $sin^2(\theta_W) = .0295$ and weak bosons having Compton length of order cell size and ordinary value of Planck constant. This also explains the large parity breaking effects in living matter. The almost vacuum extremal property conforms with the vision about cell membrane as a quantum critical system ideal for acting as a sensory receptor.

7.4.2 Detailed Model For The Qualia

The proposed vision about qualia requires a lot of new physics provided by TGD. What leads to a highly unique proposal is the intriguing coincidence of fundamental elementary particle time scales with basic time scales of biology and neuro science and the model of DNA as topological quantum computer [K66].

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 (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) beween 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 [C13]. 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 [J20]). 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 [K46]. 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 neutron.... If Josephson photons are able to regenerate the quale in second neuron this would make it possible to replicate the quale along entire sensory pathway. The problem is that Josephson radiation has polarization orthogonal to axons and must propagate along the axon whereas the flux tube connection must be orthogonal to axon. Hence the temporary flux tube connection is most naturally between receptor cells and would mean horizontal integration of receptor cells to a larger structure. A holistic process in directions parallel and orthogonal to the sensory pathway would be in question. Of course, the flux tube could be also curved and connect the receptor to the next neuron along the sensory pathway.

8. The specialization of the neuron to sensory receptor would require in the framework of positive energy ontology that -as far as qualia assignable to the electro-weak quantum numbers are considered - all DNA nucleotides are identical by the corresponds of nucleotides with quarks and antiquarks. This cannot be the case. In zero energy ontology and for wormhole flux tubes it is however enough to assume that the net electroweak quantum numbers for the quark antiquark pairs assignable to the DNA wormhole contact are same for all nucleotides. This condition is easy to satisfy. It must be however emphasized that there is no reason to require that all nucleotides involved generate same quale and at the level of neurons sensory maps assigning different qualia to different nucleotides and lipids allowing DNA to sensorily perceive the external world are possible.

The model should be consistent with the assignment of the fundamental bio-rhythms with the CDs of electron and quarks.

1. Quark color should be free in long enough scales and cellular length scales are required at least. The QCD in question should therefore 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.

7.4.3 Overall View About Qualia

This picture leads to the following overall view about qualia. There are two options depending on whether single quark-antiquark pair or two of them labels the qualia. In the following only the simpler option with single quark-antiquark pair is discussed.

1. All possible pairings of spin and electroweak isospin (or em charge) define 16 basic combinations if one assumes color singletness. If arbitrary color is allowed, there is a nine-fold increase of quantum numbers decomposable to color singlet and octet qualia and further into 3×15 qualia with vanishing increments of color quantum numbers and 6×16 qualia with non-vanishing increments of color quantum numbers. The qualia with vanishing increments for electroweak quantum numbers could correspond to visual colors. If electroweak quantum numbers of the quark-anti-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 qualiaandelectroweak 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.

7.4.4 About Detailed Identification Of The Qualia

One can make also guesses about detailed correspondence between qualia and quantum number increments.

1. Visual colors would correspond to the increments of only color quantum numbers. Each biologically important ion would correspond to its own color increment in one-one correspondence with the three pairs of color-charged gluons and these would correspond to blue-yellow, red-green, and black white [K41]. Black-white vision would mean a restriction to the $SU(2)$ subgroup of color group. The model for the cell membrane as a nearly vacuum extremal assigns the peak frequencies corresponding to fundamental colors with biologically important ions. Josephson radiation could induce artificially the same color qualia in other neurons and this might provide an manner to communicate the qualia to the brain where they could be re-experienced at neuronal level. Some organisms are able to perceive also the polarization of light. This requires receptors sensitive to polarization. The spin of quark pair would naturally code for polarization quale.

2. Also tastes and odours define qualia with “colors”. Certainly the increments of electroweak numbers are involved but since these qualia do not have any directional flavor, spin is probably not involved. This would give c 3×4 basic combinations are possible and can certainly explain the 5 or 6 basic tastes (counted as the number of different receptors). Whether there is a finite number of odours or not has been a subject of a continual debate and it might be that odours already correspond to a distribution of primary qualia for the receptor cell. That odours are coded by nerve pulse patterns for a group of neurons [J29] 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 sub-selves should be negentropically entangled in time direction. If not, the experience corresponds to a sequence of sound pulses with no well-defined pitch and responsible for the rhythmic aspects of music. Right brain sings-left brain talks metaphor would suggests that right and left brain have different kind of specializations already at the level of sensory receptors.

4. Somato-sensory system gives rise to tactile qualia like pain, touch, temperature, proprioception (body position). There are several kinds of receptors: nocireceptors, mechanoreceptors,

thermoreceptors, etc... Many of these qualia have also emotional coloring and it might be that the character of entanglement involved (negentropic/entropic defines the emotional color of the quale. If this is the case, one might consider a pure quale of touch as something analogous to hearing quale. One can argue that directionality is basic aspect of some of these qualia -say sense of touch- so that spin could be involved besides electroweak quantum numbers. The distribution of these qualia for the receptor neuron might distinguish between different tactile qualia.

7.4.5 Recent TGD based view about qualia

The TGD inspired theory of qualia [K16] has evolved gradually and the recent view differs from the above described picture in some aspects.

1. The original vision was that qualiaandother aspects of consciousness experience are determined by the change of quantum state in the reduction: the increments of quantum numbers would determine qualia. I had not yet realized that repeated state function reduction (Zeno effect) realized in ZEO is central for consciousness. The objection was that qualia change randomly from reduction to reduction.

2. Later I ended up with the vision that the rates for the changes of quantum numbers would determine qualia: this idea was realized in terms of sensory capacitor model in which qualia would correspond to kind of generalized di-electric breakdown feeding to subsystem responsible for quale quantum numbers characterizing the quale. The Occamistic objection is that the model brings in an additional element not present in quantum measurement theory.

3. The view that emerged while writing the critics of IIT of Tononi is that qualia correspond to the quantum numbers measured in the state function reduction. That in ZEO the qualia remain the same for the entire sequence of repeated state function reductions is not a problem since qualia are associated with sub-self (sub-CD), which can have lifetime of say about .1 seconds! Only the generalization of standard quantum measurement theory is needed to reduce the qualia to fundamental physics. This for instance supports the conjecture that visual colors correspond to QCD color quantum numbers. This makes sense in TGD framework predicting a scaled variants of QCD type physics even in cellular length scales.

   This view implies that the model of sensory receptor based on the generalization of di-electric breakdown [K28] is wrong as such since the rate for the transfer of the quantum numbers would not define the quale. A possible modification of the model simple: the analog of di-electric breakdown generates Bose-Einstein condensate and the quantum numbers for the BE condensate give rise to qualia assignable to sub-self.

7.5 Could Cell Membrane Correspond To Almost Vacuum Extremal?

The question whether cell membrane or even cell could correspond almost vacuum extremal of Kähler action (in some cases) was the question which led to the realization that the frequencies of peak sensitivity for photoreceptors correspond to the Josephson frequencies of biologically important ions if one accepts that the value of the Weinberg angle equals to $sin^2(\theta_W) = .0295$ instead of the value .23 in the normal phase, in which the classical electromagnetic field is proportional to the induced Kähler form of CP_2 in a good approximation. Another implication made possible by the large value of Planck constant is the identification of Josephson photons as the counterparts of bio-photons 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 [K41].

7.5.1 Cell Membrane As Almost Vacuum Extremal

Although the fundamental role of vacuum extremals for quantum criticality and life has been obvious from the beginning, it took a long time to realize how one could model living cell as this kind of system.

1. Classical electric fields are in a fundamental role in biochemistry and living biosystems are typically electrets containing regions of spontaneous electric polarization. Fröhlich [I33] proposed that oriented electric dipoles form macroscopic quantum systems with polarization density serving as a macroscopic order parameter. Several theories of consciousness share this hypothesis. Experimentally this hypothesis has not been verified.

2. TGD suggests much more profound role for the unique di-electric properties of the biosystems. The presence of strong electric dipole fields is a necessary prerequisite for cognition and life and could even force the emergence of life. Strong electric fields imply also the presence of the charged wormhole BE condensates: the surface density of the charged wormholes on the boundary is essentially equal to the normal component of the electric field so that wormholes are in some sense "square root" of the dipole condensate of Fröhlich! Wormholes make also possible pure vacuum polarization type dipole fields: in this case the magnitudes of the em field at the two space-time sheets involved are same whereas the directions of the fields are opposite. The splitting of wormhole contacts creates fermion pairs which might be interpreted as cognitive fermion pairs. Also microtubules carry strong longitudinal electric fields. This formulation emerged much before the identification of ordinary gauge bosons and their superpartners as wormhole contacts.

Cell membrane is the basic example about electret and one of the basic mysteries of cell biology is the resting potential of the living cell. Living cell membranes carry huge electric fields: something like 10^7 Volts per meter. For neuron resting potential corresponds to about.07 eV energy gained when unit charge travels through the membrane potential. In TGD framework it is not at all clear whether the presence of strong electromagnetic field necessitates the presence of strong Kähler field. The extremely strong electric field associated with the cell membrane is not easily understood in Maxwell's theory and almost vacuum extremal property could change the situation completely in TGD framework.

1. The configuration could be a small deformation of vacuum extremal so that the system would be highly critical as one indeed expects on basis of the general visiona about living matter as a quantum critical system. For vacuum extremals classical em and Z^0 fields would be proportional to each other. The second half of Maxwell's equations is not in general satisfied in TGD Universe and one cannot exclude the presence of vacuum charge densities in which case elementary particles as the sources of the field would not be necessarily. If one assumes that this is the case approximately, the presence of Z^0 charges creating the classical Z^0 fields is implied. Neutrinos are the most candidates for the carrier of Z^0 charge. Also nuclei could feed their weak gauge fluxes to almost non-vacuum extremals but not atomic electrons since this would lead to dramatic deviations from atomic physics. This would mean that weak bosons would be light in this phase and also Weinberg angle could have a non-standard value.

2. There are also space-time surfaces for CP_2 projection belongs to homologically non-trivial geodesic sphere. In this case classical Z^0 field can vanish [L1], [L1] 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 electroweak 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 [L1] , [L1]

$$\gamma = 3J - \frac{p}{2}Z^0 \quad , \quad Q_Z = I_L^3 - pQ_{em} \quad , \quad p = sin^2(\theta_W) \tag{7.5.1}$$

it follows that for the vacuum extremals the part of the classical electro-weak force proportional to the electromagnetic charge vanishes for $p = 0$ so that only the left-handed couplings to the weak gauge bosons remain. The absence of electroweak symmetry breaking and vanishing or at least smallness of p would make sense below the Compton length of dark weak bosons. If this picture makes sense it has also implications for astrophysics and cosmology since small deformations of vacuum extremals are assumed to define the interesting extremals. Dark matter hierarchy might explain the presence of unavoidable long ranged Z^0 fields as being due to dark matter with arbitrarily large values of Planck constant so that various elementary particle Compton lengths are very long.

6. The simplest option is that the dark matter -say quarks with Compton lengths of order cell size and Planck constant of order $10^7\hbar_0$ - are responsible for dark weak fields making almost vacuum extremal property possible. The condition that Josephson photons correspond to EEG frequencies implys $\hbar \sim 10^{13}\hbar_0$ and would mean the scaling of intermediate gauge boson Compton length to that corresponding to the size scale of a larger neuron. The quarks involved with with DNA as topological quantum computer model could be in question and membrane potential might be assignable to the magnetic flux tubes. The ordinary ionic

currents through cell membrane -having no coupling to classical Z^0 fields and not acting as its sourse- would be accompanied by compensating currents of dark fermions taking care that the almost vacuum extremal property is preserved. The outcome would be large parity breaking effects in cell scale from the left handed couplings of dark quarks and leptons to the classical Z^0 field. The flow of Na^+ ions during nerve pulse could take along same dark flux tube as the flow of dark quarks and leptons. This near vacuum extremal property might be fundamental property of living matter at dark space-time sheets at least.

Could nuclei and neutrinos couple to light variants of weak gauge fields in the critical phase?

One of the hard-to-kill ideas of quantum TGD inspired model of quantum biology is that neutrinos might have something do with hearing and cognition. This proposal looks however unrealistic in the recent vision. I would be more than happy to get rid of bio-neutrinos but the following intriguing finding does not allow me to have this luxury.

1. Assume that the endogenous magnetic field $B_{end} = .2$ Gauss is associated with a nearly vacuum extremal and therefore accompanied by $B_Z = 2B_{end}/p$. Assume for definiteness $m_\nu = .3$ eV and $p = sin^2(\theta_W) = .23$. The neutrino cyclotron frequency is given by the following expression

$$f_\nu = \frac{m_e}{m_\nu}\frac{1}{2sin^2(\theta_W)}f_e \quad .$$

   From $f_e \simeq .57\times$ MHz and $p = sin^2(\theta_W) = .23$ one obtains $E_\nu = 1.7\times 10^{-2}$ eV, which is roughly one third to the Josephson frequency of electron assignable to cell membrane. Could Josephson frequency of cell membrane excite neutrino cyclotron transitions?

2. The model for photoreceptors to be discussed below forces to conlude that the value of Weinberg angle in the phase near vacuum extremal must be $p = .0295$ if one wants to reproduces the peak energies of photoreceptors as Josephson frequencies of basic biological ions. This would predict $E_\nu = .41$ eV, which is rather near to the metabolic energy quantum. The non-relativistic formula however fails in this case and one must use the relativistic formula giving

$$E = \sqrt{g_Z Q_Z B_Z 2\pi} \simeq .48 \ \ eV$$

   giving the metabolic energy quantum. Does this mean that Z^0 cyclotron frequency for neutrino is related to the transfer of metabolic energy using Z^0 MEs in the phase near vacuum extremals.

3. Josephson frequency is proportional to $1/\hbar$, whereas neutrino cyclotron frequency does not depend on $\hbar$ at non-relativistic energies. For larger values of $\hbar$ the neutrino becomes relativistic so that the mass in the formula for cyclotron frequency must be replaced with energy. This gives

$$E = \sqrt{n}r^{1/2}\sqrt{g_Z Q_Z B_Z 2\pi} \simeq r^{1/2}\times .48 \ \ eV \ \ , \ \ r = \sqrt{\hbar/\hbar_0} \ \ .$$

   Here n refers to the cyclotron harmonic.

These observations raise the question whether the three frequencies with maximum response assignable to the three different types of receptors of visible light in retina could correspond to the three cyclotron frequencies assignable to the three neutrinos with different mass scales? The first objection is that the dependence on mass disappears completely at the relativistic limit. The second objection is that the required value value of Planck constant is rather small and far from being enough to have electroweak boson Compton length of order cell size. One can of course ask whether the electroweak gauge bosons are actually massless inside almost vacuum extremals. If fermions -including neutrino- receive their masses from p-adic thermodynamics then massless electroweak gauge bosons would be consistent with massive fermions. Vacuum extremals are indeed analogous to the unstable extrema of Higgs potential at which the Higgs vacuum expecation vanishes so that this interpretation might make sense.

Ionic Josephson frequencies defined by the resting potential for nearly vacuum extremals

If cell membrane corresponds to an almost vacuum extremal, the membrane potential potential is replaced with an effective 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 [J5] as Josephson frequencies for biologically important ions. Furthermore, most Josephson energies are in visible and UV range and the interpretation in terms of bio-photons is suggestive. If the value of Planck constant is large enough Josephson frequencies are in EEG frequency range so that bio-photons and EEG photons could be both related to Josephson photons with large $\hbar$.

1. One must assume that the interior of the cell corresponds to many fermion state -either a state filled with neutrinos up to Fermi energy or Bose-Einstein condensate of neutrino Cooper pairs creating a harmonic oscillator potential. The generalization of nuclear harmonic oscillator model so that it applies to multi-neutrino state looks natural.

2. For exact vacuum extremals elementary fermions couple only via left-handed isospin to the classical Z^0 field whereas the coupling to classical em field vanishes. Both K_+, Na_+, and Cl_- $A-Z=Z+1$ so that by p-n pairing inside nucleus they have the weak isospin of neuron (opposite to that of neutrino) whereas Ca_{++} nucleus has a vanishing weak isospin. This might relate to the very special role of Ca_{++} ions in biology. For instance, Ca_{++} defines an action potential lasting a time of order.1 seconds whereas Na_+ defines a pulse lasting for about 1 millisecond [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

$$
\begin{aligned}
(\frac{Z-N}{4}-pZ)Z^0+q_{em}\gamma &= Q_{eff}\gamma \ , \\
Q_{eff} &= -\frac{Z-N}{2p}+2Z+q_{em} \ .
\end{aligned}
\tag{7.5.2}
$$

Here γ denotes em gauge potential. For K^+, Cl^-, Na^+, Ca^{++} one has $Z=(19,17,11,20)$, $Z-N=(-1,-1,-1,0)$, and $q_{em}=(1,-1,1,2)$. **Table 7.1** 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. This is basically due to the large value of weak isospin for nuclei.

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7.5.2 Are Photoreceptors Nearly Vacuum Extremals?

In Hodgkin-Huxley model ionic currents are Ohmian currents. If one accepts the idea that the cell membrane acts as a Josephson junction, there are also non-dissipative oscillatory Josephson currents of ions present, which run also during flow equilibrium for the ionic parts of the currents. A more radical possibility is that 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.

$E(Ion)/eV$	$V = -40\ mV$	$V = -60\ mV$	$V = -70\ mV$
Na^+	1.01	1.51	1.76
Cl^-	1.40	2.11	2.46
K^+	1.64	2.47	2.88
Ca^{++}	1.68	2.52	2.94

Table 7.1: Values of the Josephson energy of cell membrane for some values of the membrane voltage for $p = .23$. The value $V = -40$ mV corresponds to the resting potential for photoreceptors and $V = -70$ mV to the resting state of a typical neuron.

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 [L21, J5]. 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 7.1** 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 [J5] 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 hyper-polarization to $V = .055$ V, which is quite reasonable value. The value of the Weinberg angle parameter can be fixed from the condition that other peak energies are reproduced optimally. The result of $p = .0295$.

The predictions of the model come as follows summarized also by the **Table 7.2**.

1. The resting potential for photoreceptors is $V = -40$ mV [J6]. In this case all Josephson energies are below the range of visible frequencies for $p = .23$. Also for maximal hyper-polarization Na^+ Josephson energy is below the visible range for this value of Weinberg angle.

2. For $V = -40$ mV and $p = .0295$ required by the model the energies of Cl^- and K^+ Josephson photons correspond to red light. 2 eV for Cl^- corresponds to a basic metabolic quantum. For Na^+ and Ca^{++} the wave length is below the visible range. Na^+ Josephson energy is below visible range. This conforms with the interpretation of Na^+ current as a counterpart for the sensation of darkness.

3. For $V = -55$ mV - the threshold for the nerve pulse generation- and for $p = .0295$ the Josephson energies of Na^+, Ca^{++}, and K^+ a correspond to the peak energies for cones sensitive to red, green, and blue respectively. Also Cl^- is in the blue region. Ca^{++} Josephson energy can be identified as the peak energy for rods. The increase of the hyper-polarization 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

Ion	Na^+	Cl^-	K^+	Ca^{++}
$E_J(.04\ \ mV, p = .23)/eV$	1.01	1.40	1.51	1.76
$E_J(.065\ \ V, p = .23)/eV$	1.64	2.29	2.69	2.73
$E_J(40\ \ mV, p = .0295)/eV$	1.60	2.00	2.23	1.68
$E_J(50\ \ mV, p = .0295)/eV$	2.00	2.49	2.79	2.10
$E_J(55\ \ mV, p = .0295)/eV$	2.20	2.74	3.07	2.31
$E_J(65\ \ mV, p = .0295)/eV$	2.60	3.25	3.64	2.73
$E_J(70\ \ mV, p = .0295)/eV$	2.80	3.50	3.92	2.94
$E_J(75\ \ mV, p = .0295)/eV$	3.00	3.75	4.20	3.15
$E_J(80\ \ mV, p = .0295)/eV$	3.20	4.00	4.48	3.36
$E_J(90\ \ mV, p = .0295)/eV$	3.60	4.50	5.04	3.78
$E_J(95\ \ mV, p = .0295)/eV$	3.80	4.75	5.32	3.99
Color	R	G	B	W
E_{max}	2.19	2.32	3.06	2.49
energy-interval/eV	1.77-2.48	1.97-2.76	2.48-3.10	

Table 7.2: 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 if one allows that ions - rather than their Cooper pairs - are charge carriers.

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 bio-photons (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 hyper-polarization is $V = -65$ mV [J6], 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.

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 hyper-polarization 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 **Table 7.1** 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 bio-photons. The bio-photons detected outside body could represent sensory leakage. An interesting question is whether the IR Josephson frequencies could make possible some kind of IR vision.

To sum up, the basic criticism against the model is that the value of Weinberg angle must be by a factor of 1/10 smaller than the standard model value, and at this moment it is difficult to say anything about its value for nearly vacuum extremals.

A possible cure could be that the voltage is not same for different ions. This is possible since at microscopic level the Josephson junctions correspond to transmembrane proteins acting as channels and pumps. The membrane potential through receptor protein is different for color receptors. For this option one would have the correspondences
$Na^+ \leftrightarrow$ 2.19 eV (R) and $eV = 86.8$ eV,
$Cl^- \leftrightarrow$ 2.32 eV (G) and $eV = 65.8$ eV,
$K^+ \leftrightarrow$ 2.49 eV (W) and $eV = 60.2$ eV,
$Ca^{++} \leftrightarrow$ 3.06 eV (B) and $eV = 67.3$ meV.
For Na^+ the value of the membrane potential is suspiciously large.

It is interesting to look what happens when the model is generalized so that Josephson energy includes the difference of cyclotron energies at the two sides of the cell membrane and Weinberg angle has its standard model value.

1. Consider first *near to vacuum extremals*. In the formula for cyclotron frequencies in the effective magnetic field the factor Z/A in the formula of is replaced with

$$\frac{\frac{N-Z}{2p} + 2Z + q_{em}}{A} \ ,$$

   which is not far from unity so that the cyclotron frequency would be near to that for proton for all ions. Also neutral atoms would experience classical and magnetic Z^0 fields. Cyclotron frequency would be almost particle independent so that cyclotron contribution gives an almost constant shift to the generalized Josephson energy. When the difference of cyclotron energies vanishes, the model reduces to that discussed above.

   The weak independence of the cyclotron frequency on particle properties does not conform with the idea that EEG bands correspond to bosonic ions or Cooper pairs of fermionic ions.

2. For *far from vacuum extremals* the proportionality of cyclotron energy to h_{eff} and B_{end} allows easy reproduction the energies for which photon absorption is maximal if one allows the cyclotron energies to differ at the two sides of the membrane for sensory receptors.

A remark about decade later: The model just discussed neglects the fact that superconductivity requires that Cooper pairs of fermionic ions are present unless one assumes that the nuclei are bosonic counterparts of fermionic nuclei with same chemical properties - TGD inspired nuclear physics indeed predicts this kind of exotic nuclei [L2]. For Cooper pairs of Na^+, Cl^-, and K^+, $p = .23$ and $E_J = .04$ eV assignable to visual receptors the Josephson energies are doubled being $2.02, 2.80, 3.02$ eV. These energies could correspond to peak energies for visible photons. The assumption of ionic Cooper pairs is rather attractive since it would allow to avoid two questionable assumptions.

For electron the Josephson energy would be scaled by a factor $-1 + 1/2p$ to $E_J = 1.0859 \times eV_{rest}$ for $p = .2397$. For neutrino the energy would be given by $E_J = -0.0859 \times V_{rest}$: for $p = 1/4$ it would vanish by the vanishing of vectorial part of Z^0 charge. For proton the energy would be $E_J = (3 - 1/2p)V_{rest} = .914 \times V_{rest}$ and for neutron $E_J = V_{rest}/2p = 2.086 \times V_{rest}$.

7.6 Pollack's Findings About Fourth Phase Of Water And The Model Of Cell

The discovery of negatively charged exclusion zone formed in water bounded by gel phase has led Pollack to propose the notion of gel like fourth phase of water. In this article this notion is discussed in TGD framework. The proposal is that the fourth phase corresponds to negatively charged regions - exclusion zones - with size up to 100-200 microns generated when energy is fed into the water - say as radiation, in particular solar radiation. The stoichiometry of the exclusion zone is $H_{1.5}O$ and can be understood if every fourth proton is dark proton residing at the flux tubes of the magnetic body assignable to the exclusion zone and outside it.

This leads to a model for prebiotic cell as exclusion zone. Dark protons are proposed to form dark nuclei whose states can be grouped to groups corresponding to DNA, RNA, amino-acids, and tRNA and for which vertebrate genetic code is realized in a natural manner. The voltage associated with the system defines the analog of membrane potential, and serves as a source of metabolic energy as in the case of ordinary metabolism. The energy is liberated in a reverse phase transition in which dark protons transform to ordinary ones. Dark proton strings serve as analogs of basic biopolymers and one can imagine analog of bio-catalysis with enzymes replaced with their dark analogs. The recent discovery that metabolic cycles emerge spontaneously in absence of cell support this view.

One can find a biographical sketch [I4] (`http://tinyurl.com/ycqtuchp`) giving a list of publications containing items related to the notions of exclusion zone and fourth phase of water discussed in the talk.

7.6.1 Pollack's Findings

I list below some basic experimental findings about fourth gel like phase of water made in the laboratory led by Gerald Pollack [L8].

1. In water bounded by a gel a layer of thickness up to 100-200 microns is formed. All impurities in this layer are taken outside the layer. This motivates the term "exclusion zone". The layer consists of layers of molecular thickness and in these layers the stoichiometry is $H_{1.5}O$. The layer is negatively charged. The outside region carries compensating positive charge. This kind of blobs are formed in living matter. Also in the splitting of water producing Brown's gas negatively charged regions are reported to emerge [H17, H2].

2. The process requires energy and irradiation by visible light or thermal radiation generates the layer. Even the radiation on skin can induce the phase transition. For instance, the blood flow in narrow surface veins requires metabolic energy and irradiation forces the blood to flow.

3. The layer can serve as a battery: Pollack talks about a form of free energy deriving basically from solar radiation. The particles in the layer are taken to the outside region, and this makes possible disinfection and separation of salt from sea water. One can even understand how clouds are formed and mysteries related to the surface tension of water as being due the presence of the layer formed by $H_{1.5}O$.

4. In the splitting of water producing Brown's gas [H17, H2] having a natural identification as Pollack's fourth phase of water the needed energy can come from several alternative sources: cavitation, electric field, etc...

7.6.2 Dark Nuclei And Pollack's Findings

While listening the lecture of Pollack I realized that a model for dark water in term of dark proton sequences is enough to explain the properties of the exotic water according to experiments done in the laboratory of Pollack. There is no need to assume sequences of half-dark water molecules containing one dark proton each.

Model for the formation of exclusion zones

The data about formation of exclusion zones allows to construct a more detailed model for what might happen in the formation of exclusion zones.

1. The dark proton sequences with dark proton having size of order atomic nucleus would reside at the flux tubes of dark magnetic field which is dipole like field in the first approximation and defines the magnetic body of the negatively charged water blob. This explains the charge separation if the flux tubes have length considerably longer than the size scale of the blob which is given by size of small cell. In the model inspired by Moray B. King's lectures charge separation is poorly understood.

2. An interesting question is whether the magnetic body is created by the electronic currents or whether it consists of flux tubes carrying monopole flux: in the latter case no currents would be needed. This is obviously purely TGD based possibility and due to the topology of CP_2.

3. This means that in the model inspired by the lectures of Moray B. King discussed above, one just replaces the sequences of partially dark water molecules with sequences of dark protons at the magnetic body of the $H1.5O$ blob. The model for the proto-variants of photosynthesis and metabolism remain as such. Also now genetic code would be realized [K19, L2].

4. The transfer of impurities from the exclusion zone could be interpreted as a transfer of them to the magnetic flux tubes outside the exclusion zone as dark matter.

These primitive forms of photosynthesis and metabolism form could be key parts of their higher level chemical variants. Photosynthesis by irradiation would induce a phase transition generating dark magnetic flux tubes (or transforming ordinary flux tubes to dark ones) and the dark proton sequences at them. Metabolism would mean burning of the resulting blobs of dark water to ordinary water leading to the loss of charge separation. This process would be analogous to the catabolism of organic polymers liberating energy. Also organic polymers in living matter carry their metabolic energy as dark proton sequences: the layer could also prevent their hydration. That these molecules are typically negatively charged would conform with the idea that dark protons at magnetic flux tubes carry the metabolic energy.

The liberation of energy would involve increase of the p-adic prime characterizing the flux tubes and reduction of Planck constant so that the thickness of the flux tubes remains the same but the intensity of the magnetic field is reduced. The cyclotron energy of dark protons is liberated in coherent fashion and in good approximation the frequencies of the radiation corresponds to multiplies of cyclotron frequency: this prediction is consistent with that in the original model for the findings of Blackman and others [J16].

The phase transition generating dark magnetic flux tubes containing dark proton sequences would be the fundamental step transforming inanimate matter to living matter and the fundamental purpose of metabolism would be to make this possible.

Minimal metabolic energy consumption and the value of membrane potential

This picture raises a question relating to the possible problems with physiological temperature.

1. The Josephson radiation generated by cell membrane has photon energies coming as multiples of ZeV, where V is membrane potential about.06 V and $Z = 2$ is the charge of electron Cooper pair. This gives $E = .12$ eV.

2. There is a danger that thermal radiation masks Josephson radiation. The energy for photons at the maximum of the energy density of blackbody radiation as function of frequency is given as the maximum of function $x^3/(e^x - 1)$, $x = E/T$ given by $e^{-x} + x/3 - 1 = 0$. The maximum is given approximately by $x = 3$ and thus $E_{max} \simeq 3T$ (in units $c = 1, k_B = 1$). At physiological temperature $T = 310$ K (37 C) this gives .1 eV, which is slightly below Josephson energy: living matter seems to have minimized the value of Josephson energy - presumably to minimize metabolic costs. Note however that for the thermal energy density as function of *wavelength* the maximum is at $E \simeq 5T$ corresponding to 1.55 eV which is larger than Josephson energy. The situation is clearly critical.

3. One can ask whether also a local reduction of temperature around cell membrane in the fourth phase of water is needed.

   "Electric expansion" of water giving rise to charge separation and presumably creating fourth phase of water is reported to occur [H17, H2].

