TGD Inspired Model for Nerve Pulse

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Contents

Abstract

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

1. Background

The basic philosophy behind the model is following.

1. In TGD Universe the function of EEG and its variants is to make possible communications from the cell membrane to the magnetic body and the control of the biological body by the magnetic body via magnetic flux sheets traversing DNA by inducing gene expression. This leads to the notions of super- and hyper-genome predicting coherent gene expression at level of organs and population.
2. The assignment the predicted ranged classical weak and color gauge fields to dark matter hierarchy was a crucial step in the evolution of the model, and led among other things to a model of high T_c superconductivity predicting the basic scales of cell, and also to a possible generalization of EXG to a hierarchy of ZXGs, WXGs, and GXGs corresponding to Z^0, W bosons and gluons.
3. Dark matter hierarchy and the associated hierarchy of Planck constants play a key role in the model. For instance, in the case of EEG Planck constant must be so large that the energies of dark EEG photons are above thermal energy at the physiological temperature. The assumption that a considerable fraction of the ionic currents through the cell membrane are dark currents flowing along the magnetic flux tubes explains the strange findings about ionic currents through cell membrane. Concerning the model of nerve pulse generation, one input comes from the model of DNA as a topological quantum computer and experimental findings challenging Hodgkin-Huxley model as even approximate description of the situation.
4. The identification of the cell interior as gel phase containing most of water as structured water around cytoskeleton - rather than water containing bio-molecules as solutes as assumed in Hodkin-Huxley model - allows to understand many of the anomalous behaviors associated with the cell membrane and also the different densities of ions in the interior and exterior of cell at qualitative level. The proposal of Pollack that basic biological functions involve phase transitions of gel phase generalizes in TGD framework to a proposal that these phase transitions are induced by quantum phase transitions changing the value of Planck constant. In particular, gel-sol phase transition for the peripheral cytoskeleton induced by the primary wave would accompany nerve pulse propagation. This view about nerve pulse is not consistent with Hodkin-Huxley model.
5. Pollack's experiments [**?**]emonstrate the existence of what he calls the fourth phase of water. This phase contains negatively charged regions - exclusion zones - serving in TGD Universe as candidates for prebiotic cells. The positive charge resides outside the exclusion region at the flux tubes of the magnetic body associated with the exclusion zones as dark proton strings defining dark nuclei realizing vertebrate genetic code [K19]. This vision leads to a generalization of the model of cell membrane Josephson junctions assignable to transmembrane proteins. Josephson energy becomes sum of Coulombic term and difference of cyclotron energies at the two sides of the membrane. The thermodynamical model for cell membrane is replaced with its "square root" forced by Zero Energy Ontology, and means the replacement of Boltzmann weights with their square roots appearing in the wave functions for dark particles. The phase transitions changing Planck constant change the equilibrium distributions of ions and this process should be behind the generation of nerve pulse.

2. New view about nerve pulse generation

The basic hypothesis has been that quantum jump takes the resting potential below the threshold for the generation of nerve pulse. One can imagine several manners for how this could happen. For years ago I learned that nerve pulse propagation seems to be an adiabatic process

and thus does not dissipate: the authors propose that 2-D acoustic soliton is in question. Adiabaticity is what one expects if the ionic currents are dark currents (large $\hbar$ and low dissipation) or even supra currents. Furthermore, Josephson currents are oscillatory so that no pumping is needed. Combining this input with the model of DNA as topological quantum computer (tqc) leads to a rather precise model for the generation of nerve pulse.

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

   In the microscopic description continuous Josephson junction is replaced with a distribution of Josephson junctions defined by transmembrane proteins such acting as pumps and channels.

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

3. Nerve pulse itself would correspond to a phase transition changing the value of Planck constant h_{eff} at the either side or both sides of the cell membrane at the flux tube associated with the transmembrane protein. This would induce transition to a new ionic equilibrium since cyclotron energies for ions change. This transition would give rise to the change of the membrane potential. Cyclotron energy difference would however dominate in the generalized Josephson energy. This phase transition should be adiabatic and should not require heat or generate it.

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

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

3. The function of neural transmitters

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

4. Microtubular level

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

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

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

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

1 Introduction

The model of nerve pulse has developed through several tortuous twists reflecting the development of the basic ideas of TGD inspired theory of consciousness and of bio-systems as macroscopic quantum systems, and is certainly not final yet. The chapters about EEG provide a necessary background for the model of nerve pulse. The chapter [K34] was written before dark matter revolution made possible a more detailed modelling of mew physics aspects of EEG. The newer chapter [K14] related to EEG provides a very general vision about the hierarchy of EEGs based on dark matter hierarchy and about its possible generalization to ZEG, WEG, and even GEB (Z, W and G denote for dark Z^0, W boson, and gluon fields with interaction range which can be arbitrary long at higher levels of dark matter hierarchy). This model derives from the model of

bio-superconductivity [K30, K31] as quantum critical high T_c super-conductivity [K7, K8]. The consistency with the model of DNA as topological quantum computer [K1] poses additional strong constraints on the model. The findings of Gerald Pollack about fourth phase of water [L7] lead to additional strong constraints on the model of cell membrane as Josephson junction.