   (b) Could the electric expansion/phase transition to dark phase be adiabatic involving therefore no heat transfer between the expanding water and environment? If so, it would transform some thermal energy of expanding water to work and reduce its temperature. The formula for the adiabatic expansion of ideal gas with f degrees of freedom for particle ($f = 3$ if there are no other than translational degrees of freedom) is $(T/T_0) = (V/V_0)^{-\gamma}$, $\gamma = (f + 2)/f$. This gives some idea about how large reduction of temperature might be involved. If p-adic scaling for water volume by a power of two takes place, the reduction of temperature can be quite large and it does not look realistic.

   (c) The electric expansion of water need not however involve the increase of Planck constant for water volume. Only the Planck constant for flux tubes must increase and would allow the formation of dark proton sequences and the generation of cyclotron Bose-Einstein condensates or their dark analog in which fermions (electrons in particular) effectively behave as bosons (the anti-symmetrization of wave function would occur in dark degrees of freedom corresponding to multi-sheeted covering formed in the process).

7.6.3 Fourth Phase Of Water And Pre-Biotic Life In TGD Universe

Metabolism and fourth phase of water

If the fourth phase of water defines pre-biotic life form then the phase transition generating fourth phase of water and its reversal are expected to be fundamental elements of the ordinary metabolism, which would have developed from the pre-biotic metabolism. The following arguments conforms with this expectation.

1. Cell interiors, in particular the interior of the inner mitochondrial membrane are negatively charged as the regions formed in Pollack's experiments. Furthermore, the citric acid cycle, (`http://tinyurl.com/y8ubjgnc`), which forms the basic element of both photosynthesis (`http://tinyurl.com/yauwzkho`) and cellular respiration `http://tinyurl.com/ybeefxmb`, involves electron transport chain (`http://tinyurl.com/yat3m4vk`) in which electron loses gradually its energy via production of NADP and proton at given step. Protons are pumped to the other side of the membrane and generates proton gradient serving as metabolic energy storage just like battery. The interpretation for the electron transport chain in terms of Pollack's experiment would be in terms of generation of dark protons at the other side of the membrane.

2. When ATP is generated from ADP three protons per ATP flow back along the channel formed by the ATP synthase molecule (`http://tinyurl.com/yd5ndcyk`) (perhaps Josephson junction) and rotate the shaft of a "motor" acting as a catalyst generating three ATP molecules per turn by phosphorylating ADP. The TGD based interpretation is that dark protons are transformed back to ordinary ones and possible negentropic entanglement is lost.

3. ATP is generated also in glycolysis (`http://tinyurl.com/ybzgdgve`), which is ten-step process occurring in cytosol so that membrane like structure need not be involved. Glycolysis involves also generation of two NADH molecules and protons. An open question (to me) is whether the protons are transferred through an endoplasmic reticulum or from a region of ordered water (fourth phase of water) to its exterior so that it would contribute to potential gradient and could go to magnetic flux tubes as dark proton. This would be natural since glycolysis is realized for nearly all organisms and electron transport chain is preceded by glycolysis and uses as input the output of glycolysis (two pyruvate molecules (`http://tinyurl.com/y8v7aq9s`)).

4. Biopolymers - including DNA and ATP - are typically negatively charged. They could thus be surrounded by fourth phase of water and neutralizing protons would reside at the magnetic bodies. This kind of picture would conform with the idea that the fourth phase (as also magnetic body) is fractal like. In phosphorylation the metabolic energy stored to a potential difference is transferred to shorter length scales (from cell membrane scale to molecular scale).

In glycolysis (`http://tinyurl.com/ybzgdgve`) the net reaction $C_6H_{12}O_6{+}6O_2 \rightarrow 6CO_2(g){+}6H_2O(l){+}heat$ takes place. The Gibbs free energy change is $\Delta G = -2880$ kJ per mole of $C_6H_{12}O_6$ and is negative so that the process takes place spontaneously. Single glucose molecule is theoretized to produce $N = 38$ ATP molecules in optimal situation but there are various energy losses involved and the actual value is estimated to be 29-30. From $Joule = 6.84 \times 10^{18}$ eV and $mol = 6.02 \times 10^{23}$ and for $N = 38$ one would obtain the energy yield.86 eV per single ATP. The nominal value that I have used.5 eV. This is roughly 5 to 8 times higher than $E = ZeV, Z = 2$, which varies in the range.1-.16 eV so that the metabolic energy gain cannot be solely due to the electrostatic energy which would actually give only a small contribution.

In the thermodynamical approach to metabolism the additional contribution would be due to the difference of the chemical potential μ for cell exterior and interior, which is added to the membrane potential as effective potential energy. The discrepancy is however rather large and this forces the question the feasibility of the model. This forces to reconsider the model of osmosis in the light of Pollack's findings.

Pollack's findings in relation to osmosis and model for cell membrane and EEG

Osmosis (`http://tinyurl.com/yc5dbtzv`) has remained to me poorly understood phenomenon. Osmosis means that solvent molecules move through a semipermeable membrane to another side of the membrane if the concentration of solute is higher at that side. Solute can be water or more general liquid, supercritical liquid, and even gas.

Osmosis is not diffusion: it can occur also towards a higher concentration of water. Water molecules are not attracted by solute molecules. A force is required and the Wikipedia explanation is that solute molecules approaching pores from outside experience repulsion and gain momentum which is transferred to the water molecules.

The findings of Pollack inspire the question whether the formation of exclusion zone could relate to osmosis and be understood in terms of the fourth phase of water using genuine quantal description.

In the thermodynamical model for ionic concentrations one adds to the membrane resting potential a contribution from the difference of chemical potentials μ_i at the two sides of the membrane. Chemical potentials for the ions parametrize the properties of the cell membrane reducing basically to the properties of the channels and pumps (free diffusion and membrane potential do not entirely determine the outcome).

If the transfer of ions - now protons - through cell membrane is quantal process and through Josephson junctions defined by transmembrane proteins, then the thermodynamical model can at best be a phenomenological parameterization of the situation. One should find the quantum counterpart of thermodynamical description, and here the identification of quantum TGD as square root of thermodynamics in Zero Energy Ontology (ZEO) suggests itself. In this approach thermodynamical distributions are replaced by probability amplitudes at single particle level such that their moduli squared give Boltzmann weights.

1. Simplest Josephson junction model for cell membrane

The first guess is that quantum description is achieved by a generalization of the Josephson junction model allowing different values of Planck constant at magnetic flux tubes carrying dark matter.

1. Josephson junctions correspond microscopically to transmembrane proteins defining channels and pumps. In rougher description entire cell membrane is described as Josephson junction.

2. The magnetic field strength at flux tube can differ at the opposite side of the membrane and even the values of h_{eff} could in principle be different. The earlier modelling attempts

suggest that $h_{eff}/h = n = 2^k A$, where A is the atomic weight of ion, is a starting assumption deserving testing. This would mean that each ion resides at its own flux tubes.

The phase transitions changing the value of h_{eff} could induce ionic flows through cell membrane, say that occurring during nerve pulse since the energy difference defining the ratio of square roots of Boltzmann weights at the two sides of the membrane would change. Also the change of the local value of the magnetic field could do the same.

Consider first the simplest model taking into account only membrane potential.

1. The simplest model for Josephson junction defined by the transmembrane protein is as a two state system (Ψ_1, Ψ_2) obeying Schrödinger equation.

$$i\hbar_1 \frac{\partial \Psi_1}{\partial t} = ZeV\Psi_1 + k_1\Psi_2 \ ,$$

$$i\hbar_2 \frac{\partial \Psi_2}{\partial t} = k_2\Psi_2 \ .$$

One can use the decomposition $\Psi_i = R_i exp(i\Phi(t)$ to express the equations in a more concrete form. The basic condition is that the total probability defined as sum of moduli squared equals to one: $R_1^2 + R_2^2 = 1$. This is guaranteed if the hermiticity condition $k_1/\hbar_1 = \overline{k_2}\hbar_2$ holds true. Equations reduce to those for an ordinary Josephson junction except that the frequency for the oscillating Josephson current is scaled down by $1/h_{eff}$.

2. One can solve for R_2 assuming $\Phi_1 = eVt/\hbar_{eff}$. This gives

$$R_2(t) = sin(\Phi_0) + \frac{k_1}{\hbar_1} sin(\frac{eVt}{\hbar_1}) \ .$$

R_2 oscillates around $sin(\Phi_0)$ and the concentration difference is coded by $\Phi 0$ taking the role of chemical potential as a phenomenological parameter.

3. The counterparts of Boltzmann weights would be apart from a phase factor square roots of ordinary Boltzmann weights defined by the exponent of Coulomb energy:

$$R = sin(\phi_0) = exp(\frac{ZeV(t)}{2T}) \ .$$

Temperature would appear as a parameter in single particle wave function and the interpretation would be that thermodynamical distribution is replaced by its square root in quantum theory. In ZEO density matrix is replaced by its hermitian square root multiplied by density matrix.

2. The counterpart of chemical potential in TGD description

This model is not as such physically realistic since the counterpart of chemical potential is lacking. The most straightforward generalization of the thermodynamical model is obtained by the addition of an ion dependent chemical potential term to the membrane potential: $ZeV \rightarrow ZeV + \mu_I$. This would however require a concrete physical interpretation.

1. The most obvious possibility is that also the chemical potential actually correspond to an interaction energy - most naturally the cyclotron energy $E_c = \hbar_{eff} ZeB_{end}/m$ of ion - in this case proton - at the magnetic flux tube. Cyclotron energy is proportional to h_{eff} and can be rather large as assumed in the model for the effects of ELF em fields on brain.

2. This model would predict the dependence of the effective chemical potential on the mass and charge of ion for a fixed value of on h_{eff} and B_{end}. The scales of ionic chemical potential and ion concentrations would also depend on value of h_{eff}.

3. The model would provide a different interpretation for the energy scale of bio-photons, which is in visible range rather than infrared as suggested by the value of membrane potential.

   The earlier proposal [K16] was that cell membrane can be in near vacuum extremal configuration in which classical Z^0 field contributes to the membrane potential and gives a large contribution for ions. The problematic aspect of the model was the necessity to assume Weinberg angle in this phase to have much smaller value than usually. This difficulty could be perhaps avoided by noticing that the membrane potentials can differ for color receptors so that the earlier assignment of specific ions to color receptors could make sense for ordinary value of Weingerg angle. Second problem is that for proton the Z^0 contribution is negligible in good approximation so that this model does not explain the high value of the metabolic energy currency.

4. The simplest model the communications to magnetic body rely on Josephson radiation whose fundamental frequency f_J is at resonance identical with the cyclotron frequency $f_c(MB)$ at particular part of the flux tube of the magnetic body: $(f_c(MB) = f_J$. $f_c(MB)$ corresponds to EEG frequency in the case of brain and biophotons are produced from dark EEG photons as ordinary photons in phase transition reducing $h_{eff} = n \times h$ to h.

   In the modified model the sum $f_c + f_{J,n}$ $(f_{J,n} = E_J/n \times h)$ of h_{eff}-independent cyclotron frequency and Josephson frequency proportional to $1/h_{eff}$ equals to cyclotron frequency $f_c(MB)$ at "personal" magnetic body varying slowly along the flux tube: $f_c + f_{J,n} = f_c(MB)$. If also the variation of f_J assignable to the action potential is included, the total variation of membrane potential gives rise to a frequency band with width roughly

$$\frac{\Delta f}{f} \simeq \frac{2f_{J,n}}{f_c + f_{J,n}} = \frac{2f_{J,1}}{nf_c + f_{J,1}} \quad .$$

   If dark photons correspond to biophotons the energy is of cyclotron photon is in visible and UV range one has $nf_c = E_{bio}$ and

$$\frac{\Delta f}{f} \simeq \frac{2ZeV}{E_{bio} + ZeV} \quad .$$

   The prediction is scale invariant and same for all ions and also electron unless E_{bio} depends on ion. For $eV = .05$ eV, $Z = 1$, and $E_{bio} = 2$ eV ($f \simeq 5 \times 10^{14}$ Hz) one has $\Delta f/f \sim .1$ giving 10 per cent width for EEG bands assumed in the simpler model.

If this vision is on the correct track, the fundamental description of osmosis would be in terms of a phase transition to the fourth phase of water involving generation of dark matter transferred to the magnetic flux tubes. For instance, the swelling of cell by an in-flow of water in presence of higher concentration inside cell could be interpreted as a phase transition extending exclusion zone as a process accompanied by a phase transition increasing the value of h_{eff} so that the lengths of the flux tube portions inside the cell increase and the size of the exclusion zone increases. In general case the phase transitions changing h_{eff} and B_{end} by power of two factor are possible. This description should bring magnetic body as part of bio-chemistry and allow understanding of both equilibriumion distributions, generation of nerve pulse, and basic metabolic processes leading to the generation of ATP.

One can also model sensory receptors and try to understand the maximal sensitivity of color receptors to specific wavelengths in this framework. The new degrees of freedom make this task easy if one is only interested in reproducing these frequencies. More difficult challenge is to understand the color receptors from the first principles. It is also possible to combine the new view with the assumption that sensory receptor cells are near to vacuum extremals. This would add a cyclotron contribution to the generalized Josephson frequency depending only weakly on particle and being non-vanishing also for em neutral particles.

Why would charge separation generate large h_{eff}?

The basic question is whether and how the separation of electron and proton charges generates large h_{eff}? A possible mechanism emerged from a model [K95] explaining anomalously large gravimagnetic effect claimed by Tajmar *et al* [E4, E5] to explain the well-established anomaly related to the mass of Cooper pairs in rotating super-conduction. The mass is too large by fraction of order 10^{-4} and the proposal is that gravimagnetism changes slightly the effective Thomson magnetic field associated with the rotating super-conductor leading to wrong value of Cooper pairs mass when only ordinary Thomson field is assumed to be present. The needed gravimagnetic field is however gigantic: 28 orders larger than that predicted by GRT. Gravimagnetic field is proportional h_{eff}^2 in TGD and if one uses h_{gr} for electron-Earth system one obtains correct order of magnitude.

Nottale's finding that planetary orbits seem to correspond to Bohr orbits in gravitational potential with gigantic value of gravitational Planck constant is the basic input leading to the model of gravimagnetic anomaly.

1. By Equivalence Principle h_{gr} has the general form $h_{gr} = GMm/v_0$, where M and m are the interacting masses and v_0 is a parameter with dimensions of velocity. For 4 inner planets one has $v_0/c \simeq 2^{-11}$.

2. The notion of h_{gr} generalizes to that for other interactions. For instance, in electromagnetic case the formation of strong em fields implying charge separation leads to systems in which $h_{em} = Z_1Z_2e^2/v_0$ is large. Pollack's exclusion zone and its complement define this kind of systems and is identified as prebiotic life form.

3. Since the natural expansion parameter of perturbative expansion is the $g^2/4\pi\hbar$, one can say that transition to dark matter phase make the situation perturbative. Mother Nature is theoretician friendly.

h_{em} might be large in the exclusion zones (EZ) appearing in the water bounded by gel and their variants could play central role in living matter.

1. EZ carries very large negative charge with positive charge outside the exclusion zone.

2. TGD interpretation is in terms of $H_{1.5}O$ phase of water formed when every 4: th proton is transferred to magnetic body as dark particle with large value of h_{eff}. The proposal is that primitive life form is in question.

3. The pair formed by EZ and its complement could have large value of $h_{eff} = h_{em} = Z^2e^2/v_0$.

4. The velocity parameter v_0 should correspond to some natural rotation velocity. What comes in mind is that complement refers to Earth and v_0 is the rotation velocity at the surface of Earth. The prediction for h_{eff} would be of order $h_{em}/h = 4\pi\alpha Z^2 \times .645 \times 10^6 \simeq 5.9 \times 10^4 Z^2$.

5. Cell membrane involves also large charge separation due to very strong electric field over the cell membrane. Also now dark phases with large h_{em} or h_{gr} could be formed.

I have proposed that metabolic machinery generates large h_{eff} phase somehow. $h_{eff} = h_{em}$ hypothesis allows to develop this hypothesis in more detail.

1. I have speculated earlier [K23] that the rotating shaft of a molecular motor associated with ATP synthase plays a key role in generating dark matter phase. What comes in mind is that charge separation takes place associating exclusion zone with the shaft and the rotational velocity v_0 of the shaft appears in the formula for h_{em}. Of course, some numerical constant not far from unity could be present. The electric field over the mitochondrial membrane generates charge separation. One can imagine several identifications for the product of charges. The charge Z associated with the complement would be naturally associated with single dark flux tube containing dark nucleon consisting of dark protons. For instance, the charge associated with the exclusion zone could be the charge of the electronic Cooper pair giving $h_{em} = 2e \times Z/v_0$.

2. The value of v_0/c is expected to be of order 10^{-14} from the angular rotation rate of ADP synthase about few hundred revolutions per second. The order of magnitude for h_{em} could be same as for h_{gr} associated with Earth-particle system.

$h_{eff}(ATPsynthase) = h_{gr}(2e, Earth)$ would make possible reconnection of electromagnetic flux tubes with gravimagnetic flux tubes [K39].

Which came first: metabolism or cell membrane?

One of the basic questions of biology is whether metabolism preceded basic biopolymers or vice versa. RNA world scenario assumes that RNA and perhaps also genetic code was first.

1. The above view suggests that both approaches are correct to some degree in TGD Universe. Both metabolism and genetic code realized in terms of dark proton sequences would have emerged simultaneously and bio-chemistry self-organized around them. Dark proton sequences defining analogs of amino-acid sequences could have defined analogs of protein catalysts and played a key role in the evolution of the metabolic pathways from the primitive pathways involving only the phase transition between ordinary water and fourth phase of water.

2. There is very interesting article (see `http://tinyurl.com/ycdhd4fd`) [?]eporting that complex metabolic pathways are generated spontaneously in laboratory environments mimicking hot thermal vents. Glycolysis and pentose phosphate pathway were detected. The proposal is that these pathways are catalyzed by metals rather than protein catalysts.

3. In standard biology these findings would mean that these metabolic pathways emerged before basic biopolymers and that genetic code is not needed to code for the metabolic pathways during this period. In TGD framework dark genetic code [K19, L2] would be there, and could code for the dark pathways. Dark proton strings in one-one correspondence with the amino-acid sequences could be responsible for catalysts appearing in the pathways. Only later these catalysts would have transformed to their chemical counterparts and might be accompanied by their dark templates. One cannot even exclude the possibility that the chemical realization of the DNA-amino-acid correspondence involves its dark analog in an essential manner.

7.6.4 Could Pollack effect make cell membrane a self-loading battery?

The so called Clarendon dry pile is 175 years old battery still working. The current is very weak (nano Ampere) but the working of the battery is claimed to be not well-understood. The TGD inspired model for cold fusion leads to the proposal that Pollack effect is part of electrolysis. This inspires the idea that Pollack effect and possibly also the associated cold fusion could make Clarendon dry pile a self-loading battery. Cell membrane can be regarded as the analog of self-loading battery, and in TGD framework also as a generalised Josephson junction. Hence one can ask whether also cell membrane could be seen as a self-loading battery utilizing Pollack's mechanism. This would also allow to understand why hyperpolarization stabilizes the membrane potential and why depolarization generates nerve pulse.

Clarendon pile: 175 years old battery still working

Elemer Rosinger had a Facebook link to an article telling about Clarendon dry pile, a very long-lived battery providing energy for an electric clock (see `http://tinyurl.com/zeut69y`, `http://tinyurl.com/jhrww2a`, and `http://tinyurl.com/gvbrhra`). This clock known also as Oxford bell has been ringing for 175 years now and the article suggests that the longevity of the battery is not really understood. The bell is not actually ringing so loud that human ear could hear it but one can see the motion of the small metal sphere between the oppositely charged electrodes of the battery in the video.

The function principle of the clock is simple. The gravitational field of earth is also present. When the sphere touches the negative electrode, it receives a bunch of electrons and gives the bunch away as it touches positive electrode so that a current consisting of these bunches is running between electrons. The average current during the oscillation period of 2 seconds is nanoampere so that nanocoulomb of charge is transferred during each period (Coulomb corresponds to a 6.242×10^{18} elementary charges (electrons)).

The dry pile was discovered by priest and physicist Giuseppe Zamboni at 1812 (see `http://tinyurl.com/jkvtj6f`). The pile consists of 2,000 pairs of pairs of discs of tin foil glued to paper impregnated with Zinc sulphate and coated on the other side with manganese dioxide: 2,000 thin batteries in series. The operation of battery gradually leads to the oxidation of Zinc and the loss of magnase dioxide but the process takes place very slowly. One might actually wonder whether it takes place too slowly so that some other source of energy than the electrostatic energy of the battery would be keep the clock running. Karpen pile is analogous battery discover by Vasily Karpen (see `http://tinyurl.com/jpzcs32`). It has now worked for 50 years.

Cold fusion is associated with electrolysis. Could the functioning of this mystery clock involve cold fusion taken seriously even by American Physical Society thanks to the work of the group of prof. Holmlid. Electrolytes have of course been "understood" for aeons. Ionization leads to charge separation and current flows in the resulting voltage. With a feeling of deep shame I must confess that I cannot understand how the ionization is possible in standard physics. This of course might be just my immense stupidity - every second year physics student would immediately tell that this is "trivial" - so trivial that he would not even bother to explain why. The electric field between the electrodes is immensely weak in the scale of molecules. How can it induce the ionisation? Could ordinary electrolytes involve new physics involving cold fusion liberating energy? These are the questions which pop up in my stupid mind. Stubborn as I am in my delusions, I have proposed what this new physics might be with inspiration coming from strange experimental findings of Gerald Pollack, cold fusion, and my own view about dark matter has phases of ordinary matter with non-standard value $h_{eff} = n \times h$ of Planck constant. Continuing with my weird delusions I dare ask: Could cold fusion provide the energy for the "miracle" battery?

What batteries are?

To understand what might be involved one must first learn some basic concepts. I am trying to do the same.

1. Battery (see `http://tinyurl.com/8xqsnab`) consistes of two distinct electrochemical cells (see `http://tinyurl.com/jq8ljmo`). Cell consists of electrode and electrolyte. The electrodes are called anode and catode. By definition electron current along external wire flows to catode and leaves anode.

2. There are also ionic currents flowing inside the battery. In absence of the ionic currents the electrodes of the battery lose their charge. In the loading the electrodes get their charges. In the ideal situation the ionic current is same as electron current and the battery does not lose its charging. Chemical reactions are however taking place near and at the electrodes and in their reversals take place during charging. Chemical changes are not completely reversible so that the lifetime of the battery is finite.

   The ionic current can be rather complex: the carriers of the positive charge from anode can even change during the charge transfer: what matters that negative charge from catode is transferred to anode in some manner and this charge logistics can involve several steps. Near the catode the currents of positive ions (cations) and electrons from the anode combine to form neutral molecules. The negative current carriers from catode to the anode are called anions.

3. The charge of the clectrochemical cell is in the electrolyte near the surface of the electrode rather than inside it as one might first think and the chemical processes involve neutralization of ion and the transfer of neutral outcome to or from the electrode.

4. Catode - or better, the electrochemical cell containing the catode - can have both signs of charge. For positive charge one has a battery liberating energy as the electron current connecting the negative and positive poles goes through the load, such as LED. For negative charge current flows only if there is external energy feed: this is loading of the battery. External voltage source and thus energy is needed to drive the negative charges and positive charges to the electrodes. The chemical reactions involved can be rather complex and proceed in reverse direction during the loading process. Travel phone battery is a familiar example.

   During charging the roles of the anode and catode are changed: understanding this helps considerably.

Could dark cold fusion make possible self-loading batteries?

Could cold fusion help to understand why the Clarendon dry pile is so long lived?

1. The battery is series of very many simpler batteries. The mechanism should reduce to the level of single building brick. This is assumed in the following.

2. The charge of the battery tends to be reduced unless the ionic and electronic currents are identical. Also chemical changes occur. The mechanism involved should oppose the reduction of the charging by creating positive charge to the catode and negative charge to the anode or induce additional voltage between the electrodes of the battery inducing its loading. The energy feed involved might also change the direction of the basic chemical reactions as in the ordinary loading by raising the temperature at catode or anode.

3. Could be formation of Pollack's exclusion zones (EZs) in the elecrolytic cell containing the anode help to achieve this? EZs carry a high electronic charge. According to TGD based model protons are transformed to dark protons at magnetic flux tubes. If the positive dark charge at the flux tubes is transferred to the electrolytic cell containing catode and transformed to ordinary charge, it would increase the positive charge of the catode. The effect would be analogous to the loading of battery. The energy liberated in the process would compensate for the loss of charge energy due to electronic and ionic currents.

4. In the ordinary loading of the battery the voltage between batteries induces the reversal of the chemical processes occurring in the battery. This is due to the external energy feed. Could the energy feed from dark cold fusion induce similar effects now? For instance, could the energy liberated at the catode as positively charged dark nuclei transform to ordinary ones raise the temperature and in this manner feed the energy needed to change the direction of the chemical reactions.

Cell membrane as self-loading battery and how nerve pulse is generated?

This model might have an interesting application to the physics of cell membrane.

1. Cell membrane consisting of two lipid layers defines the analog of a battery. Cell interior plus inner lipid layer (anode) and cell exterior plus outer lipid layer (catode) are analogs of electrolyte cells.

   What has been troubling me for two decades is how this battery manages to load itself. Metabolic energy is certainly needed and ADP-ATP mechanism is essential element. I do not however understand how the membrane manages to keep its voltage.

   Second mystery is why it is hyperpolarization rather than polarization, which tends to stabilize the membrane potential in the sense that the probability for the spontaneous generation of nerve pulse is reduced. Neither do I understand why depolarization (reduction of the membrane voltage) leads to a generation of nerve pulse involving rapid change of the sign of the membrane voltage and the flow of various ionic currents between the interior and exterior of the cell.

2. In the TGD inspired model for nerve pulse cell interior and cell exterior or at least their regions near to lipid layers are regarded as super-conductors forming a generalized Josephson junction. For the ordinary Josephson junction the Coulombic energy due to the membrane voltage defines Josephson energy. Now Josephson energy is replaced by the ordinary Josephson energy plus the difference of cyclotron energies of the ion at the two sides of the membrane. Also ordinary Josephson radiation can be generated. The Josephson currents are assumed to run along magnetic flux tubes connecting cell interior and exterior. This assumption receives support from the strange finding that the small quantal currents associated with the membrane remain essentially the same when the membrane is replaced with polymer membrane.

3. The model for Clarendon dry pile suggests an explanation for the self-loading ability. The electrolytic cell containing the anode corresponds to the negatively charged cell interior,

where Pollack's EZs would be generated spontaneously and the feed of protonic charge to the outside of the membrane would be along flux tubes as dark protons to minimize dissipation. Also ions would flow along them. The dark protons driven to the outside of the membrane transform to ordinary ones or remain dark and flow spontaneously back and provide the energy needed to add phosphate to ADP to get ATP.

4. The system could be quantum critical in the sense that a small reduction of the membrane potential induces nerve pulse. Why the ability to generate Pollack's EZs in the interior would be lost for a few milliseconds during nerve pulse? The hint comes from the fact that Pollack's EZs can be generated by feeding infrared radiation to a water bounded by gel. Also the ordinary Josephson radiation generated by cell membrane Josephson junction has energy in infrared range!

   Could the ordinary Josephson radiation generate EZs by inducing the ionization of almost ionized hydrogen bonded pairs of water molecules. The hydrogen bonded pairs must be very near to the ionization energy so that ordinary Josephson energy of about .06 eV assignable to the membrane voltage is enough to induce the ionization followed by the formation of $H_{3/2}O$. The resulting EZ would consist of layers with the effective stoichiometry $H_{3/2}O$.

   As the membrane voltage is reduced, Josephson energy would not be anymore enough to induce the ionization of hydrogen bonded pair of water molecules, EZs are not generated, and the battery voltage is rapidly reduced: nerve pulse is created. In the case of hyperpolarization the energy excees the energy needed for ionization and the situation becomes more stable.

5. This model could also allow to understand the effect of anesthetes [K58] [L10]. Anesthetes could basically induce hyperpolarization so that Josephson photons would continually generate Pollack's EZ:s and creating of dark particles at the magnetic flux tubes. This need not mean that consciousness is lost at the cell level. Only sensory and motor actions are prevented because nerve pulses are not possible. This prevents formation of sensory and motor mental images at our level of hierarchy.

   Meyer-Overton correlation states that the effectiveness of the anesthete correlates with its solubility to the lipid membrane. This is the case if the presence of anesthete in the membrane induces hyperpolarization so that the energies of the photons of Josephson radiation would be higher than needed for the generation of EZs accompanied by magnetic flux tubes along which ionic Josephson currents would flow between cell interior and exterior. For these quantal currents evidence exists [K41]. In the case of battery these dark ions would flow from the cell containing anode to that containing catode. For depolarization the energy of Josephson photons would be too low to allow the kicking off protons from hydrogen bonded pairs of water molecules so that EZs would not be created and self-loading would stop and nerve pulse would be generated.

7.7 Could Photosensitive Emulsions Make Dark Matter Visible?

The article "Possible detection of tachyon monopoles in photographic emulsions" by Keith Fredericks [H14] describes in detail (`http://tinyurl.com/ybjk94f9`) very interesting observations by him and also by many other researchers about strange tracks in photographic emulsions induced by various (probably) non-biological mechanisms and also by the exposure to human hands (touching by fingertips) as in the experiments of Fredericks. That the photographic emulsion itself consists of organic matter (say gelatin) might be of significance.

7.7.1 The Findings

The tracks have width between 5 μm-110 μm (horizontal) and 5 μm-460 μm (vertical). Even tracks of length up to at least 6.9 cm have been found. Tracks begin at some point and end abruptly. A given track can have both random and almost linear portions, regular periodic structures (figs 11 and 12), tracks can appear in swarms (**Fig.** 24), bundles (**Fig.** 25), and correlated pairs (**Fig.**

16), tracks can also split and recombine (**Fig.** 32) (here and below "**Fig.**" refers to a figure of the article at `http://tinyurl.com/ybjk94f9`).

Tracks differ from tracks of known particles: the constant width of track implies that electrons are not in question. No delta rays (fast electrons caused by secondary ionization appearing as branches in the track) characteristic for ions are present. Unlike alpha particle tracks the tracks are not straight. In magnetic fields tracks have parabolic portions whereas ordinary charged particle move along spiral. The magnetic field needed to cause spiral structure for baryons should be by two orders of magnitude higher than in the experiments.

For particle physicist all these features - for instance constant width - strongly suggest pre-existing structures becoming visible for some reason. The pre-existing structure could of course correspond to something completely standard structures present in the emulsion. If one is ready to accept that biology involves new physics, it could be something more interesting.

Also evidence for cold fusion is reported by the group of Urutskoev [H9]. There is evidence for cold fusion in living matter [C7, C33]: the fact that the emulsion contains gelatin might relate to this. In [L2] a dark matter based mechanism of cold fusion allowing protons to overcome the Coulomb wall is discussed. Either dark protons or dark nuclei with much larger quantum size than usually would make this possible and protons could end up to the dark nuclei along dark flux tubes. In TGD inspired biology dark protons (large h_{eff}) with scaled up Compton length of order atomic size are proposed to play key role since their states allow interpretation in terms of vertebrate genetic code [L2, K71].

7.7.2 The Importance Of Belief System

These structures could be something quite standard or not. This readiness to consider non-standard explanations depends on belief system.

1. In the belief system of standard physics these pre-existing structures would be organic material consisting of ordinary matter so that no new physics is involved. Probably it is easy to kill this hypothesis. If this can be done, the situation becomes really interesting.

2. In my own belief system they *could* correspond to dark matter structures made visible by some mechanism. The presence of human hands could induce this phenomenon in the experiments of Fredericks. If so we might be already considering remote interactions involving dark photons and magnetic flux tubes, whose images "tracks" would be.

3. The first guess is that these structures are in the emulsion. This need not be the case! They could be structures outside- say in human hands - sending dark photon beam absorbed by the small photosensitive crystals in the emulsion. A photograph of dark matter (say in the hands of sender) would be formed! One possibility is that tracks represent a photograph of the dark matter at the flux tubes of the magnetic body of the emulsion. This would be a variant for what Gariaev perhaps managed to achieve with camera: taking a photo of dark matter [K1] !

4. Unfortunately belief system becomes important also in second manner. The reductionistic belief system tells that the tracks must be something trivial. There cannot be new physics in scale of cell as we have read in text books. Therefore these tracks are not studied by professionals who could very easily find whether there is something really interesting involved.

Dark matter in TGD based belief system corresponds to a hierarchy of phases of ordinary matter with an effective value h_{eff} of Planck constant coming as integer multiple of ordinary Planck constant. This makes possible macroscopic quantum phases consisting of dark matter. The flux tubes could carry magnetic monopole flux but the magnetic charge would be topological (made possible by the non-trivial second homology of CP_2 factor of the 8-D embedding space containing space-times as surfaces) rather than Dirac type magnetic charge.

The TGD inspired identification of tracks could be as images of magnetic flux tubes or bundles of them containing dark matter defining one of the basic new physics elements in TGD based quantum biology. One can imagine two options for the identification of the tracks as "tracks".

1. The primary structures are in the photo-sensive emulsion.

2. The structures in photograph are photographs of dark matter in external world, say structures in human hands or human body or of dark matter at some magnetic body, say at the flux tubes of the magnetic body of the emulsion.

The fact that the tracks have been observed in experimental arrangements not involving exposure to human hands, indeed suggests that tracks represent photographs about parts of the magnetic body assignable to the emulsion. For this option the external source would serve only as the source of possibly dark photons.

This would imply a close analogy with the experiments of Peter Gariaev's group interpreted in TGD framework as photographing of the magnetic body of DNA sample [K1]. Also here one has an external source of light: the light would be transformed to dark photons in DNA sample, scatter from the dark charged particles at the flux tubes of the magnetic body of DNA sample, and return back transforming to ordinary light and generating the image in the photosensitive emulsion.

7.7.3 Why Not Tachyonic Monopoles?

The identification of the tracks as orbits of particles proposed by author and also by other experimentalists is to my opinion problematic for the reasons which I have already explained. The article of Fredericks lists further details which do not conform with the particle interpretation. A further proposal is that the particles are tachyonic magnetic monopoles. One motivation for the monopole hypothesis is the (unsuccessful) attempt to explain the parabolic shape of the tracks in external magnetic field.

To my view the interpretation as a tachyonic monopole - a notion introduced by Recami and Mignani [H20] (`http://tinyurl.com/yajz68tt`) - adopted in the article is theoretically problematic. Of course, if the tracks are actually pre-existing structures made visible by some mechanism, there is no need to postulate super-luminal propagation. To see the problem, one can start from a general formula relating energy, momentum and mass. One has

$$E^2 = p^2 + m^2 \quad . \tag{7.7.1}$$

When m is imaginary as for tachyon so that one can write $m = iM$, one obtains

$$E^2 = p^2 - M^2 \quad . \tag{7.7.2}$$

If E and p are assumed to be real as is done usually the condition $E \geq 0$ and more generally the reality of E gives $p \geq M$. Tachyon cannot therefore be at rest and one cannot assign to it kinetic energy since tachyon at rest would have imaginary energy.

This has two implications.

1. The identification as tachyon and the conclusion $p \ll M$ from experiments (see figure 34 for the relation between E, p and m in various cases) is not consistent with $p \geq M$.

2. Recami and Mignani assign a kinetic energy to tachyon (formula 14). Unfortunately, this formula does not make sense if one accepts that E and p are real since one cannot assign to tachyon kinetic energy: the analogy of kinetic energy would be "kinetic momentum" defined as the difference of the actual momentum and minimal momentum $p = M$ ($p_{kin} = \sqrt{E^2 + M^2} - M \simeq E - M - M^2/2E$). As Fredericks notices, the behavior is not actually consistent with a motion of magnetic monopole in magnetic field. Parabolic orbits are in plane orthogonal to magnetic field rather than containing its direction vector (`http://tinyurl.com/ybjk94f9`)!

7.7.4 Interpretation As Dark Matter Structures Becoming Visible In Presence Of Living Matter

As such the observations are extremely interesting. I cannot however believe that the tracks represent particles. To my opinion tachyonic monopole interpretation fails because it does not make sense to talk about kinetic energy of tachyon.

To me the complex structures of tracks very strongly suggest pre-existing structures becoming visible for some reason. Looking the shape of tracks brings to my mind linear structure such as protein molecules. They contain regular helical portions and denatured portions. Now the longitudinal scale is of course much longer. The transversal scale is that for cells. This is perhaps not too surprising since organic materials such as gelatin are involved. The flux tubes could carry magnetic monopole fluxes and in purely formal sense would thus be analogous to magnetic monopoles with space-like momentum in their direction - that is tachyonic monopoles. They would be however actually ordinary systems with non-tachyonic momentum.

The particles possibly causing the tracks cannot be electrically charged since in this case they would not have managed to reach the emulsion. There seems however to be an interaction with magnetic fields since the tracks are parabola. Urutskoev *et al* [H9] propose that tracks are caused by magnetic monopoles. Unfortunately, the predicted parabolic orbit would be in the plane containing the magnetic field lines: the situation is completely analogous to the parabolic motion of projectile in the Earth's gravitational field.

"Tracks" as photographs of magnetic flux tubes?

Consider first the identification of "tracks" (for convenience I will drop the quotation marks in the sequel) as images of magnetic flux tubes.

1. The hypothesis that tracks are photographs of flux tubes explains the "track-ness". In the Earth's magnetic field the thickness of flux tubes is by flux quantization of the same order of magnitude as the thickness of thickest tracks observed for single flux quantum. Flux tube hypothesis seems to be also consistent with the other strange properties of the "tracks". In particular, the composition to random and smoothly curved portion would conform with the idea that also linear molecules are formed around templates defined by magnetic flux tubes.

2. The tracks have been observed to be created in several situations and it is not at all clear whether the exposure to hands in the experiments of Fredericks is absolutely necessary. TGD suggests that the analog of dielectric breakdown associated with nerve pulses (the electric field at cell membrane is two times higher than the electric field inducing di-electric breakdown in air) replaces the strong electric fields causing di-electric breakdown used in the experiments of Urutskoev [H9]. Dark magnetic flux tubes can accompany any kind of matter so that tracks could be also images about the dark magnetic body of an external object rather than that of emulsion. In principle, one cannot exclude the possibility that the presence of the experimenter is decisive in all cases. If so, this would be a new kind of experimenter effect.

3. To what could the abrupt ending of the track correspond in this picture? Magnetic flux tubes cannot end but they can go to another space-time sheet through wormhole contact and apparently disappear. This would indeed take place for the closed flux tubes representing elementary particles and carrying magnetic monopole flux. The flux tubes could quite generally carry a multiple of magnetic monopole flux. They would have rather large scale as compared to the CP_2 scale of 10^4 Planck lengths.

1. Explanation for parabolic portions of tracks

The presence of parabolic tracks in the plane orthogonal to the external static magnetic fields is very interesting feature to be explained. Parabolic character could be simply due to the simplest non-linear fit to the shape of the flux tube: it is however argued that parabolic character is exact. One should understand why the flux tube is orthogonal to the external magnetic field or magnetic field generated by the emulsion? Could this reflect the geometry of the experimental arrangement?

In TGD framework one can consider a very natural possibility that a constant electric field orthogonal to the external magnetic field is present.

1. In standard physics the presence of the electric field might be excluded easily. In TGD framework simplest space-time sheets representing constant Kähler magnetic fields allow a simple deformation to sheets containing orthogonal electric field. A simple situation (not

necessarily a preferred extremal of Kähler action) corresponds to a space-time sheet $X^4 \subset M^4 \times S^2$, S^2 a geodesic sphere of CP_2. Using spherical coordinates $(u = cos(\Theta), \Phi)$ for S^2 and Cartesian coordinates (t, z, x, y) for M^4, one has $(u = f(x), \Phi = \omega t + ky)$ $(c = 1)$. The non-vanishing components of magnetic and electric fields are apart from a coefficient of proportionality of order unity given by $E_x \equiv J_{0x} = \partial_x u \times \omega$ and $B^z \equiv J_{xy} = \partial_x u \times k$ with $E_x/B_z = \omega/k$. Electric and magnetic fields are orthogonal and the value of the ω/k ratio fixes the electric field strength in terms of the magnetic field strength. In fact, the mere assumption that the CP_2 projection is 2-dimensional implies that electric and magnetic parts of various induced gauge fields are orthogonal.

2. This field would be represented by a space-time sheet at which the flux tubes of the external magnetic are topologically condensed (glued by wormhole contacts). The charged particles inside the flux tube would experience the presence of this electric field as a constant force trying to force them out from the flux tube. If the flux tube adopts a parabolic shape of the orbit of individual charged particle, the electric force is parallel to the flux tube and one has equilibrium situation. *All* charged particles inside flux tube must move with the same velocity at given point of flux tube: this conforms with super-conductivity implying the existence of global order parameter. Note that the dark charged particles inside flux tube would not directly interact with the emulsion or with air so that they can reach the emulsion easily.

3. For non-relativistic motion the equation for the parabolic orbit is $y = x^2/L$, where the length $L = 2mv^2/qE$ characterizes the size scale of the parabola. Parametrizing E in terms of voltage and length L as $E = V_e/L$ one has $eV_c/mc^2 = 2(v/c)^2$. For electron rest energy $m_e c^2 = .5$ MeV and $v/c = 10^{-3}$ one would have $V_c = 1$ V. For proton the electric field would be by a factor 2^{11} stronger for the same orbit parameters.

   For a given electric field the parameters of the parabola allow to distinguish between flux tubes carrying different charged particles since the kinetic energies from the are expected to be different. I have indeed proposed that magnetic flux tubes could serve as a kind of filter allowing to distill ions with different masses at their own magnetic flux tubes: the equilibrium condition would make the flux tubes filters. The cyclotron energy scale $E_c = \hbar_{eff} ZeB/m$ would give a rough guess for the order of magnitude of kinetic energy of the particle: cyclotron energy scale is proportional to h_{eff} so that quite high energies can be considered. eV as a typical atomic energy scale and also as the energy scale of bio-photons (interpreted as decay products of dark photons [K61]) is the first guess for the energy scale.

4. It should be easy to check whether the emulsion is accompanied by electric field and also to deduce bounds for its values. Living matter is electret and one could imagine that gelatin contains some kind of remnants of bio-electric fields - perhaps as dark variants.

2. The decrease of the track thickness with the increase of distance

Urutskoev *et al* [H9] have reported the decrease of the track thickness with the increase of the source distance. Does this mean that the flux tubes photographed are near the source and the reduction of track thickness with distance is an optical effect similar to that for ordinary photographs?

If the flux tubes belong to the magnetic body of emulsion, this explanation fails. It is however easy to invent plausible explanation also in this case. based on a simple model for the quantization of the magnetic flux.

1. The reconnection for flux tubes of the source and emulsion can take place only for flux tubes with same magnetic field strength and by flux conservation same transversal area S. Note that conservation of magnetic flux implies $B \times S = constant$ so that increasing the thickness of flux tube decreases the strength of the magnetic field.

2. If the flux tubes have a fractal structure with flux tubes containing bundles of flux tubes (bundle structure has been observed for the tracks), one can argue that the weaker the magnetic field, the smaller the number of flux tubes in the typical bundle and the smaller

the radius of the bundle if the flux tubes inside bundle have constant density. For dipole field the weakening of the average field with distance could mean that flux tube bundles split to smaller bundles. A "temporary" splitting of at track to a bundle of widely separated tracks has been observed for tracks and would mean reduction of the average magnetic field strength.

3. If the number of grains corresponds to the number of flux tubes within a bundle, the number of flux tubes in the bundle would be thousands. The average size of the grain suggests a diameter of order .34 μ m for the flux tubes. If the magnetic length $L_B = \sqrt{h/eB}$ equals to $L_B = .17\ \mu$m (scaling rule: 1 Tesla corresponds to $L_B = 64$ nm), the magnetic field strength would be 354 Gauss (the Earth's magnetic field has nominal value of.5 Gauss). The external magnetic field of 20 Gauss used by Urutskoev *et al* defines a good candidate for the flux tube radius. For this field single flux tube would correspond to 18-19 crystals.

If this model is on correct track, these photographs could among other things provide means for the detailed study of the quantized dynamics of magnetic fields based on decomposition to flux tubes consisting of flux tubes consisting of...

What could be the source of dark photons?

Photographic emulsion would work as usually by detecting photons. What is clear that the photons must be dark when they scatter from the magnetic flux tubes of the magnetic body of the emulsion. There are however several options for how the dark photons are produced.

1. Ordinary photons from the source could hit the emulsion, transform to dark photons and propagate to the magnetic flux tubes, reflect back, transform to ordinary photons, and interact with the micro-crystals of the emulsion and generate the visible track as the image of the flux tube. Emulsion would take the role possessed by DNA sample in Gariaev's experiments and the external source would take the role of lamps used to generate visible light [K1].

2. Dark photons could also originate from the source. They could arrive along the flux tubes of its magnetic body. In the experimental situations considered these would reconnect with the flux tubes of the magnetic body of the emulsion and scatter from dark matter at them. After this the photons would propagate to the emulsion and transform to ordinary photons and give rise to the image. Reconnection of the flux tubes is the basic mechanism of attention in TGD inspired theory of consciousness and in TGD inspired biology, and also used to explain various findings of Persinger *et al* [K71].

3. The emission of dark photons is expected to take place in critical systems in which large values of effective Planck constant h_{eff} making possible long range correlations can be present. The situations studied (glow discharge plasma processes, exploding wires and foils, low energy discharges in water, super-compression of solid targets using electron beams) indeed seem to be critical. Only the search of monopoles of solar origin at the north pole represents a situation in which criticality is not present in obvious manner (the measurement method might involve criticality to guarantee maximal sensitivity). This kind of situations would generate time varying magnetic fields, whose flux tubes could reconnect with the magnetic flux tubes assignable to the photographic emulsion. This in turn would make possible for dark photons to propagate from source to the emulsion. In some experiments also static magnetic fields are present.

4. What is interesting that the "cold currents" reported already by Tesla in his experiments involving di-electric breakdowns at surfaces of wires of coils could correspond to dark currents propagating along the magnetic flux tubes [L4] [L4]. Most of these experiments correspond to critical situations making possible the manifestation of otherwise hidden new physics. Whether one can see these manifestations of course depends on whether one believes on the reductionistic Bible or not.

Chapter i

Appendix

A-1 Introduction

Originally this appendix was meant to be a purely technical summary of basic facts but in its recent form it tries to briefly summarize those basic visions about TGD which I dare to regarded stabilized. I have added illustrations making it easier to build mental images about what is involved and represented briefly the key arguments. This chapter is hoped to help the reader to get fast grasp about the concepts of TGD.

The basic properties of embedding space and related spaces are discussed and the relationship of CP_2 to the standard model is summarized. The basic vision is simple: the geometry of the embedding space $H = M^4 \times CP_2$ geometrizes standard model symmetries and quantum numbers. The assumption that space-time surfaces are basic objects, brings in dynamics as dynamics of 3-D surfaces based on the induced geometry. Second quantization of free spinor fields of H induces quantization at the level of H, which means a dramatic simplification.

The notions of induction of metric and spinor connection, and of spinor structure are discussed. Many-sheeted space-time and related notions such as topological field quantization and the relationship many-sheeted space-time to that of GRT space-time are discussed as well as the recent view about induced spinor fields and the emergence of fermionic strings. Also the relationship to string models is discussed briefly.

Various topics related to p-adic numbers are summarized with a brief definition of p-adic manifold and the idea about generalization of the number concept by gluing real and p-adic number fields to a larger book like structure analogous to adele [L18, L17]. In the recent view of quantum TGD [L46], both notions reduce to physics as number theory vision, which relies on $M^8 - H$ duality [L37, L38] and is complementary to the physics as geometry vision.

Zero energy ontology (ZEO) [L36] [K108] has become a central part of quantum TGD and leads to a TGD inspired theory of consciousness as a generalization of quantum measurement theory having quantum biology as an application. Also these aspects of TGD are briefly discussed.

A-2 Embedding space $M^4 \times CP_2$

Space-times are regarded as 4-surfaces in $H = M^4 \times CP_2$ the Cartesian product of empty Minkowski space - the space-time of special relativity - and compact 4-D space CP_2 with size scale of order 10^4 Planck lengths. One can say that embedding space is obtained by replacing each point m of empty Minkowski space with 4-D tiny CP_2. The space-time of general relativity is replaced by a 4-D surface in H which has very complex topology. The notion of many-sheeted space-time gives an idea about what is involved.

Fig. 1. Embedding space $H = M^4 \times CP_2$ as Cartesian product of Minkowski space M^4 and complex projective space CP_2. `http://tgdtheory.fi/appfigures/Hoo.jpg`

Denote by M^4_+ and M^4_- the future and past directed lightcones of M^4. Denote their intersection, which is not unique, by CD. In zero energy ontology (ZEO) [L36, L40] [K108] causal diamond

(CD) is defined as cartesian product $CD \times CP_2$. Often I use CD to refer just to $CD \times CP_2$ since CP_2 factor is relevant from the point of view of ZEO.

Fig. 2. Future and past light-cones M^4_+ and M^4_-. Causal diamonds (CD) are defined as their intersections. `http://tgdtheory.fi/appfigures/futurepast.jpg`

Fig. 3. Causal diamond (CD) is highly analogous to Penrose diagram but simpler. `http://tgdtheory.fi/appfigures/penrose.jpg`

A rather recent discovery was that CP_2 is the only compact 4-manifold with Euclidian signature of metric allowing twistor space with Kähler structure. M^4 is in turn is the only 4-D space with Minkowskian signature of metric allowing twistor space with Kähler structure [A13] so that $H = M^4 \times CP_2$ is twistorially unique.

One can loosely say that quantum states in a given sector of "world of classical worlds" (WCW) are superpositions of space-time surfaces inside CDs and that positive and negative energy parts of zero energy states are localized and past and future boundaries of CDs. CDs form a hierarchy. One can have CDs within CDs and CDs can also overlap. The size of CD is characterized by the proper time distance between its two tips. One can perform both translations and also Lorentz boosts of CD leaving either boundary invariant. Therefore one can assign to CDs a moduli space and speak about wave function in this moduli space.

In number theoretic approach it is natural to restrict the allowed Lorentz boosts to some discrete subgroup of Lorentz group and also the distances between the tips of CDs to multiples of CP_2 radius defined by the length of its geodesic. Therefore the moduli space of CDs discretizes. The quantization of cosmic recession velocities for which there are indications, could relate to this quantization.

A-2.1 Basic facts about CP_2

CP_2 as a four-manifold is very special. The following arguments demonstrate that it codes for the symmetries of standard models via its isometries and holonomies.

CP_2 as a manifold

CP_2, the complex projective space of two complex dimensions, is obtained by identifying the points of complex 3-space C^3 under the projective equivalence

$$(z^1, z^2, z^3) \equiv \lambda(z^1, z^2, z^3) \ . \tag{A-2.1}$$

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 homoeomorphic 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 [A9] will be used and their relation to the complex coordinates is given by

$$\begin{aligned} \xi^1 &= z + it \ , \\ \xi^2 &= x + iy \ . \end{aligned} \tag{A-2.2}$$

These are related to the "spherical coordinates" via the equations

$$\begin{aligned} \xi^1 &= rexp(i\frac{(\Psi + \Phi)}{2})cos(\frac{\Theta}{2}) \ , \\ \xi^2 &= rexp(i\frac{(\Psi - \Phi)}{2})sin(\frac{\Theta}{2}) \ . \end{aligned} \tag{A-2.3}$$

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 $b = 1$.

Fig. 4. CP_2 as manifold. `http://tgdtheory.fi/appfigures/cp2.jpg`

Metric and Kähler structure of CP_2

In order to obtain a natural metric for CP_2, observe that CP_2 can be thought of as a set of the orbits of the isometries $z^i \rightarrow exp(i\alpha)z^i$ on the sphere S^5: $\sum z^i\bar{z}^i = R^2$. The metric of CP_2 is obtained by projecting the metric of S^5 orthogonally to the orbits of the isometries. Therefore the distance between the points of CP_2 is that between the representative orbits on S^5.

The line element has the following form in the complex coordinates

$$ds^2 = g_{a\bar{b}}d\xi^a d\bar{\xi}^b \ , \tag{A-2.4}$$

where the Hermitian, in fact Kähler metric $g_{a\bar{b}}$ is defined by

$$g_{a\bar{b}} = R^2\partial_a\partial_{\bar{b}}K \ , \tag{A-2.5}$$

where the function K, Kähler function, is defined as

$$\begin{aligned} K &= log(F) \ , \\ F &= 1 + r^2 \ . \end{aligned} \tag{A-2.6}$$

The Kähler function for S^2 has the same form. It gives the S^2 metric $dzd\bar{z}/(1+r^2)^2$ related to its standard form in spherical coordinates by the coordinate transformation $(r, \phi) = (tan(\theta/2), \phi)$.

The representation of the CP_2 metric is deducible from S^5 metric is obtained by putting the angle coordinate of a geodesic sphere constant in it and is given

$$\frac{ds^2}{R^2} = \frac{(dr^2 + r^2\sigma_3^2)}{F^2} + \frac{r^2(\sigma_1^2 + \sigma_2^2)}{F} \ , \tag{A-2.7}$$

where the quantities σ_i are defined as

$$\begin{aligned} r^2\sigma_1 &= Im(\xi^1 d\xi^2 - \xi^2 d\xi^1) \ , \\ r^2\sigma_2 &= -Re(\xi^1 d\xi^2 - \xi^2 d\xi^1) \ , \\ r^2\sigma_3 &= -Im(\xi^1 d\bar{\xi}^1 + \xi^2 d\bar{\xi}^2) \ . \end{aligned} \tag{A-2.8}$$

R denotes the radius of the geodesic circle of CP_2. The vierbein forms, which satisfy the defining relation

$$s_{kl} = R^2\sum_A e_k^A e_l^A \ , \tag{A-2.9}$$

are given by

$$\begin{aligned} e^0 &= \tfrac{dr}{F} \ , & e^1 &= \tfrac{r\sigma_1}{\sqrt{F}} \ , \\ e^2 &= \tfrac{r\sigma_2}{\sqrt{F}} \ , & e^3 &= \tfrac{r\sigma_3}{F} \ . \end{aligned} \tag{A-2.10}$$

The explicit representations of vierbein vectors are given by

$$
\begin{array}{lllllll}
e^0 & = & \frac{dr}{F} \ , & e^1 & = & \frac{r(sin\Theta cos\Psi d\Phi+sin\Psi d\Theta)}{2\sqrt{F}} & , \\
e^2 & = & \frac{r(sin\Theta sin\Psi d\Phi-cos\Psi d\Theta)}{2\sqrt{F}} \ , & e^3 & = & \frac{r(d\Psi+cos\Theta d\Phi)}{2F} & .
\end{array}
\quad \text{(A-2.11)}
$$

The explicit representation of the line element is given by the expression

$$
ds^2/R^2 = \frac{dr^2}{F^2} + \frac{r^2}{4F^2}(d\Psi + cos\Theta d\Phi)^2 + \frac{r^2}{4F}(d\Theta^2 + sin^2\Theta d\Phi^2) \ . \quad \text{(A-2.12)}
$$

From this expression one finds that at coordinate infinity $r = \infty$ line element reduces to $\frac{r^2}{4F}(d\Theta^2 + sin^2\Theta d\Phi^2)$ of S^2 meaning that 3-sphere degenerates metrically to 2-sphere and one can say that CP_2 is obtained by adding to R^4 a 2-sphere at infinity.

The vierbein connection satisfying the defining relation

$$
de^A = -V^A_B \wedge e^B \ , \quad \text{(A-2.13)}
$$

is given by

$$
\begin{array}{llllll}
V_{01} & = & -\frac{e^1}{r} \ , & V_{23} & = & \frac{e^1}{r} \ , \\
V_{02} & = & -\frac{e^2}{r} \ , & V_{31} & = & \frac{e^2}{r} \ , \\
V_{03} & = & (r-\frac{1}{r})e^3 \ , & V_{12} & = & (2r+\frac{1}{r})e^3 \ .
\end{array}
\quad \text{(A-2.14)}
$$

The representation of the covariantly constant curvature tensor is given by

$$
\begin{array}{llllll}
R_{01} & = & e^0 \wedge e^1 - e^2 \wedge e^3 \ , & R_{23} & = & e^0 \wedge e^1 - e^2 \wedge e^3 \ , \\
R_{02} & = & e^0 \wedge e^2 - e^3 \wedge e^1 \ , & R_{31} & = & -e^0 \wedge e^2 + e^3 \wedge e^1 \ , \\
R_{03} & = & 4e^0 \wedge e^3 + 2e^1 \wedge e^2 \ , & R_{12} & = & 2e^0 \wedge e^3 + 4e^1 \wedge e^2 \ .
\end{array}
\quad \text{(A-2.15)}
$$

Metric defines a real, covariantly constant, and therefore closed 2-form J

$$
J = -is_{a\bar{b}} d\xi^a d\bar{\xi}^b \ , \quad \text{(A-2.16)}
$$

the so called Kähler form. Kähler form J defines in CP_2 a symplectic structure because it satisfies the condition

$$
J^k_{\ r} J^{rl} = -s^{kl} \ . \quad \text{(A-2.17)}
$$

The condition states that J and g give representations of real unit and imaginary units related by the formula $i^2 = -1$.

Kähler form is expressible locally in terms of Kähler gauge potential

$$
J = dB \ , \quad \text{(A-2.18)}
$$

where B is the so called Kähler potential, which is not defined globally since J describes homological magnetic monopole.

$dJ = ddB = 0$ gives the topological half of Maxwell equations (vanishing of magnetic charges and Faraday's induction law) and self-duality $*J = J$ reduces the remaining equations to $dJ = 0$. Hence the Kähler form 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).

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

$$\begin{aligned} B &= 2re^3 \ , \\ J &= 2(e^0\wedge e^3+e^1\wedge e^2) = \frac{r}{F^2}dr\wedge(d\Psi+cos\Theta d\Phi)+\frac{r^2}{2F}sin\Theta d\Theta\wedge d\Phi \ . \end{aligned} \tag{A-2.19}$$

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 (or symplectic or Darboux) coordinates in which the Kähler potential and Kähler form have very simple expressions

$$\begin{aligned} B &= \sum_{k=1,2} P_k dQ_k \ , \\ J &= \sum_{k=1,2} dP_k\wedge dQ_k \ . \end{aligned} \tag{A-2.20}$$

The relationship of the canonical coordinates to the "spherical" coordinates is given by the equations

$$\begin{aligned} P_1 &= -\frac{1}{1+r^2} \ , \\ P_2 &= -\frac{r^2cos\Theta}{2(1+r^2)} \ , \\ Q_1 &= \Psi \ , \\ Q_2 &= \Phi \ . \end{aligned} \tag{A-2.21}$$

Spinors In CP_2

CP_2 doesn't allow spinor structure in the conventional sense [A7]. However, the coupling of the spinors to a half odd multiple of the Kähler potential leads to a respectable spinor structure. Because the delicacies associated with the spinor structure of CP_2 play a fundamental role in TGD, the arguments of Hawking are repeated here.

To see how the space can fail to have an ordinary spinor structure consider the parallel transport of the vierbein in a simply connected space M. The parallel propagation around a closed curve with a base point x leads to a rotated vierbein at x: $e^A = R^A_Be^B$ and one can associate to each closed path an element of $SO(4)$.

Consider now a one-parameter family of closed curves $\gamma(v): v\in(0,1)$ with the same base point x and $\gamma(0)$ and $\gamma(1)$ trivial paths. Clearly these paths define a sphere S^2 in M and the element $R^A_B(v)$ defines a closed path in $SO(4)$. When the sphere S^2 is contractible to a point e.g., homologically trivial, the path in $SO(4)$ is also contractible to a point and therefore represents a trivial element of the homotopy group $\Pi_1(SO(4)) = Z_2$.

For a homologically nontrivial 2-surface S^2 the associated path in $SO(4)$ can be homotopically nontrivial and therefore corresponds to a nonclosed path in the covering group Spin(4) (leading from the matrix 1 to -1 in the matrix representation). Assume this is the case.

Assume now that the space allows spinor structure. Then one can parallel propagate also spinors and by the above construction associate a closed path of Spin(4) to the surface S^2. Now, however this path corresponds to a lift of the corresponding $SO(4)$ path and cannot be closed. Thus one ends up with a contradiction.