The basic hypothesis has been that quantum jump takes the resting potential below the threshold for the generation of nerve pulse. One can imagine several way for how this could happen.

1. The first idea was that axonal membrane acts as a Josephson junction and that a soliton propagating along it induces the nerve pulse. The model for the high T_c electronic superconductivity allowed to construct a detailed model for this Josephson junction and "time-like" and possibly also space-like soliton sequences are indeed present. Time-like soliton sequences however represent oscillations at a frequency of order 10^{13} Hz. It is however clear that moving solitons cannot correspond to nerve pulses.

   Quite recently (2014), strong motivations for generalizing the notion of Josephson junction so that Josephson energy includes also the difference of cyclotron energies at the two sides of the junction has emerged. It is also possible to reduce cell membrane as Josephson junction to a collection of Josephson junctions defined by various transmembrane proteins such as pumps and channels.

2. The strange findings about ionic membrane currents discussed in [K30, K31] challenge the assumption cell membrane could be described in term of known biochemistry alone. Pollack's experiments [L7] demonstrate the existence of what he calls the fourth phase of water. This phase contains negatively charged regions - exclusion zones - serving in TGD Universe as candidates for prebiotic cells. The positive charge resides outside the exclusion region at the flux tubes of the magnetic body associated with the exclusion zones as dark proton strings defining dark nuclei realizing vertebrate genetic code [K19]. This vision leads to a generalization of the model of cell membrane Josephson junctions assignable to transmembrane proteins. Josephson energy becomes sum of Coulombic term and difference of cyclotron energies at the two sides of the membrane. The thermodynamical model for cell membrane is replaced with its "square root" forced by Zero Energy Ontology, and means the replacement of Boltzmann weights with their square roots appearing in the wave functions for dark particles. The phase transitions changing Planck constant change the equilibrium distributions of ions and this process should be behind the generation of nerve pulse.

3. There exists also evidence that nerve pulse propagation is be an adiabatic process [J5, J9, J26, J27, J29] (thanks to Ulla Mattfolk) and thus does not dissipate: the authors propose that 2-D acoustic soliton is in question. Adiabaticity is what one expects if the ionic currents are dark currents (large $\hbar$ and low dissipation) or even supra currents. Furthermore, Josephson currents are oscillatory so that no pumping is needed. If h_{eff} changing phase transition changing the equilibrium ionic concentrations occurs, the phase transition in question should not absorb or liberate heat. Combining this input with the model of DNA as topological quantum computer (TQC) [K1] leads to a rather precise model for the generation of nerve pulse.

1.1 The Most Recent Model For The Generation Of Nerve Pulse

Quite recently I learned [J5, J9, J26, J27, J29] (thanks to Ulla Mattfolk) that nerve pulse propagation seems to be an adiabatic process and thus does not dissipate: the authors propose that 2-D acoustic soliton is in question. Adiabaticity is what one expects if the ionic currents are dark currents (large $\hbar$ and low dissipation) or even supra currents. Furthermore, Josephson currents are oscillatory so that no pumping is needed. Combining this input with the model of DNA as topological quantum computer (TQC) [K1] leads to a rather precise model for the generation of nerve pulse.

1. The system would consist of two superconductors- microtubule space-time sheet and the space-time sheet in cell exterior- connected by Josephson junctions represented by magnetic flux tubes defining also braiding in the model of TQC. The phase difference between two super-conductors would obey Sine-Gordon equation allowing both standing and propagating

solitonic solutions. A sequence of rotating gravitational penduli coupled to each other would be the mechanical analog for the system. Soliton sequences having as a mechanical analog penduli rotating with constant velocity but with a constant phase difference between them would generate moving kHz synchronous oscillation. Periodic boundary conditions at the ends of the axon rather than chemistry determine the propagation velocities of kHz waves and kHz synchrony is an automatic consequence since the times taken by the pulses to travel along the axon are multiples of same time unit. Also moving oscillations in EEG range can be considered and would require larger value of Planck constant in accordance with vision about evolution as gradual increase of Planck constant.

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

3. At microscopic level nerve pulse could correspond to a phase transition changing the value of Planck constant h_{eff} at the either side or both sides of the cell membrane at the flux tube associated with the transmembrane protein. This would induce transition to a new ionic equilibrium since cyclotron energies for ions change. This transition would give rise to the change of the membrane potential. Cyclotron energy difference would however dominate in the generalized Josephson energy. This phase transition should be adiabatic and should not require heat or generate it.

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

5. New physics would enter in several way. Ions should form Bose-Einstein cyclotron condensates. The new nuclear physics predicted by TGD [L4]. [L4] predicts that ordinary fermionic ions (such as K^+, Na^+, Cl^-) have bosonic chemical equivalents with slightly differing mass number. Anomalies of nuclear physics and cold fusion provide experimental support for the predicted new nuclear physics. Electronic supra current pulse from microtubules could induce the kick of pendulum inducing nerve pulse and induce a small heating and expansion of the axon. The return flux of ionic Josephson currents would induce convective cooling of the axonal membrane. Clearly, the temperature at dark magnetic flux tubes could be lower than the physiological temperature. The model for the role of DC currents and potentials in healing discussed in [K4] suggests that metabolic energy quanta of order 1 meV are involved in bio-control so that the temperature at magnetic flux tubes containing ions could be by a factor of order 10^{-2} lower than the physiological temperature. A small transfer of small positive charge into the inner lipid layer could induce electronic supra current by attractive Coulomb interaction. The exchange of exotic W bosons which are scaled up variants of ordinary $W^{\pm}$ bosons is a natural ways to achieve this if new nuclear physics is indeed present.