From the preceding argument it is clear that one could compensate the non-allowed -1-factor associated with the parallel transport of the spinor around the sphere S^2 by coupling it to a gauge potential in such a way that in the parallel transport the gauge potential introduces a compensating -1-factor. For a $U(1)$ gauge potential this factor is given by the exponential

$exp(i2\Phi)$, where Φ is the magnetic flux through the surface. This factor has the value -1 provided the $U(1)$ potential carries half odd multiple of Dirac charge $1/2g$. In case of CP_2 the required gauge potential is half odd multiple of the Kähler potential B defined previously. In the case of $M^4 \times CP_2$ one can in addition couple the spinor components with different chiralities independently to an odd multiple of $B/2$.

Geodesic sub-manifolds of CP_2

Geodesic sub-manifolds are defined as sub-manifolds having common geodesic lines with the embedding space. As a consequence the second fundamental form of the geodesic manifold vanishes, which means that the tangent vectors h^k_α (understood as vectors of H) are covariantly constant quantities with respect to the covariant derivative taking into account that the tangent vectors are vectors both with respect to H and X^4.

In [A17] 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

$$[X,[Y,Z]] \in t \ \text{ for } \ X,Y,Z \in t \ . \qquad \text{(A-2.22)}$$

$SU(3)$ allows, besides geodesic lines, two nonequivalent (not isometry related) geodesic spheres. This is understood by observing that $SU(3)$ allows two nonequivalent $SU(2)$ algebras corresponding to subgroups $SO(3)$ (orthogonal 3×3 matrices) and the usual isospin group $SU(2)$. By taking any subset of two generators from these algebras, one obtains a Lie triple system and by exponentiating this system, one obtains a 2-dimensional geodesic sub-manifold of CP_2.

Standard representatives for the geodesic spheres of CP_2 are given by the equations

$$S^2_I \ : \ \xi^1 = \bar{\xi}^2 \ \text{ or equivalently } \ (\Theta = \pi/2, \Psi = 0) \ ,$$

$$S^2_{II} \ : \ \xi^1 = \xi^2 \ \text{ or equivalently } \ (\Theta = \pi/2, \Phi = 0) \ .$$

The non-equivalence of these sub-manifolds is clear from the fact that isometries act as holomorphic transformations in CP_2. The vanishing of the second fundamental form is also easy to verify. The first geodesic manifold is homologically trivial: in fact, the induced Kähler form vanishes identically for S^2_I. S^2_{II} is homologically nontrivial and the flux of the Kähler form gives its homology equivalence class.

A-2.2 CP_2 geometry and Standard Model symmetries

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 [B12] 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

$$\begin{aligned} \Gamma\Psi &= e\Psi \ , \\ e &= \pm 1 \ , \end{aligned} \qquad \text{(A-2.23)}$$

where Γ denotes the matrix $\Gamma_9 = \gamma_5 \otimes \gamma_5$, $1 \otimes \gamma_5$ and $\gamma_5 \otimes 1$ 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: $SO(4)$ having as its covering group $SU(2)_L \times SU(2)_R$.

The covariant derivatives are defined by the spinorial connection

$$A = V + \frac{B}{2}(n_+ 1_+ + n_- 1_-) \ . \tag{A-2.24}$$

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

$$\begin{array}{llllll} V_{01} & = & -\frac{e^1}{r} \ , & V_{23} & = & \frac{e^1}{r} \ , \\ V_{02} & = & -\frac{e^2}{r} \ , & V_{31} & = & \frac{e^2}{r} \ , \\ V_{03} & = & (r - \frac{1}{r})e^3 \ , & V_{12} & = & (2r + \frac{1}{r})e^3 \ , \end{array} \tag{A-2.25}$$

and

$$B = 2re^3 \ , \tag{A-2.26}$$

respectively. The explicit representation of the vielbein is not needed here.

Let us first show that the charged part of the spinor connection couples purely left handedly. Identifying Σ_3^0 and Σ_2^1 as the diagonal (neutral) Lie-algebra generators of $SO(4)$, one finds that the charged part of the spinor connection is given by

$$A_{ch} = 2V_{23}I_L^1 + 2V_{13}I_L^2 \ , \tag{A-2.27}$$

where one have defined

$$\begin{aligned} I_L^1 &= \frac{(\Sigma_{01} - \Sigma_{23})}{2} \ , \\ I_L^2 &= \frac{(\Sigma_{02} - \Sigma_{13})}{2} \ . \end{aligned} \tag{A-2.28}$$

A_{ch} is clearly left handed so that one can perform the identification of the gauge potential as

$$W^\pm = \frac{2(e^1 \pm ie^2)}{r} \ , \tag{A-2.29}$$

where $W^\pm$ denotes the charged intermediate vector boson.

The covariantly constant curvature tensor is given by

$$\begin{array}{l} R_{01} = -R_{23} = e^0 \wedge e^1 - e^2 \wedge e^3 \ , \\ R_{02} = -R_{31} = e^0 \wedge e^2 - e^3 \wedge e^1 \ , \\ R_{03} = 4e^0 \wedge e^3 + 2e^1 \wedge e^2 \ , \\ R_{12} = 2e^0 \wedge e^3 + 4e^1 \wedge e^2 \ . \end{array} \tag{A-2.30}$$

The charged part of the curvature tensor is left handed.

This is to be compared with the Weyl tensor, which defines a representation of quaternionic imaginary units.

$$\begin{array}{l} W_{03} = W_{12} \equiv 2I_3 = 2(e^0 \wedge e^3 + e^1 \wedge e^2) \ , \\ W_{01} = W_{23} \equiv I_1 = -e^0 \wedge e^1 - e^2 \wedge e^3 \ , \\ W_{02} = W_{31} \equiv I_2 = -e^0 \wedge e^2 - e^3 \wedge e^1 \ . \end{array} \tag{A-2.31}$$

The charged part of the Weyl tensor is right-handed and that the relative sign of the two terms in the curvature tensor and Weyl tensor are opposite.

Consider next the identification of the neutral gauge bosons γ and Z^0 as appropriate linear combinations of the two functionally independent quantities

$$\begin{aligned} X &= re^3 \ , \\ Y &= \frac{e^3}{r} \ , \end{aligned} \tag{A-2.32}$$

appearing in the neutral part of the spinor connection. We show first that the mere requirement that photon couples vectorially implies the basic coupling structure of the GWS model leaving only the value of Weinberg angle undetermined.

To begin with let us define

$$\begin{aligned} \bar{\gamma} &= aX + bY \ , \\ \bar{Z}^0 &= cX + dY \ , \end{aligned} \tag{A-2.33}$$

where the normalization condition

$$ad - bc = 1 \ ,$$

is satisfied. The physical fields γ and Z^0 are related to $\bar{\gamma}$ and $\bar{Z}^0$ by simple normalization factors.

Expressing the neutral part of the spinor connection in term of these fields one obtains

$$\begin{aligned} A_{nc} &= [(c+d)2\Sigma_{03} + (2d-c)2\Sigma_{12} + d(n_+1_+ + n_-1_-)]\bar{\gamma} \\ &+ [(a-b)2\Sigma_{03} + (a-2b)2\Sigma_{12} - b(n_+1_+ + n_-1_-)]\bar{Z}^0 \ . \end{aligned} \tag{A-2.34}$$

Identifying Σ_{12} and $\Sigma_{03} = 1 \times \gamma_5 \Sigma_{12}$ as vectorial and axial Lie-algebra generators, respectively, the requirement that γ couples vectorially leads to the condition

$$c = -d \ . \tag{A-2.35}$$

Using this result plus previous equations, one obtains for the neutral part of the connection the expression

$$A_{nc} = \gamma Q_{em} + Z^0(I_L^3 - sin^2\theta_W Q_{em}) \ . \tag{A-2.36}$$

Here the electromagnetic charge Q_{em} and the weak isospin are defined by

$$\begin{aligned} Q_{em} &= \Sigma^{12} + \frac{(n_+1_+ + n_-1_-)}{6} \ , \\ I_L^3 &= \frac{(\Sigma^{12} - \Sigma^{03})}{2} \ . \end{aligned} \tag{A-2.37}$$

The fields γ and Z^0 are defined via the relations

$$\begin{aligned} \gamma &= 6d\bar{\gamma} = \frac{6}{(a+b)}(aX + bY) \ , \\ Z^0 &= 4(a+b)\bar{Z}^0 = 4(X - Y) \ . \end{aligned} \tag{A-2.38}$$

The value of the Weinberg angle is given by

$$sin^2\theta_W = \frac{3b}{2(a+b)} \ , \tag{A-2.39}$$

and is not fixed completely. Observe that right handed neutrinos decouple completely from the electro-weak interactions.

The determination of the value of the Weinberg angle is a dynamical problem. The original approach was based on the assumption that it makes sense to talk about electroweak action defined at fundamental level and introduce a symmetry breaking by adding an additional term proportional to Kähler action. The recent view is that Kähler action plus volume term defines the fundamental action.

The Weinberg angle is completely fixed if one requires that the electroweak action contains no cross term of type γZ^0. This 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. As a matter fact, color gauge action identifying color gauge field as proportional to $H^A J_{\alpha\beta}$ is proportional to Kähler action. A possible interpretation would be as a sum of electroweak and color gauge interactions.

To evaluate the value of the Weinberg angle one can express the neutral part F_{nc} of the induced gauge field as

$$F_{nc} = 2R_{03}\Sigma^{03} + 2R_{12}\Sigma^{12} + J(n_+1_+ + n_-1_-) \ , \tag{A-2.40}$$

where one has

$$\begin{aligned} R_{03} &= 2(2e^0\wedge e^3 + e^1\wedge e^2) \ , \\ R_{12} &= 2(e^0\wedge e^3 + 2e^1\wedge e^2) \ , \\ J &= 2(e^0\wedge e^3 + e^1\wedge e^2) \ , \end{aligned} \tag{A-2.41}$$

in terms of the fields γ and Z^0 (photon and Z- boson)

$$F_{nc} = \gamma Q_{em} + Z^0(I_L^3 - sin^2\theta_W Q_{em}) \ . \tag{A-2.42}$$

Evaluating the expressions above, one obtains for γ and Z^0 the expressions

$$\begin{aligned} \gamma &= 3J - sin^2\theta_W R_{12} \ , \\ Z^0 &= 2R_{03} \ . \end{aligned} \tag{A-2.43}$$

For the Kähler field one obtains

$$J = \frac{1}{3}(\gamma + sin^2\theta_W Z^0) \ . \tag{A-2.44}$$

Expressing the neutral part of the symmetry broken YM action

$$\begin{aligned} L_{ew} &= L_{sym} + fJ^{\alpha\beta}J_{\alpha\beta} \ , \\ L_{sym} &= \frac{1}{4g^2}Tr(F^{\alpha\beta}F_{\alpha\beta}) \ , \end{aligned} \tag{A-2.45}$$

where the trace is taken in spinor representation, in terms of γ and Z^0 one obtains for the coefficient X of the γZ^0 cross term (this coefficient must vanish) the expression

$$\begin{aligned} X &= -\frac{K}{2g^2} + \frac{fp}{18} \ , \\ K &= Tr\left[Q_{em}(I_L^3 - sin^2\theta_W Q_{em})\right] \ , \end{aligned} \tag{A-2.46}$$

This parameter can be calculated by substituting the values of quark and lepton charges and weak isospins.

In the general case the value of the coefficient K is given by

$$K = \sum_i \left[-\frac{(18 + 2n_i^2)sin^2\theta_W}{9}\right] \ , \tag{A-2.47}$$

where the sum is over the spinor chiralities, which appear as elementary fermions and n_i is the integer describing the coupling of the spinor field to the Kähler potential. The cross term vanishes provided the value of the Weinberg angle is given by

$$sin^2\theta_W = \frac{9\sum_i 1}{(fg^2 + 2\sum_i(18 + n_i^2))} \ . \tag{A-2.48}$$

In the scenario where both leptons and quarks are elementary fermions the value of the Weinberg angle is given by

$$sin^2\theta_W = \frac{9}{(\frac{fg^2}{2} + 28)} \ . \tag{A-2.49}$$

The bare value of the Weinberg angle is 9/28 in this scenario, which is not far from the typical value 9/24 of GUTs at high energies [B3]. The experimental value at the scale length scale of the electron can be deduced from the ratio of W and Z boson masses as $sin^2\theta_W = 1 - (m_W/m_Z)^2 \simeq .22290$. This ratio and also the weak boson masses depend on the length scale.

If one interprets the additional term proportional to J as color actoon, one could perhaps interpret the value of Weinberg angle as expressing a connection between strong and weak coupling constant evolution. The limit $f \rightarrow 0$ should correspond to an infinite value of color coupling strength and at this limit one would have $sin^2\theta_W = \frac{9}{28}$ for $f/g^2 \rightarrow 0$. This does not make sense since the Weinberg angle is in the standard model much smaller in QCD scale Λ corresponding roughly to pion mass scale. The Weinberg angle is in principle predicted by the p-adic coupling constant evolution fixed by the number theoretical vision of TGD.

One could however have a sum of electroweak action, correction terms changing the value of Weinberg angle, and color action and coupling constant evolution could be understood in terms of the coupling parameters involved.

Discrete symmetries

The treatment of discrete symmetries C, P, and T is based on the following requirements:

1. Symmetries must be realized as purely geometric transformations.
2. 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 of is given by

$$\Psi \rightarrow P\Psi = \gamma^0 \otimes \gamma^0\Psi \ . \tag{A-2.50}$$

in the representation of the gamma matrices for which γ^0 is diagonal. It should be noticed that W and Z^0 bosons break parity symmetry as they should since their charge matrices do not commute with the matrix of P.

The guess that a complex conjugation in CP_2 is associated with T transformation of the physicist turns out to be correct. One can verify by a direct calculation that pure Dirac action is invariant under T realized according to

$$\begin{aligned} m^k &\rightarrow T(M^k) \ , \\ \xi^k &\rightarrow \bar{\xi}^k \ , \\ \Psi &\rightarrow \gamma^1\gamma^3 \otimes 1\Psi \ . \end{aligned} \tag{A-2.51}$$

The operation bearing closest resemblance to the ordinary charge conjugation corresponds geometrically to complex conjugation in CP_2:

$$\begin{aligned} \xi^k &\rightarrow \bar{\xi}^k \ , \\ \Psi &\rightarrow \Psi^\dagger\gamma^2\gamma^0 \otimes 1 \ . \end{aligned} \tag{A-2.52}$$

As one might have expected symmetries CP and T are exact symmetries of the pure Dirac action.

A-3 Induction procedure and many-sheeted space-time

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.

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 Induction procedure for gauge fields and spinor connection

Induction procedure for gauge potentials and spinor structure is a standard procedure of bundle theory. If one has embedding of some manifold to the base space of a bundle, the bundle structure can be induced so that it has as a base space the imbedded manifold, whose points have as fiber the fiber if embedding space at their image points. In the recent case the embedding of space-time surface to embedding space defines the induction procedure. The induced gauge potentials and gauge fields are projections of the spinor connection of the embedding space to the space-time surface (see `http://tgdtheory.fi/appfigures/induct.jpg`).

Induction procedure makes sense also for the spinor fields of embedding space and one obtains geometrization of both electroweak gauge potentials and of spinors. The new element is induction of gamma matrices which gives their projections at space-time surface.

As a matter fact, the induced gamma matrices cannot appear in the counterpart of massless Dirac equation. To achieve super-symmetry, Dirac action must be replaced with Kähler-Dirac action for which gamma matrices are contractions of the canonical momentum currents of Kähler action with embedding space gamma matrices. Induced gamma matrices in Dirac action would correspond to 4-volume as action.

Fig. 9. Induction of spinor connection and metric as projection to the space-time surface. `http://tgdtheory.fi/appfigures/induct.jpg`.

A-3.2 Induced gauge fields for space-times for which CP_2 projection is a geodesic sphere

If one requires that space-time surface is an extremal of Kähler action and has a 2-dimensional CP_2 projection, only vacuum extremals and space-time surfaces for which CP_2 projection is a geodesic sphere, are allowed. Homologically non-trivial geodesic sphere correspond to vanishing W fields and homologically non-trivial sphere to non-vanishing W fields but vanishing γ and Z^0. This can be verified by explicit examples.

$r = \infty$ surface gives rise to a homologically non-trivial geodesic sphere for which e_0 and e_3 vanish imply the vanishing of W field. For space-time sheets for which CP_2 projection is $r = \infty$ homologically non-trivial geodesic sphere of CP_2 one has

$$\gamma = (\frac{3}{4} - \frac{sin^2(\theta_W)}{2})Z^0 \simeq \frac{5Z^0}{8} \quad .$$

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-3.3 Many-sheeted space-time

TGD space-time is many-sheeted: in other words, there are in general several space-sheets which have projection to the same M^4 region. Second manner to say this is that CP_2 coordinates are many-valued functions of M^4 coordinates. The original physical interpretation of many-sheeted space-time time was not correct: it was assumed that single sheet corresponds to GRT space-time and this obviously leads to difficulties since the induced gauge fields are expressible in terms of only four embedding space coordinates.

Fig. 10. Illustration of many-sheeted space-time of TGD. `http://tgdtheory.fi/appfigures/manysheeted.jpg`

Superposition of effects instead of superposition of fields

The first objection against TGD is that superposition is not possible for induced gauge fields and induced metric. The resolution of the problem is that it is effects which need to superpose, not the fields.

Test particle topologically condenses simultaneously to all space-time sheets having a projection to same region of M^4 (that is touches them). The superposition of effects of fields at various space-time sheets replaces the superposition of fields.This is crucial for the understanding also how GRT space-time relates to TGD space-time, which is also in the appendix of this book).

Wormhole contacts

Wormhole contacts are key element of many-sheeted space-time. One does not expect them to be stable unless there is non-trivial Kähler magnetic flux flowing through then so that the throats look like Kähler magnetic monopoles.

Fig. 11. Wormhole contact. `http://tgdtheory.fi/appfigures/wormholecontact.jpg`

Since the flow lines of Kähler magnetic field must be closed this requires the presence of another wormhole contact so that one obtains closed monopole flux tube decomposing to two Minkowskian pieces at the two space-time sheets involved and two wormhole contacts with Euclidian signature of the induced metric. These objects are identified as space-time correlates of elementary particles and are clearly analogous to string like objects.

The relationship between the many-sheeted space-time of TGD and of GRT space-time

The space-time of general relativity is single-sheeted and there is no need to regard it as surface in H although the assumption about representability as vacuum extremal gives very powerful constraints in cosmology and astrophysics and might make sense in simple situations.

The space-time of GRT can be regarded as a long length scale approximation obtained by lumping together the sheets of the many-sheeted space-time to a region of M^4 and providing it with an effective metric obtained as sum of M^4 metric and deviations of the induced metrics of various space-time sheets from M^4 metric. Also induced gauge potentials sum up in the similar manner so that also the gauge fields of gauge theories would not be fundamental fields.

Fig. 12. The superposition of fields is replaced with the superposition of their effects in many-sheeted space-time. `http://tgdtheory.fi/appfigures/fieldsuperpose.jpg`

Space-time surfaces of TGD are considerably simpler objects that the space-times of general relativity and relate to GRT space-time like elementary particles to systems of condensed matter physics. Same can be said about fields since all fields are expressible in terms of embedding space coordinates and their gradients, and general coordinate invariance means that the number of bosonic field degrees is reduced locally to 4. TGD space-time can be said to be a microscopic description whereas GRT space-time a macroscopic description. In TGD complexity of space-time topology replaces the complexity due to large number of fields in quantum field theory.

Topological field quantization and the notion of magnetic body

Topological field quantization also TGD from Maxwell's theory. TGD predicts topological light rays ("massless extremals (MEs)") as space-time sheets carrying waves or arbitrary shape propagating with maximal signal velocity in single direction only and analogous to laser beams and carrying light-like gauge currents in the generi case. There are also magnetic flux quanta and electric flux quanta. The deformations of cosmic strings with 2-D string orbit as M^4 projection gives rise to magnetic flux tubes carrying monopole flux made possible by CP_2 topology allowing homological Kähler magnetic monopoles.

Fig. 13. Topological quantization for magnetic fields replaces magnetic fields with bundles of them defining flux tubes as topological field quanta. `http://tgdtheory.fi/appfigures/field.jpg`

The imbeddability condition for say magnetic field means that the region containing constant magnetic field splits into flux quanta, say tubes and sheets carrying constant magnetic field. Unless one assumes a separate boundary term in Kähler action, boundaries in the usual sense are forbidden except as ends of space-time surfaces at the boundaries of causal diamonds. One obtains typically pairs of sheets glued together along their boundaries giving rise to flux tubes with closed cross section possibly carrying monopole flux.

These kind of flux tubes might make possible magnetic fields in cosmic scales already during primordial period of cosmology since no currents are needed to generate these magnetic fields: cosmic string would be indeed this kind of objects and would dominated during the primordial period. Even superconductors and maybe even ferromagnets could involve this kind of monopole flux tubes.

A-3.4 Embedding space spinors and induced spinors

One can geometrize also fermionic degrees of freedom by inducing the spinor structure of $M^4 \times CP_2$.

CP_2 does not allow spinor structure in the ordinary sense but one can couple the opposite H-chiralities of H-spinors to an $n = 1$ ($n = 3$) integer multiple of Kähler gauge potential to obtain a respectable modified spinor structure. The em charges of resulting spinors are fractional (integer valued) and the interpretation as quarks (leptons) makes sense since the couplings to the induced spinor connection having interpretation in terms electro-weak gauge potential are identical to those assumed in standard model.

The notion of quark color differs from that of standard model.

1. Spinors do not couple to color gauge potential although the identification of color gauge potential as projection of $SU(3)$ Killing vector fields is possible. This coupling must emerge

only at the effective gauge theory limit of TGD.

2. Spinor harmonics of embedding space correspond to triality $t = 1$ ($t = 0$) partial waves. The detailed correspondence between color and electroweak quantum numbers is however not correct as such and the interpretation of spinor harmonics of embedding space is as representations for ground states of super-conformal representations. The wormhole pairs associated with physical quarks and leptons must carry also neutrino pair to neutralize weak quantum numbers above the length scale of flux tube (weak scale or Compton length). The total color quantum numbers or these states must be those of standard model. For instance, the color quantum numbers of fundamental left-hand neutrino and lepton can compensate each other for the physical lepton. For fundamental quark-lepton pair they could sum up to those of physical quark.

The well-definedness of em charge is crucial condition.

1. Although the embedding space spinor connection carries W gauge potentials one can say that the embedding space spinor modes have well-defined em charge. One expects that this is true for induced spinor fields inside wormhole contacts with 4-D CP_2 projection and Euclidian signature of the induced metric.

2. The situation is not the same for the modes of induced spinor fields inside Minkowskian region and one must require that the CP_2 projection of the regions carrying induced spinor field is such that the induced W fields and above weak scale also the induced Z^0 fields vanish in order to avoid large parity breaking effects. This condition forces the CP_2 projection to be 2-dimensional. For a generic Minkowskian space-time region this is achieved only if the spinor modes are localized at 2-D surfaces of space-time surface - string world sheets and possibly also partonic 2-surfaces.

3. Also the Kähler-Dirac gamma matrices appearing in the modified Dirac equation must vanish in the directions normal to the 2-D surface in order that Kähler-Dirac equation can be satisfied. This does not seem plausible for space-time regions with 4-D CP_2 projection.

4. One can thus say that strings emerge from TGD in Minkowskian space-time regions. In particular, elementary particles are accompanied by a pair of fermionic strings at the opposite space-time sheets and connecting wormhole contacts. Quite generally, fundamental fermions would propagate at the boundaries of string world sheets as massless particles and wormhole contacts would define the stringy vertices of generalized Feynman diagrams. One obtains geometrized diagrammatics, which brings looks like a combination of stringy and Feynman diagrammatics.

5. This is what happens in the the generic situation. Cosmic strings could serve as examples about surfaces with 2-D CP_2 projection and carrying only em fields and allowing delocalization of spinor modes to the entire space-time surfaces.

A-3.5 About induced gauge fields

In the following the induced gauge fields are studied for general space-time surface without assuming the preferred extremal property (Bohr orbit property). Therefore 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

$$\begin{aligned} J &= \frac{r}{F^2} dr \wedge (d\Psi + cos(\Theta) d\Phi) + \frac{r^2}{2F} sin(\Theta) d\Theta \wedge d\Phi \ , \\ F &= 1 + r^2 \ . \end{aligned} \tag{A-3.1}$$

The general expression of electromagnetic field reads as

$$
\begin{aligned}
F_{em} &= (3+2p)\frac{r}{F^2}dr \wedge (d\Psi + cos(\Theta)d\Phi) + (3+p)\frac{r^2}{2F}sin(\Theta)d\Theta \wedge d\Phi \ , \\
p &= sin^2(\Theta_W) \ ,
\end{aligned} \tag{A-3.2}
$$

where Θ_W denotes Weinberg angle.

1. The vanishing of the electromagnetic fields is guaranteed, when the conditions

$$
\begin{aligned}
\Psi &= k\Phi \ , \\
(3+2p)\frac{1}{r^2F}(d(r^2)/d\Theta)(k+cos(\Theta)) &+ (3+p)sin(\Theta) = 0 \ ,
\end{aligned} \tag{A-3.3}
$$

hold true. The conditions imply that CP_2 projection of the electromagnetically neutral space-time is 2-dimensional. Solving the differential equation one obtains

$$
\begin{aligned}
r &= \sqrt{\frac{X}{1-X}} \ , \\
X &= D\left[|\frac{k+u}{C}|\right]^{\epsilon} \ , \\
u &\equiv cos(\Theta) \ , \ C = k + cos(\Theta_0) \ , \ D = \frac{r_0^2}{1+r_0^2} \ , \ \epsilon = \frac{3+p}{3+2p} \ ,
\end{aligned} \tag{A-3.4}
$$

where C and D are integration constants. $0 \leq X \leq 1$ is required by the reality of r. $r=0$ would correspond to $X=0$ giving $u=-k$ achieved only for $|k| \leq 1$ and $r=\infty$ to $X=1$ giving $|u+k| = [(1+r_0^2)/r_0^2)]^{(3+2p)/(3+p)}$ achieved only for

$$
sign(u+k) \times [\frac{1+r_0^2}{r_0^2}]^{\frac{3+2p}{3+p}} \leq k+1 \ ,
$$

where $sign(x)$ denotes the sign of x.

The expressions for Kähler form and Z^0 field are given by

$$
\begin{aligned}
J &= -\frac{p}{3+2p}Xdu \wedge d\Phi \ , \\
Z^0 &= -\frac{6}{p}J \ .
\end{aligned} \tag{A-3.5}
$$

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.

2. 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.

3. The vanishing Kähler field corresponds to $\epsilon = 1, p = 0$ in the formula for em neutral space-times. In this case classical em and Z^0 fields are proportional to each other:

$$\begin{aligned} Z^0 &= 2e^0 \wedge e^3 = \frac{r}{F^2}(k+u)\frac{\partial r}{\partial u}du \wedge d\Phi = (k+u)du \wedge d\Phi \ , \\ r &= \sqrt{\frac{X}{1-X}} \ , \ X = D|k+u| \ , \\ \gamma &= -\frac{p}{2}Z^0 \ . \end{aligned} \tag{A-3.6}$$

For a vanishing value of Weinberg angle ($p = 0$) em field vanishes and only Z^0 field remains as a long range gauge field. Vacuum extremals for which long range Z^0 field vanishes but em field is non-vanishing are not possible.

The effective form of CP_2 metric for surfaces with 2-dimensional CP_2 projection

The effective form of the CP_2 metric for a space-time having vanishing em,Z^0, or Kähler field is of practical value in the case of vacuum extremals and is given by

$$\begin{aligned} ds^2_{eff} &= (s_{rr}(\frac{dr}{d\Theta})^2 + s_{\Theta\Theta})d\Theta^2 + (s_{\Phi\Phi} + 2ks_{\Phi\Psi})d\Phi^2 = \frac{R^2}{4}[s^{eff}_{\Theta\Theta}d\Theta^2 + s^{eff}_{\Phi\Phi}d\Phi^2] \ , \\ s^{eff}_{\Theta\Theta} &= X \times \left[\frac{\epsilon^2(1-u^2)}{(k+u)^2} \times \frac{1}{1-X} + 1 - X\right] \ , \\ s^{eff}_{\Phi\Phi} &= X \times \left[(1-X)(k+u)^2 + 1 - u^2\right] \ , \end{aligned} \tag{A-3.7}$$

and is useful in the construction of vacuum embedding of, say Schwartchild metric.

Topological quantum numbers

Space-times for which either em, Z^0, or Kähler field vanishes decompose into regions characterized by six vacuum parameters: two of these quantum numbers (ω_1 and ω_2) are frequency type parameters, two (k_1 and k_2) are wave vector like quantum numbers, two of the quantum numbers (n_1 and n_2) are integers. The parameters ω_i and n_i will be referred as electric and magnetic quantum numbers. The existence of these quantum numbers is not a feature of these solutions alone but represents a much more general phenomenon differentiating in a clear cut manner between TGD and Maxwell's electrodynamics.

The simplest manner to avoid surface Kähler charges and discontinuities or infinities in the derivatives of CP_2 coordinates on the common boundary of two neighboring regions with different vacuum quantum numbers is topological field quantization, 3-space decomposes into disjoint topological field quanta, 3-surfaces having outer boundaries with possibly macroscopic size.

Under rather general conditions the coordinates Ψ and Φ can be written in the form

$$\begin{aligned} \Psi &= \omega_2 m^0 + k_2 m^3 + n_2\phi + \text{Fourier expansion} \ , \\ \Phi &= \omega_1 m^0 + k_1 m^3 + n_1\phi + \text{Fourier expansion} \ . \end{aligned} \tag{A-3.8}$$

m^0,m^3 and ϕ denote the coordinate variables of the cylindrical M^4 coordinates) so that one has $k = \omega_2/\omega_1 = n_2/n_1 = k_2/k_1$. The regions of the space-time surface with given values of the vacuum parameters ω_i,k_i and n_i and m and C are bounded by the surfaces at which space-time surface becomes ill-defined, say by $r > 0$ or $r < \infty$ surfaces.

The space-time surface decomposes into regions characterized by different values of the vacuum parameters r_0 and Θ_0. At $r = \infty$ surfaces n_2,ω_2 and m can change since all values of Ψ correspond to the same point of CP_2: at $r = 0$ surfaces also n_1 and ω_1 can change since all values of Φ correspond to same point of CP_2, too. If $r = 0$ or $r = \infty$ is not in the allowed range space-time surface develops a boundary.

This implies what might be called topological quantization since in general it is not possible to find a smooth global embedding for, say a constant magnetic field. Although global embedding 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

$$\Omega \equiv \frac{\omega_2}{n_2} - \frac{\omega_1}{n_1} = 0 \ , \tag{A-3.9}$$

is satisfied. In particular, the ratio ω_2/ω_1 is rational number for the electromagnetically neutral regions of space-time surface. The change of the parameter n_1 and n_2 (ω_1 and ω_2) in general generates magnetic field and therefore these integers will be referred to as magnetic (electric) quantum numbers.

A-4 The relationship of TGD to QFT and string models

The recent view of the relationship of TGD to QFT and string models has developed slowly during years and it seems that in a certain sense TGD means a return to roots: instead of QFT like description involving path integral one would have wave mechanics for 3-surfaces.

A-4.1 TGD as a generalization of wave mechanism obtained by replacing point-like particles with 3-surfaces

The first vision of TGD was as a generalization of quantum field theory (string models) obtained by replacing pointlike particles (strings) as fundamental objects with 3-surfaces.

The later work has revealed that TGD could be seen as a generalization of the wave mechanism based on the replacement of a point-like particle with 3-D surface. This is due to holography implied by general coordinate invariance. The definition of the metric of the "world of classical worlds" (WCW) must assign a unique or at least almost unique space-time surface to a given 3-surface. This 4-surface is analogous to Bohr orbit so that also Bohr orbitology becomes an exact part of quantum physics. The failure of strict determinism forces to replace 3-surfaces with 4-surfaces and this leads to zero energy ontology (ZEO) in which quantum states are superpositions of space-time surfaces [K20, K14, K65] [L41, L46].

Fig. 5. TGD replaces point-like particles with 3-surfaces. `http://tgdtheory.fi/appfigures/particletgd.jpg`

A-4.2 Extension of superconformal invariance

The fact that light-like 3-surfaces are effectively metrically 2-dimensional and thus possess generalization of 2-dimensional conformal symmetries with light-like radial coordinate defining the analog of second complex coordinate suggests that this generalization could work and extend the super-conformal symmetries to their 4-D analogs.

The boundary $\delta M^4_+ = S^2 \times R_+$- of 4-D light-cone M^4_+ is also metrically 2-dimensional and allows extended conformal invariance. Also the group of isometries of light-cone boundary and of light-like 3-surfaces is infinite-dimensional since the conformal scalings of S^2 can be compensated by S^2-local scaling of the light-like radial coordinate of R_+. These simple facts mean that 4-dimensional Minkowski space and 4-dimensional space-time surfaces are in a completely unique position as far as symmetries are considered.

In fact, this leads to a generalization of the Kac-Moody type symmetries of string models. $\delta M^4_+ \times CP_2$ allows huge supersymplectic symmetries for which the radial light-like coordinate of δM^4_+ plays the role of complex string coordinate in string models. These symmetries are assumed to act as isometries of WCW.

A-4.3 String-like objects and strings

String like objects obtained as deformations of cosmic strings $X^2 \times Y^2$, where X^2 is minimal surface in M^4 and Y^2 a holomorphic surface of CP_2 are fundamental extremals of Kähler action having string world sheet as M^4 projections. Cosmic strings dominate the primordial cosmology of the TGD Universe and the inflationary period corresponds to the transition to radiation dominated cosmology for which space-time sheets with 4-D M^4 projection dominate.

Also genuine string-like objects emerge from TGD. The conditions that the em charge of modes of induces spinor fields is well-defined requires in the generic case the localization of the modes at 2-D surfaces -string world sheets and possibly also partonic 2-surfaces. This in Minkowskian space-time regions.

Fig. 6. Well-definedness of em charge forces the localization of induced spinor modes to 2-D surfaces in generic situations in Minkowskian regions of space-time surface. `http://tgdtheory.fi/appfigures/fermistring.jpg`

A-4.4 TGD view of elementary particles

The TGD based view about elementary particles has two key aspects.

1. The space-time correlates of elementary particles are identified as pairs of wormhole contacts with Euclidean signature of metric and having 4-D CP_2 projection. Their throats behave effectively as Kähler magnetic monopoles so that wormhole throats must be connected by Kähler magnetic flux tubes with monopole flux so that closed flux tubes are obtained.

2. At the level of H Fermion number is carried by the modes of the induced spinor field. In space-time regions with Minkowski signature the modes are localized at string world sheets connecting the wormhole contacts.

Fig. 7. TGD view about elementary particles. a) Particle orbit corresponds to a 4-D generalization of a world line or b) with its light-like 3-D boundary (holography). c) Particle world lines have Euclidean signature of the induced metric. d) They can be identified as wormhole contacts. e) The throats of wormhole contacts carry effective Kähler magnetic charges so that wormhole contacts must appear as pairs in order to obtain closed flux tubes. f) Wormhole contacts are accompanied by fermionic strings connecting the throats at the same sheet: the strings do not extend inside the wormhole contacts. `http://tgdtheory.fi/appfigures/elparticletgd.jpg`

Particle interactions involve both stringy and QFT aspects.

1. The boundaries of string world sheets correspond to fundamental fermions. This gives rise to massless propagator lines in generalized Feynman diagrammatics. One can speak of "long" string connecting wormhole contacts and having a hadronic string as a physical counterpart. Long strings should be distinguished from wormhole contacts which due to their super-conformal invariance behave like "short" strings with length scale given by CP_2 size, which is 10^4 times longer than Planck scale characterizing strings in string models.

2. Wormhole contact defines basic stringy interaction vertex for fermion-fermion scattering. The propagator is essentially the inverse of the superconformal scaling generator L_0. Wormhole contacts containing fermion and antifermion at its opposite throats behave like virtual bosons so that one has BFF type vertices typically.

3. In topological sense one has 3-vertices serving as generalizations of 3-vertices of Feynman diagrams. In these vertices 4-D "lines" of generalized Feynman diagrams meet along their 3-D ends. One obtains also the analogs of stringy diagrams but stringy vertices do not have the usual interpretation in terms of particle decays but in terms of propagation of particles along two different routes.

Fig. 8. a) TGD analogs of Feynman and string diagrammatics at the level of space-time topology. b) The 4-D analogs of both string diagrams and QFT diagrams appear but the interpretation of the analogs stringy diagrams is different. `http://tgdtheory.fi/appfigures/tgdgraphs.jpg`

A-5 About the selection of the action defining the Kähler function of the "world of classical worlds" (WCW)

The proposal is that space-time surfaces correspond to preferred extremals of some action principle, being analogous to Bohr orbits, so that they are almost deterministic. The action for the preferred extremal would define the Kähler function of WCW [K20, K65].

How unique is the choice of the action defining WCW Kähler metric? The problem is that twistor lift strongly suggests the identification of the preferred extremals as 4-D surfaces having 4-D generalization of complex structure and that a large number of general coordinate invariant actions constructible in terms of the induced geometry have the same preferred extremals.

A-5.1 Could twistor lift fix the choice of the action uniquely?

The twistor lift of TGD [K90] [L41, L42, L43] generalizes the notion of induction to the level of twistor fields and leads to a proposal that the action is obtained by dimensional reduction of the action having as its preferred extremals the counterpart of twistor space of the space-time surface identified as 6-D surface in the product $T(M^4) \times T(CP_2)$ twistor spaces of $T(M^4)$ and $T(CP_2)$ of M^4 and CP_2. Only M^4 and CP_2 allow a twistor space with Kähler structure [A13] so that TGD would be unique. Dimensional reduction is forced by the condition that the 6-surface has S^2-bundle structure characterizing twistor spaces and the base space would be the space-time surface.

1. Dimensional reduction of 6-D Kähler action implies that at the space-time level the fundamental action can be identified as the sum of Kähler action and volume term (cosmological constant). Other choices of the action do not look natural in this picture although they would have the same preferred extremals.

2. Preferred extremals are proposed to correspond to minimal surfaces with singularities such that they are also extremals of 4-D Kähler action outside the singularities. The physical analogue are soap films spanned by frames and one can localize the violation of the strict determinism and of strict holography to the frames.

3. The preferred extremal property is realized as the holomorphicity characterizing string world sheets, which generalizes to the 4-D situation. This in turn implies that the preferred extremals are the same for any general coordinate invariant action defined on the induced gauge fields and induced metric apart from possible extremals with vanishing CP_2 Kähler action.

   For instance, 4-D Kähler action and Weyl action as the sum of the tensor squares of the components of the Weyl tensor of CP_2 representing quaternionic imaginary units constructed from the Weyl tensor of CP_2 as an analog of gauge field would have the same preferred extremals and only the definition of Kähler function and therefore Kähler metric of WCW would change. One can even consider the possibility that the volume term in the 4-D action could be assigned to the tensor square of the induced metric representing a quaternionic or octonionic real unit.

Action principle does not seem to be unique. On the other hand, the WCW Kähler form and metric should be unique since its existence requires maximal isometries.

Unique action is not the only way to achieve this. One cannot exclude the possibility that the Kähler gauge potential of WCW in the complex coordinates of WCW differs only by a complex gradient of a holomorphic function for different actions so that they would give the same Kähler form for WCW. This gradient is induced by a symplectic transformation of WCW inducing a U(1) gauge transformation. The Kähler metric is the same if the symplectic transformation is an isometry.

Symplectic transformations of WCW could give rise to inequivalent representations of the theory in terms of action at space-time level. Maybe the length scale dependent coupling parameters of an effective action could be interpreted in terms of a choice of WCW Kähler function, which maximally simplifies the computations at a given scale.

1. The 6-D analogues of electroweak action and color action reducing to Kähler action in 4-D case exist. The 6-D analog of Weyl action based on the tensor representation of quaternionic imaginary units does not however exist. One could however consider the possibility that only the base space of twistor space $T(M^4)$ and $T(CP_2)$ have quaternionic structure.

2. Kähler action has a huge vacuum degeneracy, which clearly distinguishes it from other actions. The presence of the volume term removes this degeneracy. However, for minimal surfaces having CP_2 projections, which are Lagrangian manifolds and therefore have a vanishing induced Kähler form, would be preferred extremals according to the proposed definition. For these 4-surfaces, the existence of the generalized complex structure is dubious.

   For the electroweak action, the terms corresponding to charged weak bosons eliminate these extremals and one could argue that electroweak action or its sum with the analogue of color action, also proportional Kähler action, defines the more plausible choice. Interestingly, also the neutral part of electroweak action is proportional to Kähler action.

Twistor lift strongly suggests that also M^4 has the analog of Kähler structure. M^8 must be complexified by adding a commuting imaginary unit i. In the E^8 subspace, the Kähler structure of E^4 is defined in the standard sense and it is proposed that this generalizes to M^4 allowing also generalization of the quaternionic structure. M^4 Kähler structure violates Lorentz invariance but could be realized at the level of moduli space of these structures.

The minimal possibility is that the M^4 Kähler form vanishes: one can have a different representation of the Kähler gauge potential for it obtained as generalization of symplectic transformations acting non-trivially in M^4. The recent picture about the second quantization of spinors of $M^4 \times CP_2$ assumes however non-trivial Kähler structure in M^4.

A-5.2 Two paradoxes

TGD view leads to two apparent paradoxes.

1. If the preferred extremals satisfy 4-D generalization of holomorphicity, a very large set of actions gives rise to the same preferred extremals unless there are some additional conditions restricting the number of preferred extremals for a given action.

2. WCW metric has an infinite number of zero modes, which appear as parameters of the metric but do not contribute to the line element. The induced Kähler form depends on these degrees of freedom. The existence of the Kähler metric requires maximal isometries, which suggests that the Kähler metric is uniquely fixed apart from a conformal scaling factor Ω depending on zero modes. This cannot be true: galaxy and elementary particle cannot correspond to the same Kähler metric.

Number theoretical vision and the hierarchy of inclusions of HFFs associated with supersymplectic algebra actings as isometries of WcW provide equivalent realizations of the measurement resolution. This solves these paradoxes and predicts that WCW decomposes into sectors for which Kähler metrics of WCW differ in a natural way.

The hierarchy subalgebras of supersymplectic algebra implies the decomposition of WCW into sectors with different actions

Supersymplectic algebra of $\delta M^4_+ \times CP_2$ is assumed to act as isometries of WCW [L46]. There are also other important algebras but these will not be discussed now.

1. The symplectic algebra A of $\delta M^4_+ \times CP_2$ has the structure of a conformal algebra in the sense that the radial conformal weights with non-negative real part, which is half integer, label the elements of the algebra have an interpretation as conformal weights.

   The super symplectic algebra A has an infinite hierarchy of sub-algebras [L46] such that the conformal weights of sub-algebras $A_{n(SS)}$ are integer multiples of the conformal weights of the entire algebra. The superconformal gauge conditions are weakened. Only the subalgebra

$A_{n(SS)}$ and the commutator $[A_{n(SS)}, A]$ annihilate the physical states. Also the corresponding classical Noether charges vanish for allowed space-time surfaces.

This weakening makes sense also for ordinary superconformal algebras and associated Kac-Moody algebras. This hierarchy can be interpreted as a hierarchy symmetry breakings, meaning that sub-algebra $A_{n(SS)}$ acts as genuine dynamical symmetries rather than mere gauge symmetries. It is natural to assume that the super-symplectic algebra A does not affect the coupling parameters of the action.

2. The generators of A correspond to the dynamical quantum degrees of freedom and leave the induced Kähler form invariant. They affect the induced space-time metric but this effect is gravitational and very small for Einsteinian space-time surfaces with 4-D M^4 projection.

   The number of dynamical degrees of freedom increases with $n(SS)$. Therefore WCW decomposes into sectors labelled by $n(SS)$ with different numbers of dynamical degrees of freedom so that their Kähler metrics cannot be equivalent and cannot be related by a symplectic isometry. They can correspond to different actions.

Number theoretic vision implies the decomposition of WCW into sectors with different actions

The number theoretical vision leads to the same conclusion as the hierarchy of HFFs. The number theoretic vision of TGD based on $M^8 - H$ duality [L46] predicts a hierarchy with levels labelled by the degrees $n(P)$ of rational polynomials P and corresponding extensions of rationals characterized by Galois groups and by ramified primes defining p-adic length scales.

These sequences allow us to imagine several discrete coupling constant evolutions realized at the level H in terms of action whose coupling parameters depend on the number theoretic parameters.

1. Coupling constant evolution with respect to $n(P)$

The first coupling constant evolution would be with respect to $n(P)$.

1. The coupling constants characterizing action could depend on the degree $n(P)$ of the polynomial defining the space-time region by $M^8 - H$ duality. The complexity of the space-time surface would increase with $n(P)$ and new degrees of freedom would emerge as the number of the rational coefficients of P.

2. This coupling constant evolution could naturally correspond to that assignable to the inclusion hierarchy of hyperfinite factors of type II_1 (HFFs). I have indeed proposed [L46] that the degree $n(P)$ equals to the number $n(braid)$ of braids assignable to HFF for which super symplectic algebra subalgebra $A_{n(SS)}$ with radial conformal weights coming as $n(SS)$-multiples of those of entire algebra A. One would have $n(P) = n(braid) = n(SS)$. The number of dynamical degrees of freedom increases with n which just as it increases with $n(P)$ and $n(SS)$.

3. The actions related to different values of $n(P) = n(braid) = n(SS)$ cannot define the same Kähler metric since the number of allowed space-time surfaces depends on $n(SS)$.

   WCW could decompose to sub-WCWs corresponding to different actions, a kind of theory space. These theories would not be equivalent. A possible interpretation would be as a hierarchy of effective field theories.

4. Hierarchies of composite polynomials define sequences of polynomials with increasing values of $n(P)$ such that the order of a polynomial at a given level is divided by those at the lower levels. The proposal is that the inclusion sequences of extensions are realized at quantum level as inclusion hierarchies of hyperfinite factors of type II_1.

   A given inclusion hierarchy corresponds to a sequence $n(SS)_i$ such that $n(SS)_i$ divides $n(SS)_{i+1}$. Therefore the degree of the composite polynomials increases very rapidly. The values of $n(SS)_i$ can be chosen to be primes and these primes correspond to the degrees of so called prime polynomials [L44] so that the decompositions correspond to prime factorizations of integers. The "densest" sequence of this kind would come in powers of 2 as

$n(SS)_i = 2^i$. The corresponding p-adic length scales (assignable to maximal ramified primes for given $n(SS)_i$) are expected to increase roughly exponentially, say as 2^{r2^i}. $r = 1/2$ would give a subset of scales $2^{r/2}$ allowed by the p-adic length scale hypothesis. These transitions would be very rare.

A theory corresponding to a given composite polynomial would contain as sub-theories the theories corresponding to lower polynomial composites. The evolution with respect to $n(SS)$ would correspond to a sequence of phase transitions in which the action genuinely changes. For instance, color confinement could be seen as an example of this phase transition.

5. A subset of p-adic primes allowed by the p-adic length scale hypothesis $p \simeq 2^k$ defining the proposed p-adic length scale hierarchy could relate to n_S changing phase transition. TGD suggests a hierarchy of hadron physics corresponding to a scale hierarchy defined by Mersenne primes and their Gaussian counterparts [K29, K30]). Each of them would be characterized by a confinement phase transition in which n_S and therefore also the action changes.

2. Coupling constant evolutions with respect to ramified primes for a given value of $n(P)$

For a given value of $n(P)$, one could have coupling constant sub-evolutions with respect to the set of ramified primes of P and dimensions $n = h_{eff}/h_0$ of algebraic extensions. The action would only change by U(1) gauge transformation induced by a symplectic isometry of WCW. Coupling parameters could change but the actions would be equivalent.

The choice of the action in an optimal manner in a given scale could be seen as a choice of the most appropriate effective field theory in which radiative corrections would be taken into account. One can interpret the possibility to use a single choice of coupling parameters in terms of quantum criticality.

The range of the p-adic length scales labelled by ramified primes and effective Planck constants h_{eff}/h_0 is finite for a given value of $n(SS)$.

The first coupling constant evolution of this kind corresponds to ramified primes defining p-adic length scales for given $n(SS)$.

1. Ramified primes are factors of the discriminant $D(P)$ of P, which is expressible as a product of non-vanishing root differents and reduces to a polynomial of the n coefficients of P. Ramified primes define p-adic length scales assignable to the particles in the amplitudes scattering amplitudes defined by zero energy states.

   P would represent the space-time surface defining an interaction region in $N-$-particle scattering. The N ramified primes dividing $D(P)$ would characterize the p-adic length scales assignable to these particles. If $D(P)$ reduces to a single ramified prime, one has elementary particle [L44], and the forward scattering amplitude corresponds to the propagator.

   This would give rise to a multi-scale p-adic length scale evolution of the amplitudes analogous to the ordinary continuous coupling constant evolution of n-point scattering amplitudes with respect to momentum scales of the particles. This kind of evolutions extend also to evolutions with respect to $n(SS)$.

2. According to [L44], physical constraints require that $n(P)$ and the maximum size of the ramified prime of P correlate.

   A given rational polynomial of degree $n(P)$ can be always transformed to a polynomial with integer coefficients. If the integer coefficients are smaller than $n(P)$, there is an upper bound for the ramified primes. This assumption also implies that finite fields become fundamental number fields in number theoretical vision [L44].

3. p-Adic length scale hypothesis [L47] in its basic form states that there exist preferred primes $p \simeq 2^k$ near some powers of 2. A more general hypothesis states that also primes near some powers of 3 possibly also other small primes are preferred physically. The challenge is to understand the origin of these preferred scales.

   For polynomials P with a given degree $n(P)$ for which discriminant $D(P)$ is prime, there exists a maximal ramified prime. Numerical calculations suggest that the upper bound depends exponentially on $n(P)$.

Could these maximal ramified primes satisfy the p-adic length scale hypothesis or its generalization? The maximal prime defines a fixed point of coupling constant evolution in accordance with the earlier proposal. For instance, could one think that one has $p \simeq 2^k$, $k = n(SS)$? Each p-adic prime would correspond to a p-adic coupling constant sub-evolution representable in terms of symplectic isometries.

Also the dimension n of the algebraic extension associated with P, which is identified in terms of effective Planck constant $h_{eff}/h_0 = n$ labelling different phases of the ordinary matter behaving like dark matter, could give rise to coupling constant evolution for given $n(SS)$. The range of allowed values of n is finite. Note however that several polynomials of a given degree can correspond to the same dimension of extension.

Number theoretic discretization of WCW and maxima of WCW Kähler function

Number theoretic approach involves a unique discretization of space-time surface and also of WCW. The question is how the points of the discretized WCW correspond to the preferred extremals.

1. The exponents of Kähler function for the maxima of Kähler function, which correspond to the universal preferred extremals, appear in the scattering amplitudes. The number theoretical approach involves a unique discretization of space-time surfaces defining the WCW coordinates of the space-time surface regarded as a point of WCW.

   In [L46] it is assumed that these WCW points appearing in the number theoretical discretization correspond to the maxima of the Kähler function. The maxima would depend on the action and would differ for ghd maxima associated with different actions unless they are not related by symplectic WCW isometry.

2. The symplectic transformations of WCW acting as isometries are assumed to be induced by the symplectic transformations of $\delta M^4_+ \times CP_2$ [K20, K14]. As isometries they would naturally permute the maxima with each other.

A-6 Number theoretic vision of TGD

Physics as number theory vision is complementary to the physics as geometry vision and has developed gradually since 1993. Langlands program is the counterpart of this vision in mathematics [L45].

The notion of p-adic number fields emerged with the motivation coming from the observation that elementary particle mass scales and mass ratios could be understood in terms of the so-called p-adic length scale hypothesis [K63, K26, K13]. The fusion of the various p-adic physics leads to what I call adelic physics [L18, L17]. Later the hypothesis about hierarchy of Planck constants labelling phases of ordinary matter behaving like dark matter emerged [K76, K77, K78, K78].

Eventually this led to that the values of effective Planck constant could be identified as the dimension of an algebraic extension of rationals assignable to polynomials with rational coefficients. This led to the number theoretic vision in which so-called $M^8 - H$ duality [L37, L38] plays a key role. M^8 (actually a complexification of real M^8) is analogous to momentum space so that the duality generalizes momentum position duality for point-like particles. M^8 has an interpretation as complexified octonions.

The dynamics of 4-surfaces in M^8 is coded by polynomials with rational coefficients, whose roots define mass shells H^3 of $M^4 \subset M^8$. It has turned out that the polynomials satisfy stringent additional conditions and one can speak of number theoretic holography [L44, L45]. Also the ordinary $3 \rightarrow 4$ holography is needed to assign 4-surfaces with these 3-D mass shells. The number theoretic dynamics is based on the condition that the normal space of the 4-surface in M^8 is associative (quaternionic) and contains a commutative complex sub-space. This makes it possible to assign to this surface space-time surface in $H = M^4 \times CP_2$.

At the level of H the space-time surfaces are by holography preferred extremals and are assumed to be determined by the twistor lift of TGD [K90] giving rise to an action which is sum of the Kähler action and volume term. The preferred extremals would be minimal surfaces analogous to soap films spanned by frames. Outside frames they would be simultaneous extremals of the Kähler action, which requires a generalization of the holomorphy characterizing string world sheets.

In the following only p-adic numbers and hierarchy of Planck constants will be discussed.

A-6.1 p-Adic numbers and TGD

p-Adic number fields

p-Adic numbers (p is prime: 2, 3, 5, ...) can be regarded as a completion of the rational numbers using a norm, which is different from the ordinary norm of real numbers [A6]. p-Adic numbers are representable as power expansion of the prime number p of form

$$x = \sum_{k\geq k_0} x(k)p^k ,\ x(k) = 0, ..., p-1 \ . \tag{A-6.1}$$

The norm of a p-adic number is given by

$$|x| = p^{-k_0(x)} \ . \tag{A-6.2}$$

Here $k_0(x)$ is the lowest power in the expansion of the p-adic number. The norm differs drastically from the norm of the ordinary real numbers since it depends on the lowest pinary digit of the p-adic number only. Arbitrarily high powers in the expansion are possible since the norm of the p-adic number is finite also for numbers, which are infinite with respect to the ordinary norm. A convenient representation for p-adic numbers is in the form

$$x = p^{k_0}\varepsilon(x) \ , \tag{A-6.3}$$

where $\varepsilon(x) = k + ...$ with $0 < k < p$, is p-adic number with unit norm and analogous to the phase factor $exp(i\phi)$ of a complex number.

The distance function $d(x,y) = |x-y|_p$ defined by the p-adic norm possesses a very general property called ultra-metricity:

$$d(x,z) \leq max\{d(x,y), d(y,z)\} \ . \tag{A-6.4}$$

The properties of the distance function make it possible to decompose R_p into a union of disjoint sets using the criterion that x and y belong to same class if the distance between x and y satisfies the condition

$$d(x,y) \leq D \ . \tag{A-6.5}$$

This division of the metric space into classes has following properties:

1. Distances between the members of two different classes X and Y do not depend on the choice of points x and y inside classes. One can therefore speak about distance function between classes.

2. Distances of points x and y inside single class are smaller than distances between different classes.

3. Classes form a hierarchical tree.

Notice that the concept of the ultra-metricity emerged in physics from the models for spin glasses and is believed to have also applications in biology [B10]. The emergence of p-adic topology as the topology of the effective space-time would make ultra-metricity property basic feature of physics.

Canonical correspondence between p-adic and real numbers

The basic challenge encountered by p-adic physicist is how to map the predictions of the p-adic physics to real numbers. p-Adic probabilities provide a basic example in this respect. Identification via common rationals and canonical identification and its variants have turned out to play a key role in this respect.

1. Basic form of the canonical identification

There exists a natural continuous map $I : R_p \to R_+$ from p-adic numbers to non-negative real numbers given by the "pinary" expansion of the real number for $x \in R$ and $y \in R_p$ this correspondence reads

$$
\begin{aligned}
y &= \sum_{k>N} y_k p^k \to x = \sum_{k<N} y_k p^{-k} \quad , \\
y_k &\in \{0,1,..,p-1\} \quad .
\end{aligned}
\tag{A-6.6}
$$

This map is continuous as one easily finds out. There is however a little difficulty associated with the definition of the inverse map since the pinary expansion like also decimal expansion is not unique ($1 = 0.999...$) for the real numbers x, which allow pinary expansion with finite number of pinary digits

$$
\begin{aligned}
x &= \sum_{k=N_0}^{N} x_k p^{-k} \quad , \\
x &= \sum_{k=N_0}^{N-1} x_k p^{-k} + (x_N - 1)p^{-N} + (p-1)p^{-N-1} \sum_{k=0,..} p^{-k} \quad .
\end{aligned}
\tag{A-6.7}
$$

The p-adic images associated with these expansions are different

$$
\begin{aligned}
y_1 &= \sum_{k=N_0}^{N} x_k p^k \quad , \\
y_2 &= \sum_{k=N_0}^{N-1} x_k p^k + (x_N - 1)p^N + (p-1)p^{N+1} \sum_{k=0,..} p^k \\
&= y_1 + (x_N - 1)p^N - p^{N+1} \quad ,
\end{aligned}
\tag{A-6.8}
$$

so that the inverse map is either two-valued for p-adic numbers having expansion with finite pinary digits or single valued and discontinuous and non-surjective if one makes pinary expansion unique by choosing the one with finite pinary digits. The finite pinary digit expansion is a natural choice since in the numerical work one always must use a pinary cutoff on the real axis.

2. The topology induced by canonical identification

The topology induced by the canonical identification in the set of positive real numbers differs from the ordinary topology. The difference is easily understood by interpreting the p-adic norm as a norm in the set of the real numbers. The norm is constant in each interval $[p^k, p^{k+1})$ (see **Fig. A-6.1**) and is equal to the usual real norm at the points $x = p^k$: the usual linear norm is replaced with a piecewise constant norm. This means that p-adic topology is coarser than the usual real topology and the higher the value of p is, the coarser the resulting topology is above a given length scale. This hierarchical ordering of the p-adic topologies will be a central feature as far as the proposed applications of the p-adic numbers are considered.

Ordinary continuity implies p-adic continuity since the norm induced from the p-adic topology is rougher than the ordinary norm. p-Adic continuity implies ordinary continuity from right as is clear already from the properties of the p-adic norm (the graph of the norm is indeed continuous from right). This feature is one clear signature of the p-adic topology.

Fig. 14. The real norm induced by canonical identification from 2-adic norm. `http://tgdtheory.fi/appfigures/norm.png`

The linear structure of the p-adic numbers induces a corresponding structure in the set of the non-negative real numbers and p-adic linearity in general differs from the ordinary concept of linearity. For example, p-adic sum is equal to real sum only provided the summands have no common pinary digits. Furthermore, the condition $x +_p y < max\{x, y\}$ holds in general for the p-adic sum of the real numbers. p-Adic multiplication is equivalent with the ordinary multiplication only provided that either of the members of the product is power of p. Moreover one has $x \times_p y < x \times y$ in general. The p-Adic negative -1_p associated with p-adic unit 1 is given by $(-1)_p = \sum_k (p-1)p^k$ and defines p-adic negative for each real number x. An interesting possibility is that p-adic linearity might replace the ordinary linearity in some strongly nonlinear systems so these systems would look simple in the p-adic topology.

These results suggest that canonical identification is involved with some deeper mathematical structure. The following inequalities hold true:

$$\begin{aligned} (x+y)_R &\leq x_R + y_R \ , \\ |x|_p|y|_R \leq (xy)_R &\leq x_R y_R \ , \end{aligned} \tag{A-6.9}$$

where $|x|_p$ denotes p-adic norm. These inequalities can be generalized to the case of $(R_p)^n$ (a linear vector space over the p-adic numbers).

$$\begin{aligned} (x+y)_R &\leq x_R + y_R \ , \\ |\lambda|_p|y|_R \leq (\lambda y)_R &\leq \lambda_R y_R \ , \end{aligned} \tag{A-6.10}$$

where the norm of the vector $x \in T_p^n$ is defined in some manner. The case of Euclidian space suggests the definition

$$(x_R)^2 = (\sum_n x_n^2)_R \ . \tag{A-6.11}$$

These inequalities resemble those satisfied by the vector norm. The only difference is the failure of linearity in the sense that the norm of a scaled vector is not obtained by scaling the norm of the original vector. Ordinary situation prevails only if the scaling corresponds to a power of p.

These observations suggests that the concept of a normed space or Banach space might have a generalization and physically the generalization might apply to the description of some non-linear systems. The nonlinearity would be concentrated in the nonlinear behavior of the norm under scaling.

3. Modified form of the canonical identification

The original form of the canonical identification is continuous but does not respect symmetries even approximately. This led to a search of variants which would do better in this respect. The modification of the canonical identification applying to rationals only and given by

$$I_Q(q = p^k \times \frac{r}{s}) = p^k \times \frac{I(r)}{I(s)} \tag{A-6.12}$$

is uniquely defined for rationals, maps rationals to rationals, has also a symmetry under exchange of target and domain. This map reduces to a direct identification of rationals for $0 \leq r < p$ and $0 \leq s < p$. It has turned out that it is this map which most naturally appears in the applications. The map is obviously continuous locally since p-adically small modifications of r and s mean small modifications of the real counterparts.

Canonical identification is in a key role in the successful predictions of the elementary particle masses. The predictions for the light elementary particle masses are within extreme accuracy same for I and I_Q but I_Q is theoretically preferred since the real probabilities obtained from p-adic ones by I_Q sum up to one in p-adic thermodynamics.

4. Generalization of number concept and notion of embedding space

TGD forces an extension of number concept: roughly a fusion of reals and various p-adic number fields along common rationals is in question. This induces a similar fusion of real and p-adic embedding spaces. Since finite p-adic numbers correspond always to non-negative reals n-dimensional space R^n must be covered by 2^n copies of the p-adic variant R_p^n of R^n each of which projects to a copy of R_+^n (four quadrants in the case of plane). The common points of p-adic and real embedding spaces are rational points and most p-adic points are at real infinity.

Real numbers and various algebraic extensions of p-adic number fields are thus glued together along common rationals and also numbers in algebraic extension of rationals whose number belong to the algebraic extension of p-adic numbers. This gives rise to a book like structure with rationals and various algebraic extensions of rationals taking the role of the back of the book. Note that Neper number is exceptional in the sense that it is algebraic number in p-adic number field Q_p satisfying $e^p \ mod \ p = 1$.

Fig. 15. Various number fields combine to form a book like structure. `http://tgdtheory.fi/appfigures/book.jpg`

For a given p-adic space-time sheet most points are literally infinite as real points and the projection to the real embedding space consists of a discrete set of rational points: the interpretation in terms of the unavoidable discreteness of the physical representations of cognition is natural. Purely local p-adic physics implies real p-adic fractality and thus long range correlations for the real space-time surfaces having enough common points with this projection.

p-Adic fractality means that M^4 projections for the rational points of space-time surface X^4 are related by a direct identification whereas CP_2 coordinates of X^4 at these points are related by I, I_Q or some of its variants implying long range correlates for CP_2 coordinates. Since only a discrete set of points are related in this manner, both real and p-adic field equations can be satisfied and there are no problems with symmetries. p-Adic effective topology is expected to be a good approximation only within some length scale range which means infrared and UV cutoffs. Also multi-p-fractality is possible.

The notion of p-adic manifold

The notion of p-adic manifold is needed in order to fuse real physics and various p-adic physics to a larger structure which suggests that real and p-adic number fields should be glued together along common rationals bringing in mind adeles. The notion is problematic because p-adic topology is totally disconnected implying that p-adic balls are either disjoint or nested so that ordinary definition of manifold using p-adic chart maps fails. A cure is suggested to be based on chart maps from p-adics to reals rather than to p-adics (see the appendix of the book)

The chart maps are interpreted as cognitive maps, "thought bubbles".

Fig. 16. The basic idea between p-adic manifold. `http://tgdtheory.fi/appfigures/padmanifold.jpg`

There are some problems.

1. Canonical identification does not respect symmetries since it does not commute with second pinary cutoff so that only a discrete set of rational points is mapped to their real counterparts by chart map arithmetic operations which requires pinary cutoff below which chart map takes rationals to rationals so that commutativity with arithmetics and symmetries is achieved in finite resolution: above the cutoff canonical identification is used

2. Canonical identification is continuous but does not map smooth p-adic surfaces to smooth real surfaces requiring second pinary cutoff so that only a discrete set of rational points is mapped to their real counterparts by chart map requiring completion of the image to smooth preferred extremal of Kähler action so that chart map is not unique in accordance with finite measurement resolution

3. Canonical identification violates general coordinate invariance of chart map: (cognition-induced symmetry breaking) minimized if p-adic manifold structure is induced from that for p-adic embedding space with chart maps to real embedding space and assuming preferred coordinates made possible by isometries of embedding space: one however obtains several in-equivalent p-adic manifold structures depending on the choice of coordinates: these cognitive representations are not equivalent.

A-6.2 Hierarchy of Planck constants and dark matter hierarchy

Hierarchy of Planck constants was motivated by the "impossible" quantal effects of ELF em fields on vertebrate cyclotron energies $E = hf = \hbar \times eB/m$ are above thermal energy is possible only if $\hbar$ has value much larger than its standard value. Also Nottale's finding that planetary orbits migh be understood as Bohr orbits for a gigantic gravitational Planck constant.

Hierachy of Planck constant would mean that the values of Planck constant come as integer multiples of ordinary Planck constant: $h_{eff} = n \times h$. The particles at magnetic flux tubes characterized by h_{eff} would correspond to dark matter which would be invisible in the sense that only particle with same value of h_{eff} appear in the same vertex of Feynman diagram.

Hierarchy of Planck constants would be due to the non-determism of the Kähler action predicting huge vacuum degeneracy allowing all space-time surfaces which are sub-manfolds of any $M^4 \times Y^2$, where Y^2 is Lagrangian sub-manifold of CP_2. For agiven Y^2 one obtains new manifolds Y^2 by applying symplectic transformations of CP_2.

Non-determinism would mean that the 3-surface at the ends of causal diamond (CD) can be connected by several space-time surfaces carrying same conserved Kähler charges and having same values of Kähler action. Conformal symmetries defined by Kac-Moody algebra associated with the embedding space isometries could act as gauge transformations and respect the light-likeness property of partonic orbits at which the signature of the induced metric changes from Minkowskian to Euclidian (Minkowskianb space-time region transforms to wormhole contact say). The number of conformal equivalence classes of these surfaces could be finite number n and define discrete physical degree of freedom and one would have $h_{eff} = n \times h$. This degeneracy would mean "second quantization" for the sheets of n-furcation: not only one but several sheets can be realized.

This relates also to quantum criticality postulated to be the basic characteristics of the dynamics of quantum TGD. Quantum criticalities would correspond to an infinite fractal hierarchy of broken conformal symmetries defined by sub-algebras of conformal algebra with conformal weights coming as integer multiples of n. This leads also to connections with quantum criticality and hierarchy of broken conformal symmetries, p-adicity, and negentropic entanglement which by consistency with standard quantum measurement theory would be described in terms of density matrix proportional $n \times n$ identity matrix and being due to unitary entanglement coefficients (typical for quantum computing systems).

Formally the situation could be described by regarding space-time surfaces as surfaces in singular n-fold singular coverings of embedding space. A stronger assumption would be that they are expressible as as products of n_1 -fold covering of M^4 and n_2-fold covering of CP_2 meaning analogy with multi-sheeted Riemann surfaces and that M^4 coordinates are n_1-valued functions and CP_2 coordinates n_2 -valued functions of space-time coordinates for $n = n_1 \times n_2$. These singular coverings of embedding space form a book like structure with singularities of the coverings localizable at the boundaries of causal diamonds defining the back of the book like structure.

Fig. 17. Hierarchy of Planck constants. `http://tgdtheory.fi/appfigures/planckhierarchy.jpg`

A-6.3 $M^8 - H$ duality as it is towards the end of 2021

The view of $M^8 - H$ duality (see Appendix **??**) has changed considerably towards the end 2021 [L41] after the realization that this duality is the TGD counterpart of momentum position duality of wave mechanics, which is lost in QFTs. Therefore M^8 and also space-time surface is analogous to momentum space. This forced us to give up the original simple identification of the points $M^4 \subset M^4 \times E^4 = M^8$ and of $M^4 \times CP_2$ so that it respects Uncertainty Principle (UP).

The first improved guess for the duality map was the replacement with the inversion $p^k \rightarrow m^k = \hbar_{eff} p^k/p^2$ conforming in spirit with UP but turned out to be too naive.

The improved form [L41] of the $M^8 - H$ duality map takes mass shells $p^2 = m^2$ of $M^4 \subset M^8$ to cds with size $L(m) = \hbar_{eff}/m$ with a common center. The slicing by mass shells is mapped to a Russian doll like slicing by cds. Therefore would be no CDs in M^8 contrary to what I believed first.

Quantum classical correspondence (QCC) inspires the proposal that the point $p^k \in M^8$ is mapped to a geodesic line corresponding to momentum p^k starting from the common center of cds. Its intersection with the opposite boundary of cd with size $L(m)$ defines the image point. This is not yet quite enough to satisfy UP but the additional details [L41] are not needed in the sequel.

The 6-D brane-like special solutions in M^8 are of special interest in the TGD inspired theory of consciousness. They have an M^4 projection which is $E = E_n$ 3-ball. Here E_n is a root of the real polynomial P defining $X^4 \subset M^8_c$ (M^8 is complexified to M^8_c) as a "root" of its octonionic continuation [L37, L38]. E_n has an interpretation as energy, which can be complex. The original interpretation was as moment of time. For this interpretation, $M^8 - H$ duality would be a linear identification and these hyper planes would be mapped to hyperplanes in $M^4 \subset H$. This motivated the term "very special moment in the life of self" for the image of the $E = E_n$ section of $X^4 \subset M^8$ [L34]. This notion does not make sense at the level M^8 anymore.

The modified $M^8 - H$ duality forces us to modify the original interpretation [L41]. The point $(E_n, p = 0)$ is mapped $(t_n = \hbar_{eff}/E_n, 0)$. The momenta (E_n, p) in $E = E_n$ plane are mapped to the boundary of cd and correspond to a continuous time interval at the boundary of CD: "very special moment" becomes a "very special time interval".

The quantum state however corresponds to a set of points corresponding to quark momenta, which belong to a cognitive representation and are therefore algebraic integers in the extension determined by the polynomial. These active points in E_n are mapped to a discrete set at the boundary of cd(m). A "very special moment" is replaced with a sequence of "very special moments".

So called Galois confinement [L39] forces the total momenta for bound states of quarks and antiquarks to be rational integers invariant under Galois group of extension of rationals determined by the polynomial P [L41]. These states correspond to states at boundaries of sub-CDs so that one obtains a hierarchy. Galois confinement provides a universal number theoretic mechanism for the formation of bound states.

A-7 Zero energy ontology (ZEO)

ZEO is implied by the holography forced in the TGD framework by general coordinate invariance.

A-7.1 Basic motivations and ideas of ZEO

The following gives a brief summary of ZEO [L36] [K108].

1. In ZEO quantum states are not 3-dimensional but superpositions of 4-dimensional deterministic time evolutions connecting ordinary initial 3-dimensional states. By holography they are equivalent to pairs of ordinary 3-D states identified as initial and final states of time evolution. One can say that in the TGD framework general coordinate invariance implies holography and the slight failure of its determinism in turn forces ZEO.

   Quantum jumps replace this state with a new one: a superposition of deterministic time evolutions is replaced with a new superposition. Classical determinism of individual time evolution is not violated and this solves the basic paradox of quantum measurement theory. There are two kinds of quantum jumps: ordinary ("big") state function reductions (BSFRs) changing the arrow of time and "small" state function reductions (SSFRs) (weak measurements) preserving it and giving rise to the analog of Zeno effect [L36].

2. To avoid getting totally confused it is good to emphasize some aspects of ZEO.

   (a) ZEO does not mean that physical states in the usual 3-D sense as snapshots of time evolution would have zero energy state pairs defining zero energy states as initial and final states have same conserved quantities such as energy. Conservation implies that one can adopt the conventions that the values of conserved quantities are opposite for these states so that their sum vanishes: one can think that incoming and outgoing particles come from geometric past and future is the picture used in quantum field theories.

(b) ZEO means two times: subjective time as sequence of quantum jumps and geometric time as space-time coordinate. These times are identifiable but are strongly correlated.

3. In BSFRs the arrow of time is changed and the time evolution in the final state occurs backwards with respect to the time of the external observer. BSFRs can occur in all scales since TGD predicts a hierarchy of effective Planck constants with arbitrarily large values. There is empirical support for BSFRs.

   (a) The findings of Minev et al [L31] in atomic scale can be explained by the same mechanism [L31]. In BSFR a final zero energy state as a superposition of classical deterministic time evolutions emerges and for an observer with a standard arrow of time looks like a superposition of deterministic smooth time evolutions leading to the final state. Interestingly, once this evolution has started, it cannot be stopped unless one changes the stimulus signal inducing the evolution in which case the process does not lead to anywhere: the interpretation would be that BSFR back to the initial state occurs!

   (b) Libets' experiments about active aspects of consciousness [J10] can be understood. Subject person raises his finger and neural activity starts before the conscious decision to do so. In the physicalistic framework it is thought to lead to raising of the finger. The problem with the explanation is that the activity beginning .5 seconds earlier seems to be dissipation with a reversed arrow of time: from chaotic and disordered to ordered at around .15 seconds. ZEO explanation is that macroscopic quantum jump occurred and generated a signal proceeding backwards in time and generated neural activity and dissipated to randomness.

   (c) Earthquakes involve a strange anomaly: they are preceded by ELF radiation. One would expect that they generate ELF radiation. The identification as BSFR would explain the anomaly [L33]. In biology the reversal of the arrow of time would occur routinely and be a central element of biological self-organization, in particular self-organized quantum criticality (see [L35, L48].

A-7.2 Some implications of ZEO

ZEO has profound implications for understanding self-organization and self-organized quantum criticality in terms of dissipation with non-standard arrow of time looking like generation of structures [L35, L48]. ZEO could also allow understanding of what planned actions - like realizing the experiment under consideration - could be.

1. Second law in the standard sense does not favor - perhaps even not allow - realization of planned actions. ZEO forces a generalization of thermodynamics: dissipation with a non-standard arrow of time for a subsystem would look like self-organization and planned action and its realization.

   Could most if not all planned action be like this - induced by BSFR in the geometric future and only apparently planned? There would be however the experience of planning and realizing induced by the signals from geometric future by a higher level in the hierarchy of conscious entities predicted by TGD! In long time scales we would be realizing our fates or wishes of higher level conscious entities rather than agents with completely free will.

2. The notion of magnetic body (MB) serving as a boss of ordinary matter would be central. MB carries dark matter as $h_{eff} = nh_0$ phases of ordinary matter with n serving as a measure for algebraic complexity of extension of rationals as its dimension and defining a kind of universal IQ. There is a hierarchy of these phases and MBs labelled by extension of rationals and the value of n.

   MBs would form a hierarchy of bosses - a realization for master slave hierarchy. Ordinary matter would be at the bottom and its coherent behavior would be induced from quantum coherence at higher levels. BSFR for higher level MB would give rise to what looks like planned actions and experienced as planned action at the lower levels of hierarchy. One could speak of planned actions inducing a cascade of planned actions in shorter time scales and eventually proceeding to atomic level.

A-8 Some notions relevant to TGD inspired consciousness and quantum biology

Below some notions relevant to TGD inspired theory of consciousness and quantum biology.

A-8.1 The notion of magnetic body

Topological field quantization inspires the notion of field body about which magnetic body is especially important example and plays key role in TGD inspired quantum biology and consciousness theory. This is a crucial departure fromt the Maxwellian view. Magnetic body brings in third level to the description of living system as a system interacting strongly with environment. Magnetic body would serve as an intentional agent using biological body as a motor instrument and sensory receptor. EEG would communicated the information from biological body to magnetic body and Libet's findings from time delays of consciousness support this view.

The following pictures illustrate the notion of magnetic body and its dynamics relevant for quantum biology in TGD Universe.

Fig. 18. Magnetic body associated with dipole field. `http://tgdtheory.fi/appfigures/fluxquant.jpg`

Fig. 19. Illustration of the reconnection by magnetic flux loops. `http://tgdtheory.fi/appfigures/reconnect1.jpg`

Fig. 20. Illustration of the reconnection by flux tubes connecting pairs of molecules. `http://tgdtheory.fi/appfigures/reconect2.jpg`

Fig. 21. Flux tube dynamics. a) Reconnection making possible magnetic body to "recognize" the presence of another magnetic body, b) braiding, knotting and linking of flux tubes making possible topological quantum computation, c) contraction of flux tube in phase transition reducing the value of h_{eff} allowing two molecules to find each other in dense molecular soup. `http://tgdtheory.fi/appfigures/fluxtubedynamics.jpg`

A-8.2 Number theoretic entropy and negentropic entanglement

TGD inspired theory of consciousness relies heavily p-Adic norm allows an to define the notion of Shannon entropy for rational probabilities (and even those in algebraic extension of rationals) by replacing the argument of logarithm of probability with its p-adic norm. The resulting entropy can be negative and the interpretation is that number theoretic entanglement entropy defined by this formula for the p-adic prime minimizing its value serves as a measure for conscious information. This negentropy characterizes two-particle system and has nothing to do with the formal negative negentropy assignable to thermodynamic entropy characterizing single particle. Negentropy Maximization Principle (NMP) implies that number theoretic negentropy increases during evolution by quantum jumps. The condition that NMP is consistent with the standard quantum measurement theory requires that negentropic entanglement has a density matrix proportional to unit matrix so that in 2-particle case the entanglement matrix is unitary.

Fig. 22. Schrödinger cat is neither dead or alive. For negentropic entanglement this state would be stable. `http://tgdtheory.fi/appfigures/cat.jpg`

A-8.3 Life as something residing in the intersection of reality and p-adicities

In TGD inspired theory of consciousness p-adic space-time sheets correspond to space-time correlates for thoughts and intentions. The intersections of real and p-adic preferred extremals consist of points whose coordinates are rational or belong to some extension of rational numbers in preferred embedding space coordinates. They would correspond to the intersection of reality and various p-adicities representing the "mind stuff" of Descartes. There is temptation to assign life to the intersection of realities and p-adicities. The discretization of the chart map assigning to real space-time surface its p-adic counterpart would reflect finite cognitive resolution.

At the level of "world of classical worlds" (WCW) the intersection of reality and various p-adicities would correspond to space-time surfaces (or possibly partonic 2-surfaces) representable in terms of rational functions with polynomial coefficients with are rational or belong to algebraic extension of rationals.

The quantum jump replacing real space-time sheet with p-adic one (vice versa) would correspond to a buildup of cognitive representation (realization of intentional action).

Fig. 23. The quantum jump replacing real space-time surface with corresponding p-adic manifold can be interpreted as formation of though, cognitive representation. Its reversal would correspond to a transformation of intention to action. `http://tgdtheory.fi/appfigures/padictoreal.jpg`

A-8.4 Sharing of mental images

The 3-surfaces serving as correlates for sub-selves can topologically condense to disjoint large space-time sheets representing selves. These 3-surfaces can also have flux tube connections and this makes possible entanglement of sub-selves, which unentangled in the resolution defined by the size of sub-selves. The interpretation for this negentropic entanglement would be in terms of sharing of mental images. This would mean that contents of consciousness are not completely private as assumed in neuroscience.

Fig. 24. Sharing of mental images by entanglement of subselves made possible by flux tube connections between topologically condensed space-time sheets associated with mental images. `http://tgdtheory.fi/appfigures/sharing.jpg`

A-8.5 Time mirror mechanism

Zero energy ontology (ZEO) is crucial part of both TGD and TGD inspired consciousness and leads to the understanding of the relationship between geometric time and experience time and how the arrow of psychological time emerges. One of the basic predictions is the possibiity of negative energy signals propagating backwards in geometric time and having the property that entropy basically associated with subjective time grows in reversed direction of geometric time. Negative energy signals inspire time mirror mechanism (see **Fig.** `http://tgdtheory.fi/appfigures/timemirror.jpg` or **Fig.** 24 in the appendix of this book) providing mechanisms of both memory recall, realization of intentational action initiating action already in geometric past, and remote metabolism. What happens that negative energy signal travels to past and is reflected as positive energy signal and returns to the sender. This process works also in the reverse time direction.

Fig. 25. Zero energy ontology allows time mirror mechanism as a mechanism of memory recall. Essentially "seeing" in time direction is in question. `http://tgdtheory.fi/appfigures/timemirror.jpg`

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REFERENCES

Mathematics

[A1] Hamiltonian cycles on icosahedron? Available at: https://cs.smith.edu/~orourke/MathOverflow/hpaths.html.

[A2] Icosahedral graph. Wolfram MathWorld. Available at: https://mathworld.wolfram.com/IcosahedralGraph.html.

[A3] Symmetrical Icosahedral Hamiltonians. Available at: https://www.flickr.com/photos/edwynn/sets/72157625709580605/.

[A4] Yangian symmetry. Available at: https://en.wikipedia.org/wiki/Yangian.

[A5] Winfree AT. *The Geometry of Biological Time.* Springer, New York, 1980.

[A6] Shafarevich IR Borevich ZI. *Number Theory.* Academic Press, 1966.

[A7] Pope CN. Eigenfunctions and $Spin^c$ Structures on CP_2, 1980.

[A8] Moak DS. The q-analogue of the Laguerre polynomials. *J Math Anal Appl*, 81, 1981.

[A9] Hanson J Eguchi T, Gilkey B. *Phys Rep*, 66, 1980.

[A10] Eisenhart. *Riemannian Geometry.* Princeton University Press, 1964.

[A11] Pope CN Gibbons GW. CP_2 as gravitational instanton. *Comm Math Phys*, 55, 1977.

[A12] Pope CN Hawking SW. Generalized Spin Structures in Quantum Gravity. *Phys Lett*, (1), 1978.

[A13] N. Hitchin. Kählerian twistor spaces. *Proc London Math Soc*, 8(43):133–151, 1981.. Available at: https://tinyurl.com/pb8zpqo.

[A14] Milnor J. *Topology form Differential Point of View.* The University Press of Virginia, Virginia, 1965.

[A15] Spivak M. *Differential Geometry I,II,III,IV.* Publish or Perish, Boston, 1970.

[A16] Thom R. *Comm Math Helvet*, 28, 1954.

[A17] Helgason S. *Differential Geometry and Symmetric Spaces.* Academic Press, New York, 1962.

[A18] Wallace. *Differential Topology.* W. A. Benjamin, New York, 1968.

Theoretical Physics

[B1] Chern-Simons theory. Available at: https://en.wikipedia.org/wiki/Chern\OT1\textendashSimons_theory.

[B2] Montonen Olive Duality. Available at: https://en.wikipedia.org/wiki/Montonen-Olive_duality.

[B3] Zee A. *The Unity of Forces in the Universe.* World Sci Press, Singapore, 1982.

[B4] Drell S Björken J. *Relativistic Quantum Fields.* Mc Graw-Hill, New York, 1965.

[B5] Rapoport D. Stochastic processes in conformal Riemann-Cartan-Weyl gravitation, 1991. Available at: https://link.springer.com/article/10.1007/BF00675614.

[B6] Witten E Dolan L, Nappi CR. Yangian Symmetry in $D = 4$ superconformal Yang-Mills theory, 2004. Available at: https://arxiv.org/abs/hep-th/0401243.

[B7] Plefka J Drummond J, Henn J. Yangian symmetry of scattering amplitudes in $\mathcal{N} = 4$ super Yang-Mills theory, 2009. Available at: https://cdsweb.cern.ch/record/1162372/files/jhep052009046.pdf.

[B8] Arkani-Hamed N et al. The All-Loop Integrand For Scattering Amplitudes in Planar N=4 SYM, 2010. Available at: https://arxiv.org/abs/1008.2958.

[B9] Minev ZK et al. To catch and reverse a quantum jump mid-flight, 2019. Available at: https://arxiv.org/abs/1803.00545.

[B10] Parisi G. *Field Theory, Disorder and Simulations.* World Scientific, 1992.

[B11] Zuber J-B Itzykson C. *Quantum Field Theory.* Mc Graw-Hill, New York, 1980.

[B12] Huang K. *Quarks,Leptons* & *Gauge Fields.* World Scientific, 1982.

Particle and Nuclear Physics

[C1] Sonoluminescence. Available at: https://en.wikipedia.org/wiki/Sonoluminescence.

[C2] Summaries of Widom-Larsen theory. Available at: https://newenergytimes.com/v2/sr/WL/WLTheory.shtml#summary.

[C3] Widom-Larsen LENR Theory Portal. Available at: https://newenergytimes.com/v2/sr/WL/WLTheory.shtml.

[C4] Rossi Reactor, 2011. Available at: https://en.wikipedia.org/wiki/Rossi_Reactor.

[C5] Rolfs C Assenbaum HJ, Langanke K. *Z Phys A*, 327, 1987.

[C6] Kervran CL. *Biological Transmutations.* Swan House Publishing Co., 1972.

[C7] Kervran CL. *Biological transmutations, and their applications in chemistry, physics, biology, ecology, medicine, nutrition, agriculture, geology.* Swan House Publishing Co., 1972.

[C8] Lewis E. Plasmoids and Cold Fusion. *Cold Fusion Times*, 2(1), 1994.

[C9] Storms E. Review of cold fusion effect, 1996. Available at: `https://www.jse.com/storms/1.html`.

[C10] Storms E. Cold fusion, an objective assessment, 2001. Available at: `https://home.netcom.com/~storms2/review8.html`.

[C11] Barber BR et al. *Phys Rev*, 72(9):1380, 1994.

[C12] Brawley SJ et al. Electron-Like Scattering of Positronium. *Science*, 330(6005):789, 2010. Available at: `https://www.sciencemag.org/cgi/content/abstract/330/6005/789`.

[C13] Davies DT et al. Precise Charm to Strange Mass Ratio and Light Quark Masses from Full Lattice QCD. *Phys Rev*, 104, 2010. Available at: `https://prl.aps.org/abstract/PRL/v104/i13/e132003`.

[C14] Jenkins JH et al. Evidence for Correlations Between Nuclear Decay Rates and Earth-Sun Distance, 2008. Available at: `https://arxiv.org/abs/0808.3283`.

[C15] Lobashev VM et al. In Maalampi J Enqvist K, Huitu K, editor, *Neutrino 96*, Singapore, 1996. World Scientific.

[C16] Mizuno T et al. Hydrogen Evolution by Plasma Electrolysis in Aqueous solution. *Jap J Appl Phys*, 44(1):396–401, 2002.

[C17] Rolfs C et al. First hints on a change of the ^{2}2Na beta decay half-life in the metal Pd. *Eur Phys J A*, 28, 2006.

[C18] Rolfs C et al. High-Z electron screening, the cases ^{50}V(p,n)^{50}. *Eur Phys J A*, 28, 2006.

[C19] Shnoll SE et al. Realization of discrete states during fluctuations in macroscopic processes. *Usp Fis Nauk*, 41(10):1025–1035, 1998.

[C20] Taleyarkhan RP et al. Nuclear Emissions During Self-Nucleated Acoustic Cavitation, 2006. Available at: `https://adsabs.harvard.edu/abs/2006PhRvL..96c4301T`.

[C21] Weinheimer C et al. *Phys Lett B*, 300:210, 1993.

[C22] Rossi A Focardi S. A new energy source from nuclear fusion, 2011. Available at: `https://tinyurl.com/ohal8cd`.

[C23] Stephenson GJJr. In Van Thanh JT et al, editor, *Perspectives in Neutrinos, Atomic Physics and Gravitation*, page 31. Editions Frontieres, Gif-sur-Yvette, 1993.

[C24] Muir H. Cloaking effect in atoms baffles scientists. *New Scientist* . Available at: `https://tinyurl.com/38z2ymv`, 2010.

[C25] Chaudhary IU Hagelstein PL. Electron mass shift in nonthermal systems, 2008. Available at: `https://arxiv.org/abs/0801.3810`.

[C26] Rothwell J. Some recent developments in cold fusion, 1996. Available at: `https://ourworld.compuserve.com/homepages/JedRothwell/brieftec.htm`.

[C27] Bjorken JD. *Acta Phys Pol B*, 28:2773, 1997.

[C28] Collar JI. Endpoint Structure in Beta Decay from Coherent Weak-Interaction of the Neutrino, 1996. Available at: `https://arxiv.org/abs/hep-ph/9611420`.

[C29] Weiner N Kaplan DB, Nelson AE. Neutrino Oscillations as a Probe of Dark Energy, 2004. Available at: https://arxiv.org/abs/hep-ph/0401099.

[C30] McLerran L Ludham T. What Have We Learned From the Relativistic Heavy Ion Collider? *Phys Today* . Available at: https://www.physicstoday.org/vol-56/iss-10/p48.html, 2003.

[C31] Hansen PG. Nuclear structure at the drip lines, 1993.

[C32] Rodney WS Rolfs C. *Cauldrons in the Cosmos.* Universy of Chicago Press, Chicago, 1988.

[C33] Bird C Tompkins P. *The secret life of plants.* Harper & Row, New York, 1973.

[C34] Larsen L Widom A. Absorption of Nuclear Gamma Radiation by Heavy Electrons on Metallic Hydride Surfaces, 2005. Available at: https://arxiv.org/abs/cond-mat/0509269.

[C35] Larsen L Widom A. Theoretical Standard Model Rates of Proton to Neutron Conversions Near Metallic Hydride Surfaces, 2006. Available at: https://arxiv.org/abs/nucl-th/0608059.

Condensed Matter Physics

[D1] Burning salt water. Available at: https://www.youtube.com/watch?v=aGg0ATfoBgo.

[D2] Copper. Available at: https://en.wikipedia.org/wiki/Copper.

[D3] Digital camera. Available at: https://en.wikipedia.org/wiki/Digital_camera.

[D4] Faraday effect. Available at: https://en.wikipedia.org/wiki/Faraday_effect.

[D5] Geometric optics. Available at: https://en.wikipedia.org/wiki/Geometric_optics.

[D6] High temperature and other unconventional superconductors. Available at: https://www.fkf.mpg.de/metzner/research/hightc/hightc.html.

[D7] Index of refraction. Available at: https://en.wikipedia.org/wiki/Index_of_refraction.

[D8] Lense flare. Available at: https://en.wikipedia.org/wiki/Lens_flare.

[D9] Liquid crystals on line. Available at: https://www.lcionline.net/.

[D10] Mpemba effect. Available at: https://en.wikipedia.org/wiki/Mpemba_effect.

[D11] Percolation. Available at: https://en.wikipedia.org/wiki/Percolation.

[D12] Spontaneous burning. Available at: https://tinyurl.com/nlj65la.

[D13] Spontaneous human combustion. Available at: https://tinyurl.com/jb5w.

[D14] Tutorials: Lense flare. Available at: https://www.cambridgeincolour.com/tutorials/lens-flare.htm.

[D15] Scientists Detect 'Fingerprint' of High-temperature Superconductivity Above Transition Temperature. *Science Daily*, 2009. Available at: https://www.sciencedaily.com/releases/2009/08/090827141338.htm.

[D16] Munich researchers make groundbreaking discovery about gamma rays, 2012. Available at: https://tinyurl.com/p4zy9a6.

[D17] Gold lenses used to create gamma optics, 2012. Available at: https://www.mpg.de/5799885/gold_lenses_gamma_optics?.

[D18] Hellemans A. Labs Hold the Key to the 21-Micrometer Mystery. *Science*, 284(5417):1113, 1999.

[D19] Beck C. Possible Resonance Effect of Axionic Dark Matter in Josephson Junctions. *Phys Rev Lett*, 111(23), 2013. Available at: https://prl.aps.org/abstract/PRL/v111/i23/e231801.

[D20] Basov DN Carbotte J, Schachinger E. *Nature*, 401:354–356, 1999.

[D21] Pennsylvania Center Development Air Naval laboratory Bio-chemistry US. Evidence from Activation Energies for Super-conductive Tunneling in Biological Systems at Physiological Temperatures. *Physiol Chem & Phys*, 3:403–410, 1971.

[D22] Wilson CT. *Proc Phys Soc London*, 37, 1925.

[D23] Springford M (ed). *Electron: A Centennary Volume*. Cambridge University Press, Cambridge, 1997.

[D24] Eck EJ. The first 200 K superconductor, 2015. Available at:https://www.superconductors.org/400K_SC.htm.

[D25] Tranquada JM Emery VJ, Kivelson SA. Stripe phases in high-temperature superconductors. *Perspective*, 96(16), 1999. Available at: https://www.pnas.org/cgi/reprint/96/16/8814.pdf.

[D26] Aoki D et al. Coexistence of super-conductivity and ferromagnetism in URhGe. *Nature*, 413, 2001.

[D27] Barber BR et al. *Phys Rev*, 72(9):1380, 1994.

[D28] Barton JK et al. *Science*, 275(7):1465, 1997.

[D29] Cantatore G et al. Experimental observation of optical rotation generated in vacuum by a magnetic field, 2005.Available at: https://arxiv.org/abs/hep-exp/0507107.

[D30] Castleman AW et al. Al Cluster Superatoms as Halogens in Polyhalides and as Alkaline Earths in Iodide Salts. *Science*, 307, 2005.

[D31] Fong HS et al. *Phys Rev*, 75, 1995.

[D32] Gammaitoni L et al. Stochastic Resonance. *Rev Mod Phys* ., 70, 1998.Available at: https://www.umbrars.com/sr/.

[D33] Gingras JP et al. Nematicity in stripe-ordered cuprates probed via resonant x-ray scattering. *Science*, 351(6273), 2016. Available at:https://tinyurl.com/zycahrx.

[D34] Giudice Del E et al. Magnetic Flux Quantization and Josephson Behavior in Living Systems. *Phys*, 40:786–791, 1989.

[D35] Habs D et al. Refractive Index of Silicon at γ Ray Energies. *Phys Rev Lett* ., 108(18), 2012.

[D36] Hua R-H et al. From a Single-Band Metal to a High-Temperature Superconductor via Two Thermal Phase Transitions. *Science*, 331(6024):1579–1583, 2011. Available at: https://www.sciencemag.org/content/331/6024/1579.abstract.

[D37] Iranzo DA et al. Probing the ultimate plasmon confinement limits with a van der Waals heterostructure. *Science*, 360(6386):291–295, 2018. Available at: https://science.sciencemag.org/content/360/6386/291.

[D38] Knight WD et al. *Phys Rev*, 52, 1984.

[D39] Levy F et al. Magnetic Field-Induced Super-conductivity in the Ferromagnet URhGe. *Science*, August 2005.

[D40] Mathur ND et al. Magnetic superglue promotes super-conductivity. *Physics Web*, 1998.Available at: `https://physicsweb.org/articles/news/2/7/3`.

[D41] Mills R et al. Spectroscopic and NMR identification of novel hybrid ions in fractional quantum energy states formed by an exothermic reaction of atomic hydrogen with certain catalysts, 2003. Available at: `https://www.blacklightpower.com/techpapers.html`.

[D42] Moock HA et al. *Phys Rev*, 70, 1993.

[D43] Moreh R et al. Search for anomalous scattering of keV neutrons from H2O-D2O mixtures. *Phys Rev*, 94, 2005.

[D44] Morris DJ et al. Dirac Strings and Magnetic Monopoles in Spin Ice Dy2Ti2O7. *Physics World*, 326(5951):411–414, 2009.Available at: `https://physicsworld.com/cws/article/news/40302`.

[D45] Novoselov KS et al. Two-dimensional gas of massless Dirac fermions in graphene. *Nature*, 438, November 2005.

[D46] Orenstein J et al. In *Electronic properties of high T_c super conductors*, pages 254–259, Berlin, 1990. Springer.

[D47] Rosenthal EP et al. Visualization of electron nematicity and unidirectional antiferroic fluctuations at high temperatures in NaFeAs. *Nature Physics*, 10:225 232, 2014. Available at:`https://www.nature.com/nphys/journal/v10/n3/full/nphys2870.html`.

[D48] Rossat-Mignot J et al. *Phys Rev*, 235:59, 1994.

[D49] Sebastian SE et al. Unconventional fermi surface in an insulating state. *Science*, 349(6243):605–607, 2015. Available at: `ttps://en.wikipedia.org/wiki/Pi_bond`.

[D50] Wollman DA et al. Experimental determinination of the super-conducting pairing state in YBCO from the phase coherence of YBCO-Pb dc SQUIDs. *Phys Rev*, 71, 1993.

[D51] Boudin A Flouquet J. Ferromagnetic super-conductors. *Physics Web*, 2002. Available at: `https://physicsweb.org/articles/world/15/1/9`.

[D52] Burns G. *High Temperature Super Conductivity*. Academic Press, 1993.

[D53] Langmuir I. *J Am Chem Soc*, 37, 1915.

[D54] Morgenstern I. *Spin-Glass behavior of high T_c super conductors*. Springer Verlag, 1990.

[D55] Kostadinov IZ. 373 K Superconductors, 2016. Available at:`https://arxiv.org/pdf/1603.01482v1.pdf`.

[D56] Orenstein J. High-temperature superconductivity: Electrons pair themselves. *Nature*, 401:333–335, 1999.

[D57] Zaanen J. Why high Tc is exciting?, 2005. Available at: `https://www.lorentz.leidenuniv.nl/research/jan_hitc.pdf`.

[D58] Zaanen J. Superconductivity: Quantum Stripe Search. *Nature*, 2006. Available at: `https://www.lorentz.leidenuniv.nl/~jan/nature03/qustripes06.pdf`.

[D59] Zaanen J. Superconductivity: Quantum Stripe Search. *Nature*, 2006. Available at: `https://www.lorentz.leidenuniv.nl/~jan/nature03/qustripes06.pdf`.

[D60] Zaanen J. Watching Rush Hour in the World of Electrons. *Science*, 2007. Available at: `https://www.ilorentz.org/~jan/perspstripes.pdf`.

[D61] Borchardt JK. The chemical formula H2O - a misnomer. *Alchemist*, August 2003.

[D62] Ross DK Li J-C. Evidence of Two Kinds of Hydrogen Bonds in Ices. *Nature*, 365:327–329, 1993.

[D63] Buchanan M. Mind the pseudogap. *Nature*, 409:8–11, 2001.Available at: https://www.physique.usherbrooke.ca/taillefer/Projets/Nature-409008.pdf.

[D64] Chaplin M. Water Structure and Behavior, 2005. Available at: https://www.lsbu.ac.uk/water/index.html. For the icosahedral clustering see https://www.lsbu.ac.uk/water/clusters.html.

[D65] Rabinowitz M. Phenomenological Theory of Superfluidity and Super-conductivity, 2001. Available at: https://arxiv.org/abs/cond-mat/0104/0104059.

[D66] Ho M-W. Can Water burn, 2009. Available at: https://www.i-sis.org.uk/canWaterBurn.php.

[D67] Ho M-W. Living with Oxygen, 2009. Available at: https://www.i-sis.org.uk/livingWithOxygen.php.

[D68] Ho M-W. Making Fuel from Water . *Institute of Sci in Soc report.*, 2009. Available at: https://www.i-sis.org.uk/makingFuelFromWater.php.

[D69] Ho M-W. The body does burn water, 2009. Available at: https://www.i-sis.org.uk/theBodyDoesBurnWater.php.

[D70] Ho M-W. Water electric. *Institute of Sci in Soc report*, 2009.Available at: https://www.i-sis.org.uk/WaterElectric.php.

[D71] Ball P. A new kind of alchemy. *New Scientist*, 2005. Available at: https://www.newscientist.com/channel/fundamentals/mg18624951.800.

[D72] Cowley RA. Neutron-scattering experiments and quantum entanglement. *Phys B*, 350:243–245, 2004.

[D73] Sachdev S. Quantum phase transitions (summary). *Physics World*, pages 33–38, April 1999.

[D74] Pollack G Zheng J-M. Long-range forces extending from polymer-gel surfaces, 2003. Available at: https://arxiv.org/abs/cond-mat/0305093.

Cosmology and Astro-Physics

[E1] Solar data. Available at: https://hyperphysics.phy-astr.gsu.edu/hbase/solar/soldata2.html.

[E2] Nottale L Da Rocha D. Gravitational Structure Formation in Scale Relativity, 2003. Available at: https://arxiv.org/abs/astro-ph/0310036.

[E3] Shnoll SE et al. Realization of discrete fluctuations in macroscopic processes. *Physics-Uspekhi*, 41(10):1025–1035.

[E4] Tajmar M et al. Experimental Detection of Gravimagnetic London Moment, 2006. Available at: https://arxiv.org/abs/gr-gc0603033. See also the popular article "Towards new tests of general relativity", at https://www.esa.int/SPECIALS/GSP/SEM0L6OVGJE_0.html.

[E5] Matos de CJ Tajmar M. Local Photon and Graviton Mass and Its Consequences, 2006. Available at: https://arxiv.org/abs/gr-gc0603032.

Physics of Earth

[F1] Anaerobic bacteria. Available at: https://en.wikipedia.org/wiki/Anaerobic_bacteria.

[F2] Lightning. Available at: https://en.wikipedia.org/wiki/Lightning.

[F3] Auroras, Paintings in the Sky, 1999. Available at: https://www.exploratorium.edu/learning_studio/auroras/happen.html.

[F4] Sonnerup BUO. In Parker EN Lanzerotti LT, Kennel CF, editor, *Solar System Plasma Physics, vol. III*, volume 45, New York, 1979. North-Holland.

[F5] Day C. Spacecraft Probes the Site of Magnetic Reconnection in Earth's Magnetotail. *Physics to Day*, (10):16, 2001. Available at: https://www.physicstoday.org/pt/vol-54/iss-10/p16.html.

[F6] Sentman DD. *Schumann Resonances*, volume 1, pages 267–295. Boca Raton: CRC Press, 1995.

[F7] Bering EA. Apparent electrostatic ion cyclotron waves in the diffuse aurora. *Geophys Res Lett*, 10:647–650, 1983.

[F8] Williams ER. Sprites, Elves, and Glow Discharge Tubes. *Physics to Day*, 52(11), 2001.

[F9] Marklund GT et al. *Nature*, 414:724, 2001.

[F10] Oieroset M et al. *Nature*, 412.

[F11] Zgrablic G et al. Instrumental recording of electrophonic sounds from Leonid fireballs. *J. Geophys Res*, 2001. Available at: https://fizika.org/ilwcro/results/.

[F12] Hecht J. The Giant Crystal at the Heart of the Earth. *New Scientist*, page 17, 1994.

[F13] Jones N. Lightning strikes release powerful X-ray bursts. *New Scientist*, 177(2381):18, 2003. Available at: https://archive.newscientist.com.

[F14] Wescott EM Sentman DD. *Geophys Res Lett*, 20, 1993.

[F15] Hansen TL. The northern lights-what are they?, 2001. Available at: https://geo.phys.uit.no/articl/theaurora.html.

[F16] Lyons WA. *Geophys Res Lett*, 21, 1994.

Fringe Physics

[H1] Electric Currents Accompanying Tornado Activity. *Science*, 157:22.

[H2] M. B. King. Free-energy devices. Available at: https://www.free-energy-info.co.uk/MorayKing.pdf.

[H3] The Home of Primordial Energy. Patent application for the space power generator of P. Tewari. Available at: https://www.depalma.pair.com.

[H4] Thomas Townsend Brown. Available at: https://www.virtualtheater.com/ttbrown-01.html.

[H5] Twister: The Tornado Story, 2003. Wisconsin University. Available at: https://whyfiles.org/013tornado/3.html.

[H6] DePalma B. Notes on Faraday disc, 1995. Available at: https://www.depalma.pair.com.

[H7] Hudson D. Mono-atomic elements, 2003. Available at: https://www.halexandria.org/dward479.htm.

[H8] Lewis E. Luminous Tornadoes and Other Plasmoids. *Cold Fusion Times*, 1(4):4, 1994.

[H9] Urutskoev LI et al. Observation of transformation of chemical elements during electric discharge. *Ann. Fond. L. de Broglie*, 27(701), 2002. Available at: https://arxiv.org/abs/arXiv:physics/0101089.

[H10] Burridge G. In *Townsend Brown and his antigravity discs*, 1994. Available at: https://www.spiritweb.com/Spirit/anti-gravity.html.

[H11] Hutchison J. The Hutchison Effect Apparatus. *Proc first Symposium on New Energy, Denver, May*, 199, 1994.

[H12] Naudin J. Free Energy Atomic Hydrogen: the MAHG project, 2005. Available at: https://jlnlabs.imars.com/mahg/tests/index.htm.

[H13] Jochmans JR. Strange Relics from the Depths of the Earth, 1979. Available at: https://www.delusionresistance.org/creation/antedeluvian_finds.html.

[H14] Fredericks KA. Possible detection of tachyon monopoles in photographic emulsions. *just-something*, 2013. Available at: https://restframe.com/downloads/tachyon_monopoles.pdf.

[H15] Essen H Levi G, Foschi E. Indication of anomalous heat energy production in a reactor containing hydrogen loaded nickel powder, 2013. Available at: https://arxiv.org/pdf/1305.3913.pdf.

[H16] Rose M. "The Flying Saucer". The Application of the Biefield-Brown Effect to the Solution of the Problems of Space Navigation, 1952. Available at: https://www.soteria.com/brown/docs/rose.htm.

[H17] King MB. Water Electrolyzers and the Zero-Point Energy. *Phys Procedia*, 20:335–445, 2011. Available at: https://www.sciencedirect.com/science/journal/18753892.

[H18] Nieminen R Podkletnov E. Weak gravitational shielding properties of composite bulk YBa2Cu3O7-x super-conductor below 70 K under electro-magnetic field, 1992. Available at: https://arxiv.org/abs/cond-mat/9701074. Report MSU-chem 95, improved version at https://arxiv.org/abs/cond-mat/9701074.

[H19] Nelson RA. *Transmutations of Ores*. Available at: https://www.levity.com/alchemy/nelson2_2.html.

[H20] Mignani R Recami E. Classical theory of tachyons (special relativity extended to superluminal frames and objects). *Nuovo Cimento*, 4(209):209–290, 1974.

[H21] Godin SM Roshchin VV. An Experimental Investigation of the Physical Effects in a Dynamic Magnetic System. *New Energy Technologies*, 1, 2001.

[H22] Weyer J Vonnegut B. Luminous Phenomena in Nocturnal Tornadoes. *Science*, 153:9, 1966.

[H23] Corliss W. Ancient Man: A Handbook of Puzzling Artifacts, 1978. Available at: `https://www.miqel.com/text/tcookie.html`.

Biology

[I1] Aromaticity. Available at: `https://en.wikipedia.org/wiki/Aromatic_rings`.

[I2] Earth's magnetic field regions of weakness correlated to sites of political unrest and war: the paradigm quaking measurements of professor Phil Callahan. Available at: `https://www.acacialand.com/Callahan.html`.

[I3] Homeopathy. Available at: `https://en.wikipedia.org/wiki/Homeopathy`.

[I4] Pollack Laboratory- Biographical Sketch. Available at: `https://faculty.washington.edu/ghp/cv/`.

[I5] The Fourth Phase of Water: Dr. Gerald Pollack at TEDxGuelphU, 2014. Available at: `https://www.youtube.com/watch?v=i-T7tCMUDXU`.

[I6] Kaivarainen A. Abstract of conference: Toward a science of consciousness-iii, 1998, no: 1078, tucson, usa, 1998.

[I7] Kiger JAJr Ayuala FJ. *Modern Genetics*. Benjamin Cummings, 1984.

[I8] Smith C. *Learning From Water , A Possible Quantum Computing Medium*. CHAOS, 2001.

[I9] McMenamin PG Chinnery HR, Pearlman E. Cutting Edge: Membrane Nanotubes In Vivo: A Feature of MHC Class II+ Cell s in the Mouse Cornea. *J Immunol*, 180:5779–5783, 2008.

[I10] Murogoki P Comorosan S, Hristea M. On a new symmetry in biological systems. *Bull Math Biol*, page 107, 1980.

[I11] Koruga D. Micro-tubule screw symmetry: packing of spheres as a latent bioinformation code. *Ann Ny Acad Sci*, 466, 1974.

[I12] Woodbury DJ. Pure lipid vesicles can induce channel-like conductances in planar bilayers., 1989.

[I13] Levich E. *Phys Rep*, 3, 1987.

[I14] Barton K et al. *Sci*, 275, 1997.

[I15] Benveniste J et al. Human basophil degranulation triggered by very dilute antiserum against IgE. *Nature*, 333:816–818, 1988.

[I16] Benveniste J et al. Transatlantic transfer of digitized antigen signal by telephone link. *J Allergy and Clinical Immunology*, 99:175, 1989. Available at: `https://www.digibio-.com/`.

[I17] Cisse I et al. Real-Time Dynamics of RNA Polymerase II Clustering in Live Human Cells. *Science*, 341(6146):664–667, 2013. Available at: `https://science.sciencemag.org/content/341/6146/664`.

[I18] Feng B et al. Hydrophobic catalysis and a potential biological role of DNA unstacking induced by environment effects. *PNAS*, 116(35):17169–17174, 2019. Available at: https://tinyurl.com/y5kwo5b4.

[I19] Gariaev P et al. *The DNA-wave biocomputer*, volume 10. CHAOS, 2001.

[I20] Gariaev PP et al. Holographic Associative Memory of Biological Systems. *Proceedings SPIE - The International Soc for Opt Eng . Optical Memory and Neural Networks*, pages 280–291, 1991.

[I21] Gariaev PP et al. The spectroscopy of bio-photons in non-local genetic regulation. *J Non-Locality and Remote Mental Interactions*, (3), 2002. Available at: https://www.emergentmind.org/gariaevI3.htm.

[I22] Gladfelter AS et al. mRNA structure determines specificity of a polyQ-driven phase separation. *Science*, 12, 2018. Available at: https://science.sciencemag.org/content/early/2018/04/13/science.aar7432.

[I23] Lev AA et al. Rapid switching of ion current in narrow pores: implications for biological ion channels. *Proc R Soc London. Series B: Biological Sci s*, pages 187–192, 1993.

[I24] Ling GN et al. Experimental confirmation, from model studies, of a key prediction of the polarized multilayer theory of cell water. *Physiological Chem & Phys*, 10(1):87–88, 1978.

[I25] Montagnier L et al. Electromagnetic Signals Are Produced by Aqueous Nanostructures Derived from Bacterial DNA Sequences. *Interdiscip Sci Comput Life Sci* . Available at: https://www.springerlink.com/content/0557v31188m3766x/, 2009.

[I26] Montagnier L et al. DNA waves and water, 2010. Available at: https://arxiv.org/abs/1012.5166.

[I27] Bludorf F Fozar G. Scientists prove DNA Can Be Reprogrammed by Words and Frequencies, 2014.

[I28] Albrecht-Buehler G. Surface extensions of 3T3 cells towards distant infrared sources. *J Cell Biology*, 114:493–502, 1991.

[I29] Pollack G. *Cells, Gels and the Engines of Life.* Ebner and Sons, 2000. Available at: https://www.cellsandgels.com/.

[I30] Maslow MU Gariaev PP. Fractal Presentation of Natural Language Texts and Genetic Code, 2nd International Conference on Quantitative Linguistics. *QUALICO '94*, pages 193–194, 1994.

[I31] Tovmash AV Gariaev PP, Tertishni GG. Experimental investigation in vitro of holographic mapping and holographic transposition of DNA in conjuction with the information pool encircling DNA. *New Medical Technologies*, 9:42–53, 2007.

[I32] Ling GN. *A physical theory of the living state: the association-induction hypothesis; with considerations of the mechanics involved in ionic specificity.* Blaisdell Pub. Co., New York, 1962.

[I33] Fröhlich H. The extraordinary dielectric properties of biological materials and the action of enzymes. *Nature*, 72(1968):641–649, 1975.

[I34] Saunders PT Ho M-W. *Liquid Crystalline Mesophase in living organisms.* World Scientific, Singapore, 1994.

[I35] Matter-Walstra K. Unasked questions, 1999. Available at: https://www.datacomm.ch/kmatter/unaskq.htm.

[I36] Sanduloviciu M Lozneanu E. Minimal-cell system created in laboratory by self-organization. *Chaos , Solitons & Fractals*, 18(2):335, 2003. See also *Plasma blobs hint at new form of life.* New Scientist vol. 179, No. 2413 p. 20 September 2003, page 16.

[I37] Buchanan M. Shape is all. *New Scientist*, 2157, 1998.

[I38] Ho M-W. *The Rainbow and the Worm.* World Scientific, Singapore, 1993.

[I39] Stevens MJ. Simple Simulations of DNA Condensation. *Biophys. J.*, 80(1):130–139, 2001. Available at: https://www.biophysj.org/cgi/content/full/80/1/130#E8.

[I40] Rattemayer M Nagl W, Popp F-A. Evidence of Photon Emission from DNA in Living Systems. *Naturwissenschaften*, 68(5):577, 1981.

[I41] Gariaev PP. Another Understanding of the model of genetic code theoretical analysis. *Open Journal of Genetics*, 5:92–109, 2018. Available at: https://file.scirp.org/Html/5-1370212_57601.htm.

[I42] Callahan PS. Moth and Candle: the Candle Flame as a Sexual Mimic of the Coded Infrared Wavelengths from a Moth Sex Scent. *Appl Opt*, 16(12), 1977.

[I43] Orians GH Purves WK. *Life: The Sci of Biology.* Sinauer, Massachusetts, 1987.

[I44] Comorosan S. On a possible biological spectroscopy. *Bull Math Biol*, page 419, 1975.

[I45] Comorosan S. On a possible biological spectroscopy. *Bull Math Biol*, page 419, 1975.

[I46] Qin F Sachs F. Gated, ion-selective channels observed with patch pipettes in the absence of membranes: novel properties of a gigaseal. *Biophys J*, pages 1101–1107, 1993.

[I47] Neher B Sakmann B. *Single-channel recording.* Plenum, London, 1983.

[I48] Rau DC Sidorova NY. Differences between EcoRI Nonspecific and "Star" Sequence Complexes Revealed by Osmotic Stress. *Biophys J* . Available at: https://www.biophysj.org/cgi/content/full/87/4/2564, 87, 2004.

[I49] Scordino A Triglia A, Musemeci F. Biophysical aspects of the ultraweak Photon emission from the living systems during growth, 2001. Available at: https://www.datadiwan.de/iib/ib1002e1.htm.

[I50] Poponin V. DNA PHANTOM EFFECT: Direct Measurement of a New Field in the Vacuum Substructure, 1996. Available at: https://www.webcom/~hrtmath/IHM/ResearchPapers/DNAPhantom/DNAPhantom.html.

Neuroscience and Consciousness

[J1] A Secret Sense in The Human Nose? Available at: https://www.hhmi.org/senses/.

[J2] Action potential. Available at: https://en.wikipedia.org/wiki/Action_potential.

[J3] Bipolar Disorder. Available at: https://www.nimh.nih.gov/publicat/bipolar.cfm#readNow.

[J4] Color vision. Available at: https://en.wikipedia.org/wiki/Color_vision.

[J5] Photoreceptor cell. Available at: https://en.wikipedia.org/wiki/Photoreceptor_cell.

[J6] Retinal Transduction: Hyperpolarization of Primary Photoreceptors by Ligh. Available at: https://www.acbrown.com/neuro/Lectures/NrVisn/NrVisnRtnlHprp.htm.

[J7] What is Consciousness? Available at: https://www.quantumconsciousness.org/presentations/whatisconsciousness.html.

[J8] Bandyopadhyay A. Experimental Studies on a Single Microtubule (Google Workshop on Quantum Biology), 2011. Available at: https://www.youtube.com/watch?v=VQngptkPYE8.

[J9] Gibbons A. Solving the Brain 's Energy Crisis. *Science*, 280, 1998.

[J10] Libet B. Readiness potentials preceding unrestricted spontaneous and preplanned voluntary acts, 1982. Available at: https://tinyurl.com/jqp1. See also the article *Libet's Research on Timing of Conscious Intention to Act: A Commentary* of Stanley Klein at https://tinyurl.com/jqp1.

[J11] Selden G Becker RO. *The Body Electric: Electromagnetism and the Foundation of Life.* William Morrow & Company, Inc., New York, 1990.

[J12] Nordenström BEW. Biologically Closed Electric Circuits. *Nordic Med Pub*, 4:47.

[J13] Baars BJ. Understanding Subjectivity: Global Workspace Theory and the Resurrection of the Observing Self. *J Conscious Stud*, 3(3):211–16, 1996.

[J14] House DE Blackman CF, Benane SG. The influence of temperature during electric- and magnetic-field induced alteration of calcium-ion release from in vitro brain tissue. *Bioelectromagn*, 12:173–182, 1991.

[J15] Pert CB. *Molecules of Emotion.* Simon & Schuster Inc., 1997.

[J16] Blackman CF. *Effect of Electrical and Magnetic Fields on the Nervous System*, pages 331–355. Plenum, New York, 1994.

[J17] Yarrow D. Spin the tale of the dragon, 1990. Available at: https://www.ratical.org/reatvlle/RofD2.html.

[J18] Nanopoulos DV. Theory of Brain function, Quantum Mechanics, and Superstrings, 1995. Available at: https://arxiv.org/abs/hep-ph/9505374.

[J19] Mitchell E. Space Flight as an Anticipatory Computing System, 1999. Available at: https://www.isso.org/inbox/flight.htm.

[J20] Cheron G et al. Inactivation of Calcium-Binding Pr ein Genes Induces 160 Hz Oscillations in the Cerebellar Cortex of Alert Mice. *J Neurosci*, 2004:434–441, 2004.Available at: https://www.jneurosci.org/cgi/content/full/24/2/434.

[J21] Engel AK et al. Temporal Binding, Binocular Rivalry, and Consciousness, 2000Available at: https://www.phil.vt.edu/ASSC/engel/engel.html.

[J22] Jibu M et al. Quantum optical coherence in cytosceletal microtubules: implications for brain function. *Biosystems*, 32, 1994.

[J23] Schienle A et al. In *Atmospheric electromagnetism: individual differences in brain electrical response to simulated sferics*, volume 21, 1996.

[J24] Bandyopadhyay A Ghosh G, Sahu S. Evidence of massive global synchronization and the consciousness: Comment on "Consciousness in the universe: A review of the 'Orch OR' theory" by Hameroff and Penrose. *Phys Life Rev*, 11:83–84, 2014.

[J25] Penrose R Hameroff SR. *Orchestrated reduction of quantum coherence in brain micro-tubules: A model for consciousness*, pages 507–540. MIT Press, Cambridge, 1996.

[J26] Wu M Hu H. Action Potential Modulation of Neural Spin Networks Suggests Possible Role of Spin. *NeuroQuantology*, 4:309–317, 2004. Available at: https://cogprints.org/3458/1/SpinRole.pdf.

[J27] Hitt J. This is Your Brain on God. *Wired*, 1999. Available at: https://www.wired.com/wired/archive/7.11/persinger_pr.html.

[J28] Mini J. Feet on the ground , head in the clouds, 1999. Available at: https://www.remyc.com/ELZ4.html.

[J29] Miller JP. Brain Waves Deciphered. *Nature*, 384:6605, 1996. Article about the work of Wehr and Laurent.

[J30] Pribram KH. The Neurophysiology of Remembering. *Sci Am*, 1969.

[J31] Fantappie L. *Teoria Unitaria del Mondo Fisico e Biologico*. Di Renzo Editore, Roma, 1942.

[J32] Jaffe LF. Calcium Waves, 2001. Available at: https://waves.mbl.edu/calcium.waves.html.

[J33] Persinger M. The tectonic strain theory as an explanation for UFO phenomena, 1999. Available at: https://www.laurentian.ca/www/neurosci/tectonicedit.htm.

[J34] Cherry N. Conference report on effects of ELF fields on brain, 2000. Available at: https://www.tassie.net.au/emfacts/icnirp.txt.

[J35] Pietch P. Shuffle Brain: the The Quest for Hologramic Mind, 1972. Available at: https://www.indiana.edu/~pietsch/shufflebrain-book00.html.

[J36] Yogananda P. *Autobiography of Yogi*. Self-Realization Fellowship, 1993.

[J37] Penrose R. *Shadows of the Mind*. Vintage, 1994.

[J38] Krischevskii SV. Extraordinary Fantastic States/Dreams of the of the Astronauts in Near -Earth Orbit: a New Cosmic Phenomenon. *Sozn Fiz Real*, 1(4):69, 1996.

[J39] Deboer T. Brain temperature dependent changes in the electroenceplahogram power spectrum of humans and animals. *J Sleep Res*, 7(4), 1998.

[J40] Tiller WA. Towards a Quantitative Science and Technology that Includes Human Consciousness. *Vision-In-Action*, 4, 2003. Available at: https://www.via-visioninaction.org.

Books related to TGD

[K1] Pitkänen M Gariaev P. Model for the Findings about Hologram Generating Properties of DNA. In *Genes and Memes: Part I.* Available at: https:/tgdtheory.fi/pdfpool/dnahologram.pdf, 2019.

[K2] Pitkänen M. *Topological Geometrodynamics.* 1983. Thesis in Helsinki University 1983.

[K3] Pitkänen M. Basic Properties of CP_2 and Elementary Facts about p-Adic Numbers. In *Towards M-matrix.* Available at: https://www.tgdtheory.fi/public_html/pdfpool/append.pdf, 2006.

[K4] Pitkänen M. About Strange Effects Related to Rotating Magnetic Systems . In *TGD and Fringe Physics.* Available at: https:/tgdtheory.fi/pdfpool/Faraday.pdf, 2006.

[K5] Pitkänen M. About the New Physics Behind Qualia. In *Quantum Hardware of Living Matter.* Available at: https:/tgdtheory.fi/pdfpool/newphys.pdf, 2006.

[K6] Pitkänen M. *Bio-Systems as Conscious Holograms.* Online book. Available at: https://www.tgdtheory.fi/tgdhtml/holography.html., 2006.

[K7] Pitkänen M. Bio-Systems as Conscious Holograms. In *Bio-Systems as Conscious Holograms.* Available at: https:/tgdtheory.fi/pdfpool/hologram.pdf, 2006.

[K8] Pitkänen M. *Bio-Systems as Self-Organizing Quantum Systems.* Online book. Available at: https://www.tgdtheory.fi/tgdhtml/bioselforg.html., 2006.

[K9] Pitkänen M. Bio-Systems as Super-Conductors: part I. In *Quantum Hardware of Living Matter.* Available at: https:/tgdtheory.fi/pdfpool/superc1.pdf, 2006.

[K10] Pitkänen M. Bio-Systems as Super-Conductors: part II. In *Quantum Hardware of Living Matter.* Available at: https:/tgdtheory.fi/pdfpool/superc2.pdf, 2006.

[K11] Pitkänen M. Biological Realization of Self Hierarchy. In *Bio-Systems as Self-Organizing Quantum Systems.* Available at: https:/tgdtheory.fi/pdfpool/bioselfc.pdf, 2006.

[K12] Pitkänen M. Conscious Information and Intelligence. In *TGD Inspired Theory of Consciousness.* Available at: https:/tgdtheory.fi/pdfpool/intsysc.pdf, 2006.

[K13] Pitkänen M. Construction of elementary particle vacuum functionals. In *p-Adic Physics.* Available at: https:/tgdtheory.fi/pdfpool/elvafu.pdf, 2006.

[K14] Pitkänen M. Construction of WCW Kähler Geometry from Symmetry Principles. In *Quantum Physics as Infinite-Dimensional Geometry.* Available at: https:/tgdtheory.fi/pdfpool/compl1.pdf, 2006.

[K15] Pitkänen M. Dark Matter Hierarchy and Hierarchy of EEGs. In *TGD and EEG.* Available at: https:/tgdtheory.fi/pdfpool/eegdark.pdf, 2006.

[K16] Pitkänen M. General Theory of Qualia. In *Bio-Systems as Conscious Holograms.* Available at: https:/tgdtheory.fi/pdfpool/qualia.pdf, 2006.

[K17] Pitkänen M. *Genes and Memes.* Online book. Available at: https://www.tgdtheory.fi/tgdhtml/genememe.html., 2006.

[K18] Pitkänen M. Genes and Memes. In *Genes and Memes: Part I.* Available at: https:/tgdtheory.fi/pdfpool/genememec.pdf, 2006.

[K19] Pitkänen M. Homeopathy in Many-Sheeted Space-Time. In *Bio-Systems as Conscious Holograms.* Available at: https:/tgdtheory.fi/pdfpool/homeoc.pdf, 2006.

[K20] Pitkänen M. Identification of the WCW Kähler Function. In *Quantum Physics as Infinite-Dimensional Geometry.* Available at: https:/tgdtheory.fi/pdfpool/kahler.pdf., 2006.

[K21] Pitkänen M. Macro-Temporal Quantum Coherence and Spin Glass Degeneracy. In *Bio-Systems as Conscious Holograms.* Available at: https:/tgdtheory.fi/pdfpool/macro.pdf, 2006.

[K22] Pitkänen M. Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part I. In *Bio-Systems as Conscious Holograms.* Available at: https:/tgdtheory.fi/pdfpool/metab.pdf, 2006.

[K23] Pitkänen M. Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part II. In *Bio-Systems as Conscious Holograms.* Available at: https:/tgdtheory.fi/pdfpool/molephoto.pdf, 2006.

[K24] Pitkänen M. *Magnetospheric Consciousness.* Online book. Available at: https://www.tgdtheory.fi/tgdhtml/magnconsc.html., 2006.

[K25] Pitkänen M. Many-Sheeted DNA. In *Genes and Memes: Part I.* Available at: https:/tgdtheory.fi/pdfpool/genecodec.pdf, 2006.

[K26] Pitkänen M. Massless states and particle massivation. In *p-Adic Physics*. Available at: https:/tgdtheory.fi/pdfpool/mless.pdf, 2006.

[K27] Pitkänen M. *Mathematical Aspects of Consciousness Theory*. Online book. Available at: https://www.tgdtheory.fi/tgdhtml/mathconsc.html, 2006.

[K28] Pitkänen M. Negentropy Maximization Principle. In *TGD Inspired Theory of Consciousness*. Available at: https:/tgdtheory.fi/pdfpool/nmpc.pdf, 2006.

[K29] Pitkänen M. New Particle Physics Predicted by TGD: Part I. In *p-Adic Physics*. Available at: https:/tgdtheory.fi/pdfpool/mass4.pdf, 2006.

[K30] Pitkänen M. New Particle Physics Predicted by TGD: Part II. In *p-Adic Physics*. Available at: https:/tgdtheory.fi/pdfpool/mass5.pdf, 2006.

[K31] Pitkänen M. p-Adic Particle Massivation: Hadron Masses. In *p-Adic Length Scale Hypothesis and Dark Matter Hierarchy*. Available at: https:/tgdtheory.fi/pdfpool/mass3.pdf, 2006.

[K32] Pitkänen M. p-Adic Physics as Physics of Cognition and Intention. In *TGD Inspired Theory of Consciousness*. Available at: https:/tgdtheory.fi/pdfpool/cognic.pdf, 2006.

[K33] Pitkänen M. *Physics in Many-Sheeted Space-Time*. Online book. Available at: https://www.tgdtheory.fi/tgdhtml/tgdclass.html., 2006.

[K34] Pitkänen M. Quantum Antenna Hypothesis. In *Quantum Hardware of Living Matter*. Available at: https:/tgdtheory.fi/pdfpool/tubuc.pdf, 2006.

[K35] Pitkänen M. Quantum Control and Coordination in Bio-Systems. In *Bio-Systems as Self-Organizing Quantum Systems*. Available at: https:/tgdtheory.fi/pdfpool/qcococII.pdf, 2006.

[K36] Pitkänen M. Quantum Control and Coordination in Bio-systems: Part I. In *Bio-Systems as Self-Organizing Quantum Systems*. Available at: https:/tgdtheory.fi/pdfpool/qcococI.pdf, 2006.

[K37] Pitkänen M. *Quantum Hardware of Living Matter*. Online book. Available at: https://www.tgdtheory.fi/tgdhtml/bioware.html., 2006.

[K38] Pitkänen M. Quantum Model for Bio-Superconductivity: I. In *TGD and EEG*. Available at: https:/tgdtheory.fi/pdfpool/biosupercondI.pdf, 2006.

[K39] Pitkänen M. Quantum Model for Bio-Superconductivity: II. In *TGD and EEG*. Available at: https:/tgdtheory.fi/pdfpool/biosupercondII.pdf, 2006.

[K40] Pitkänen M. Quantum Model for Hearing. In *TGD and EEG*. Available at: https:/tgdtheory.fi/pdfpool/hearing.pdf, 2006.

[K41] Pitkänen M. Quantum Model for Nerve Pulse. In *TGD and EEG*. Available at: https:/tgdtheory.fi/pdfpool/pulse.pdf, 2006.

[K42] Pitkänen M. Quantum Model for Paranormal Phenomena. In *TGD Inspired Theory of Consciousness*. Available at: https:/tgdtheory.fi/pdfpool/parac.pdf, 2006.

[K43] Pitkänen M. Quantum Model of EEG. In *TGD and EEG*. Available at: https:/tgdtheory.fi/pdfpool/eegII.pdf, 2006.

[K44] Pitkänen M. *Quantum Physics as Infinite-Dimensional Geometry*. Online book.Available at: https://www.tgdtheory.fi/tgdhtml/tgdgeom.html., 2006.

[K45] Pitkänen M. Quantum Theory of Self-Organization. In *Bio-Systems as Self-Organizing Quantum Systems*. Available at: https:/tgdtheory.fi/pdfpool/selforgac.pdf, 2006.

[K46] Pitkänen M. Self and Binding: Part II. In *TGD Inspired Theory of Consciousness.* Available at: https:/tgdtheory.fi/pdfpool/selfbindc.pdf, 2006.

[K47] Pitkänen M. *TGD and EEG.* Online book. Available at: https://www.tgdtheory.fi/tgdhtml/tgdeeg.html, 2006.

[K48] Pitkänen M. *TGD and Fringe Physics.* Online book. Available at: https://www.tgdtheory.fi/tgdhtml/freenergy.html., 2006.

[K49] Pitkänen M. *TGD as a Generalized Number Theory.* Online book. Available at: https://www.tgdtheory.fi/tgdhtml/tgdnumber.html., 2006.

[K50] Pitkänen M. *TGD Inspired Theory of Consciousness.* Online book. Available at: https://www.tgdtheory.fi/tgdhtml/tgdconsc.html., 2006.

[K51] Pitkänen M. The Notion of Free Energy and Many-Sheeted Space-Time Concept. In *TGD and Fringe Physics.* Available at: https:/tgdtheory.fi/pdfpool/freenergy.pdf, 2006.

[K52] Pitkänen M. The Notion of Wave-Genome and DNA as Topological Quantum Computer. In *Genes and Memes: Part I.* Available at: https:/tgdtheory.fi/pdfpool/gari.pdf, 2006.

[K53] Pitkänen M. Time, Spacetime and Consciousness. In *Bio-Systems as Conscious Holograms.* Available at: https:/tgdtheory.fi/pdfpool/time.pdf, 2006.

[K54] Pitkänen M. *Topological Geometrodynamics: an Overview.* Online book.Available at: https://www.tgdtheory.fi/tgdhtml/tgdview.html., 2006.

[K55] Pitkänen M. Wormhole Magnetic Fields. In *Quantum Hardware of Living Matter.* Available at: https:/tgdtheory.fi/pdfpool/wormc.pdf, 2006.

[K56] Pitkänen M. Number theoretic vision, Hyper-finite Factors and S-matrix. In *Towards M-Matrix: part I.* Available at: https:/tgdtheory.fi/pdfpool/UandM.pdf, 2012.

[K57] Pitkänen M. Quantum Mind and Neuroscience. In *TGD based view about living matter and remote mental interactions: Part I.* Available at: https:/tgdtheory.fi/pdfpool/lianPN.pdf, 2012.

[K58] Pitkänen M. Quantum Mind, Magnetic Body, and Biological Body. In *TGD based view about living matter and remote mental interactions: Part I.* Available at: https:/tgdtheory.fi/pdfpool/lianPB.pdf, 2012.

[K59] Pitkänen M. *TGD Based View About Living Matter and Remote Mental Interactions.* Online book. Available at: https://www.tgdtheory.fi/tgdhtml/tgdlian.html, 2012.

[K60] Pitkänen M. About Concrete Realization of Remote Metabolism. In *TGD and Fringe Physics.* Available at: https:/tgdtheory.fi/pdfpool/remotetesla.pdf, 2013.

[K61] Pitkänen M. Are dark photons behind biophotons? In *TGD based view about living matter and remote mental interactions: Part I.* Available at: https:/tgdtheory.fi/pdfpool/biophotonslian.pdf, 2013.

[K62] Pitkänen M. *Hyper-finite Factors and Dark Matter Hierarchy.* Online book. Available at: https://www.tgdtheory.fi/tgdhtml/neuplanck.html., 2013.

[K63] Pitkänen M. *p-Adic length Scale Hypothesis.* Online book. Available at: https://www.tgdtheory.fi/tgdhtml/padphys.html., 2013.

[K64] Pitkänen M. *Quantum TGD.* Online book. Available at: https://www.tgdtheory.fi/tgdhtml/tgdquantum.html., 2013.

[K65] Pitkänen M. Recent View about Kähler Geometry and Spin Structure of WCW . In *Quantum Physics as Infinite-Dimensional Geometry.* Available at: https:/tgdtheory.fi/pdfpool/wcwnew.pdf, 2014.

[K66] Pitkänen M. DNA as Topological Quantum Computer. In *Genes and Memes: Part I.* Available at: https:/tgdtheory.fi/pdfpool/dnatqc.pdf, 2015.

[K67] Pitkänen M. Topological Quantum Computation in TGD Universe. In *Genes and Memes: Part I.* Available at: https:/tgdtheory.fi/pdfpool/tqc.pdf, 2015.

[K68] Pitkänen M. About Preferred Extremals of Kähler Action. In *Physics in Many-Sheeted Space-Time: Part I.* Available at: https:/tgdtheory.fi/pdfpool/prext.pdf, 2019.

[K69] Pitkänen M. Appendix A: Quantum Groups and Related Structures. In *Hyper-finite Factors and Dark Matter Hierarchy: Part I.* Available at: https:/tgdtheory.fi/pdfpool/bialgebra.pdf, 2019.

[K70] Pitkänen M. Basic Extremals of Kähler Action. In *Physics in Many-Sheeted Space-Time: Part I.* Available at: https:/tgdtheory.fi/pdfpool/class.pdf, 2019.

[K71] Pitkänen M. Comments on the recent experiments by the group of Michael Persinger. In *TGD based view about living matter and remote mental interactions: Part II.* Available at: https:/tgdtheory.fi/pdfpool/persconsc.pdf, 2019.

[K72] Pitkänen M. Construction of Quantum Theory: M-matrix. In *Towards M-Matrix: Part I.* Available at: https:/tgdtheory.fi/pdfpool/towards.pdf, 2019.

[K73] Pitkänen M. Cosmic Strings. In *Physics in Many-Sheeted Space-Time: Part II.* Available at: https:/tgdtheory.fi/pdfpool/cstrings.pdf, 2019.

[K74] Pitkänen M. Could Genetic Code Be Understood Number Theoretically? In *Genes and Memes: Part II.* Available at: https:/tgdtheory.fi/pdfpool/genenumber.pdf, 2019.

[K75] Pitkänen M. Criticality and dark matter. In *Hyper-finite Factors and Dark Matter Hierarchy.* Available at: https:/tgdtheory.fi/pdfpool/qcritdark.pdf, 2019.

[K76] Pitkänen M. Criticality and dark matter: part I. In *Hyper-finite Factors and Dark Matter Hierarchy: Part I.* Available at: https:/tgdtheory.fi/pdfpool/qcritdark1.pdf, 2019.

[K77] Pitkänen M. Criticality and dark matter: part II. In *Hyper-finite Factors and Dark Matter Hierarchy: Part I.* Available at: https:/tgdtheory.fi/pdfpool/qcritdark2.pdf, 2019.

[K78] Pitkänen M. Criticality and dark matter: part III. In *Hyper-finite Factors and Dark Matter Hierarchy: Part I.* Available at: https:/tgdtheory.fi/pdfpool/qcritdark3.pdf, 2019.

[K79] Pitkänen M. Dark Forces and Living Matter. In *Hyper-finite Factors and Dark Matter Hierarchy: Part II.* Available at: https:/tgdtheory.fi/pdfpool/darkforces.pdf, 2019.

[K80] Pitkänen M. Dark Nuclear Physics and Condensed Matter. In *Hyper-finite Factors and Dark Matter Hierarchy: Part II.* Available at: https:/tgdtheory.fi/pdfpool/exonuclear.pdf, 2019.

[K81] Pitkänen M. Does TGD Predict the Spectrum of Planck Constants? In *Hyper-finite Factors and Dark Matter Hierarchy: Part I.* Available at: https:/tgdtheory.fi/pdfpool/Planck.pdf, 2019.

[K82] Pitkänen M. Does the QFT Limit of TGD Have Space-Time Super-Symmetry? In *Towards M-Matrix: Part II.* Available at: https:/tgdtheory.fi/pdfpool/susy.pdf, 2019.

[K83] Pitkänen M. Evolution in Many-Sheeted Space-Time. In *Genes and Memes: Part I.* Available at: https:/tgdtheory.fi/pdfpool/prebio.pdf, 2019.

[K84] Pitkänen M. General Ideas about Many-Sheeted Space-Time: Part I. In *Physics in Many-Sheeted Space-Time: Part I.* Available at: https:/tgdtheory.fi/pdfpool/topcond.pdf, 2019.

[K85] Pitkänen M. Macroscopic Quantum Phenomena and CP_2 Geometry. In *Physics in Many-Sheeted Space-Time: Part I.* Available at: https:/tgdtheory.fi/pdfpool/super.pdf, 2019.

[K86] Pitkänen M. Nuclear String Hypothesis. In *Hyper-finite Factors and Dark Matter Hierarchy: Part II.* Available at: https:/tgdtheory.fi/pdfpool/nuclstring.pdf, 2019.

[K87] Pitkänen M. Quantum Astrophysics. In *Physics in Many-Sheeted Space-Time: Part II.* Available at: https:/tgdtheory.fi/pdfpool/qastro.pdf, 2019.

[K88] Pitkänen M. Quantum gravity, dark matter, and prebiotic evolution. In *Genes and Memes: Part I.* Available at: https:/tgdtheory.fi/pdfpool/hgrprebio.pdf, 2019.

[K89] Pitkänen M. Quantum Hall effect and Hierarchy of Planck Constants. In *Hyper-finite Factors and Dark Matter Hierarchy: Part II.* Available at: https:/tgdtheory.fi/pdfpool/anyontgd.pdf, 2019.

[K90] Pitkänen M. Some questions related to the twistor lift of TGD. In *Towards M-Matrix: Part II.* Available at: https:/tgdtheory.fi/pdfpool/twistquestions.pdf, 2019.

[K91] Pitkänen M. TGD and Astrophysics. In *Physics in Many-Sheeted Space-Time: Part II.* Available at: https:/tgdtheory.fi/pdfpool/astro.pdf, 2019.

[K92] Pitkänen M. TGD and Cosmology. In *Physics in Many-Sheeted Space-Time: Part II.* Available at: https:/tgdtheory.fi/pdfpool/cosmo.pdf, 2019.

[K93] Pitkänen M. TGD and M-Theory. In *Topological Geometrodynamics: Overview: Part I.* Available at: https:/tgdtheory.fi/pdfpool/MTGD.pdf, 2019.

[K94] Pitkänen M. TGD and Nuclear Physics. In *Hyper-finite Factors and Dark Matter Hierarchy: Part II.* Available at: https:/tgdtheory.fi/pdfpool/padnucl.pdf, 2019.

[K95] Pitkänen M. TGD and Potential Anomalies of GRT. In *Physics in Many-Sheeted Space-Time: Part I.* Available at: https:/tgdtheory.fi/pdfpool/granomalies.pdf., 2019.

[K96] Pitkänen M. TGD as a Generalized Number Theory: Infinite Primes. In *TGD as a Generalized Number Theory: Part I.* Available at: https:/tgdtheory.fi/pdfpool/visionc.pdf, 2019.

[K97] Pitkänen M. TGD as a Generalized Number Theory: p-Adicization Program. In *TGD as a Generalized Number Theory: Part I.* Available at: https:/tgdtheory.fi/pdfpool/visiona.pdf, 2019.

[K98] Pitkänen M. TGD as a Generalized Number Theory: Quaternions, Octonions, and their Hyper Counterparts. In *TGD as a Generalized Number Theory: Part I.* Available at: https:/tgdtheory.fi/pdfpool/visionb.pdf, 2019.

[K99] Pitkänen M. TGD View about Coupling Constant Evolution. In *Towards M-Matrix: Part I.* Available at: https:/tgdtheory.fi/pdfpool/ccevolution.pdf, 2019.

[K100] Pitkänen M. The classical part of the twistor story. In *Towards M-Matrix: Part II.* Available at: https:/tgdtheory.fi/pdfpool/twistorstory.pdf, 2019.

[K101] Pitkänen M. The Recent Status of Lepto-hadron Hypothesis. In *Hyper-finite Factors and Dark Matter Hierarchy: Part II.* Available at: https:/tgdtheory.fi/pdfpool/leptc.pdf, 2019.

[K102] Pitkänen M. The Recent View about Twistorialization in TGD Framework. In *Towards M-Matrix: Part II.* Available at: https:/tgdtheory.fi/pdfpool/smatrix.pdf, 2019.

[K103] Pitkänen M. The Relationship Between TGD and GRT. In *Physics in Many-Sheeted Space-Time: Part I.* Available at: https:/tgdtheory.fi/pdfpool/tgdgrt.pdf., 2019.

[K104] Pitkänen M. Three new physics realizations of the genetic code and the role of dark matter in bio-systems. In *Genes and Memes: Part II*. Available at: https:/tgdtheory.fi/pdfpool/dnatqccodes.pdf, 2019.

[K105] Pitkänen M. Unified Number Theoretical Vision. In *TGD as a Generalized Number Theory: Part I*. Available at: https:/tgdtheory.fi/pdfpool/numbervision.pdf, 2019.

[K106] Pitkänen M. Was von Neumann Right After All? In *Hyper-finite Factors and Dark Matter Hierarchy: Part I*. Available at: https:/tgdtheory.fi/pdfpool/vNeumann.pdf, 2019.

[K107] Pitkänen M. What p-Adic Icosahedron Could Mean? And What about p-Adic Manifold? In *TGD as a Generalized Number Theory: Part I*. Available at: https:/tgdtheory.fi/pdfpool/picosahedron.pdf, 2019.

[K108] Pitkänen M. Zero Energy Ontology. In *Towards M-Matrix: part I*. Available at: https:/tgdtheory.fi/pdfpool/ZEO.pdf, 2021.

Articles about TGD

[L1] Pitkänen M. Basic Properties of CP_2 and Elementary Facts about p-Adic Numbers. Available at: https:/tgdtheory.fi/pdfpool/append.pdf., 2006.

[L2] Pitkänen M. Further Progress in Nuclear String Hypothesis. Available at: https:/tgdtheory.fi/public_html/articles/nuclstring.pdf., 2007.

[L3] Pitkänen M. DNA Waves and Water. Available at: https:/tgdtheory.fi/public_html/articles/mont.pdf., 2011.

[L4] Pitkänen M. About Concrete Realization of Remote Metabolism. Available at: https:/tgdtheory.fi/public_html/articles/teslaling.pdf., 2013.

[L5] Pitkänen M. CMAP representations about TGD, and TGD inspired theory of consciousness and quantum biology. Available at: https://www.tgdtheory.fi/tgdglossary.pdf., 2014.

[L6] Pitkänen M. Geometric theory of harmony. Available at: https:/tgdtheory.fi/public_html/articles/harmonytheory.pdf., 2014.

[L7] Pitkänen M. New results about microtubules as quantum systems. Available at: https:/tgdtheory.fi/public_html/articles/microtubule.pdf., 2014.

[L8] Pitkänen M. Pollack's Findings about Fourth phase of Water : TGD View. Available at: https:/tgdtheory.fi/public_html/articles/PollackYoutube.pdf., 2014.

[L9] Pitkänen M. Does the Physics of SmB6 Make the Fundamental Dynamics of TGD Directly Visible? 2015.

[L10] Pitkänen M. TGD based model for anesthetic action. Available at: https:/tgdtheory.fi/public_html/articles/anesthetes.pdf., 2015.

[L11] Pitkänen M. About Physical Representations of Genetic Code in Terms of Dark Nuclear Strings. Available at: https:/tgdtheory.fi/public_html/articles/genecodemodels.pdf., 2016.

[L12] Pitkänen M. Holography and Quantum Error Correcting Codes: TGD View. Available at: https:/tgdtheory.fi/public_html/articles/tensornet.pdf., 2016.

[L13] Pitkänen M. Hydrinos again. Available at: https:/tgdtheory.fi/public_html/articles/Millsagain.pdf., 2016.

[L14] Pitkänen M. What's new in TGD inspired view about phase transitions? . Available at: https:/tgdtheory.fi/public_html/articles/phasetransitions.pdf., 2016.

[L15] Pitkänen M. About the double-slit experiment of Dean Radin. Available at: https:/tgdtheory.fi/public_html/articles/radinexp.pdf., 2017.

[L16] Pitkänen M. Does valence bond theory relate to the hierarchy of Planck constants? Available at: https:/tgdtheory.fi/public_html/articles/valenceheff.pdf., 2017.

[L17] Pitkänen M. Philosophy of Adelic Physics. Available at: https:/tgdtheory.fi/public_html/articles/adelephysics.pdf., 2017.

[L18] Pitkänen M. Philosophy of Adelic Physics. In *Trends and Mathematical Methods in Interdisciplinary Mathematical Sciences*, pages 241–319. Springer.Available at: https://link.springer.com/chapter/10.1007/978-3-319-55612-3_11, 2017.

[L19] Pitkänen M. Re-examination of the basic notions of TGD inspired theory of consciousness. Available at: https:/tgdtheory.fi/public_html/articles/conscrit.pdf., 2017.

[L20] Pitkänen M. About the Correspondence of Dark Nuclear Genetic Code and Ordinary Genetic Code. Available at: https:/tgdtheory.fi/public_html/articles/codedarkcode.pdf., 2018.

[L21] Pitkänen M. Dark valence electrons and color vision. Available at: https:/tgdtheory.fi/public_html/articles/colorvision.pdf., 2018.

[L22] Pitkänen M. Emotions as sensory percepts about the state of magnetic body? Available at: https:/tgdtheory.fi/public_html/articles/emotions.pdf., 2018.

[L23] Pitkänen M. Getting philosophical: some comments about the problems of physics, neuroscience, and biology. Available at: https:/tgdtheory.fi/public_html/articles/philosophic.pdf., 2018.

[L24] Pitkänen M. Homonymy of the genetic code from TGD point of view. Available at: https:/tgdtheory.fi/public_html/articles/homonymy.pdf., 2018.

[L25] Pitkänen M. How molecules in cells "find" one another and organize into structures? Available at: https:/tgdtheory.fi/public_html/articles/moleculefind.pdf., 2018.

[L26] Pitkänen M. Maxwell's lever rule and expansion of water in freezing: two poorly understood phenomena. Available at: https:/tgdtheory.fi/public_html/articles/leverule.pdf., 2018.

[L27] Pitkänen M. New insights about quantum criticality for twistor lift inspired by analogy with ordinary criticality. Available at: https:/tgdtheory.fi/public_html/articles/zeocriticality.pdf., 2018.

[L28] Pitkänen M. TGD view about coupling constant evolution. Available at: https:/tgdtheory.fi/public_html/articles/ccevolution.pdf., 2018.

[L29] Pitkänen M. The experiments of Masaru Emoto with emotional imprinting of water. Available at: https:/tgdtheory.fi/public_html/articles/Emoto.pdf., 2018.

[L30] Pitkänen M. An overall view about models of genetic code and bio-harmony. Available at: https:/tgdtheory.fi/public_html/articles/gcharm.pdf., 2019.

[L31] Pitkänen M. Copenhagen interpretation dead: long live ZEO based quantum measurement theory! Available at: https:/tgdtheory.fi/public_html/articles/Bohrdead.pdf., 2019.

[L32] Pitkänen M. Do hydrogels learn in presence of irradiation and heating? Available at: https:/tgdtheory.fi/public_html/articles/gellearns.pdf., 2019.

[L33] Pitkänen M. Earhquakes and volcanic eruptions as macroscopic quantum jumps in zero energy ontology. Available at: https:/tgdtheory.fi/public_html/articles/earthquakes.pdf., 2019.

[L34] Pitkänen M. $M^8 - H$ duality and consciousness. Available at: https:/tgdtheory.fi/public_html/articles/M8Hconsc.pdf., 2019.

[L35] Pitkänen M. Quantum self-organization by h_{eff} changing phase transitions. Available at: https:/tgdtheory.fi/public_html/articles/heffselforg.pdf., 2019.

[L36] Pitkänen M. Some comments related to Zero Energy Ontology (ZEO). Available at: https:/tgdtheory.fi/public_html/articles/zeoquestions.pdf., 2019.

[L37] Pitkänen M. A critical re-examination of $M^8 - H$ duality hypothesis: part I. Available at: https:/tgdtheory.fi/public_html/articles/M8H1.pdf., 2020.

[L38] Pitkänen M. A critical re-examination of $M^8 - H$ duality hypothesis: part II. Available at: https:/tgdtheory.fi/public_html/articles/M8H2.pdf., 2020.

[L39] Pitkänen M. About the role of Galois groups in TGD framework. https://tgdtheory.fi/public_html/articles/GaloisTGD.pdf., 2021.

[L40] Pitkänen M. Some questions concerning zero energy ontology. https://tgdtheory.fi/public_html/articles/zeonew.pdf., 2021.

[L41] Pitkänen M. TGD as it is towards the end of 2021. https://tgdtheory.fi/public_html/articles/TGD2021.pdf., 2021.

[L42] Pitkänen M. About TGD counterparts of twistor amplitudes: part I. https://tgdtheory.fi/public_html/articles/twisttgd1.pdf., 2022.

[L43] Pitkänen M. About TGD counterparts of twistor amplitudes: part II. https://tgdtheory.fi/public_html/articles/twisttgd2.pdf., 2022.

[L44] Pitkänen M. Finite Fields and TGD. https://tgdtheory.fi/public_html/articles/finitefieldsTGD.pdf., 2022.

[L45] Pitkänen M. Some New Ideas Related to Langlands Program *viz.* TGD. https://tgdtheory.fi/public_html/articles/Langlands2022.pdf., 2022.

[L46] Pitkänen M. Trying to fuse the basic mathematical ideas of quantum TGD to a single coherent whole. https://tgdtheory.fi/public_html/articles/fusionTGD.pdf., 2022.

[L47] Pitkänen M. Two objections against p-adic thermodynamics and their resolution. https://tgdtheory.fi/public_html/articles/padmass2022.pdf., 2022.

[L48] Pitkänen M and Rastmanesh R. Homeostasis as self-organized quantum criticality. Available at: https:/tgdtheory.fi/public_html/articles/SP.pdf., 2020.

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