1.2 The Function Of Neural Transmitters

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

1.3 What Happens At The Micro-Tubular Level During Nerve Pulse?

What happens at the micro-tubular level during the nerve pulse? How gel phase differs from sol phase? What occurs in sol-gel transition? These questions represent some of the principal challenges faced by quantum theories of consciousness.

There are two candidates for Bose-Einstein (BE) condensates associated with the ordered phases (say gel) of water. This derives from the fact that the zero point kinetic energy of hydrogen atom at space-time sheet k is in a good approximation same as the zero point kinetic energy of an electronic Cooper pair at space-time sheet $k + 10$ (see the article "Time, Space-time, and Consciousness" in [L2]). Thus both the BE condensates of hydrogen atoms at tubular $k = 139$ space-time sheets forming bundles behaving like liquid crystals and BE condensates of electronic Cooper pairs at $k = 149$ space-time sheets forming linear structures could accompany gel phase and ordered water phases. Positive and negative energy IR photons at energy of $\sim .125$ eV belong to the predicted fractal hierarchy of metabolic currencies, and allow to control the stability of this BE condensate so that a precisely targeted control of the cellular state by local sol-gel transitions becomes possible. Albrecht-Buehler [I12] has demonstrated that photons with energy $E \sim .1$ eV have a maximal effect on cells.

The seesaw mechanism discussed in the article "Quantum model of sensory receptor" of [L2] minimizes dissipative losses and allows to understand how micro-tubular surfaces could provide dynamical records for the cellular sol-gel transitions, and thus define a fundamental micro-tubular representation of declarative long term memories.

As far as nerve pulse is considered, one ends up with the proposal that the soliton propagating along axon might be a shadow of a more fundamental soliton propagating along microtubular surface and inducing gel-sol-gel transition meaning disassembly and reassembly of tubulins which induces a braiding of magnetic flux tubes coding the details of the sensory signal below millisecond time scale to the braiding pattern.

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 Background For The Model Of Nerve Pulse

The following sections give some background for the model of nerve pulse.

2.1 General Vision About Living Matter As A Macroscopic Quantum System

The following assumptions summarize the general vision achieved before the dark matter revolution. The picture is consistent with the findings of Libet about strange time delays of consciousness [J22, J13] discussed in the article "Time, Space-time and Consciousness" in [L2] and chapter [**?**].

1. Magnetic bodies forming a hierarchy are the fundamental volitional agents transforming intentions to actions. Intentions are represented by p-adic MEs transformed to negative energy MEs representing the desire about particular activity communicated to the lower level magnetic bodies in the geometric past and eventually to the material body. Each negative energy ME in the cascade represents a desire to realize some submodule in motor program. Eventually the cascade of negative energy MEs ends up to the glial cells serving as metabolic sources. The desired action is generated in terms of neural communications and of positive energy MEs both representing classical communications to the geometric future. The desire in question could be a desire to perform a particular motor action, a desire to direct attention or select among sensory percepts (binocular rivalry is the standard example), or a desire to remember something. Sensory perception, motor action, and memory would thus be based on essentially the same basic mechanism. The population inverted many-sheeted laser system providing the energy source in brain or body would consist of bosonic ions or of Cooper pairs of fermonic ions in excited cyclotron states.

2. Sensory representations are realized at the magnetic bodies associated with the sensory organs and sensory mental images are shared with the personal magnetic body by negative energy em MEs. Brain constructs only symbolic and cognitive representations, writes the sensory music to notes. The mental images defined by these representations can be shared by personal magnetic body or magnetic bodies associated with the sensory organs in a similar manner. Also classical communications to the personal magnetic body are possible. A tree like structure with the root represented by sensory mental images and branches and leaves represented by various symbolic and cognitive mental images results.

   The selective entanglement by negative energy MEs allows to understand the active aspects of sensory experience involving direction of attention and selection between percepts at various levels. In the case of motor actions, the negative energy MEs received from magnetic body communicate the desires of the magnetic bodies about motor actions to be performed and the response by positive energy MEs would realize these desires as nerve pulse patterns.

3. Positive energy interior MEs lie along interior of magnetic flux tubes of the personal magnetic body. These MEs could relate to the classical communication of the symbolic representations constructed from the data processed in the brain to the magnetic body. Sensory perception and memory differ only is that the time scale involved is different. Declarative memory corresponds to negative energy MEs sent from a point of the personal magnetic body at the distance $L = cT$ to the material body and reflected back as positive energy MEs. Thus the material body serves as the mirror unlike in the original variant of the mirror mechanism of memory. The distance $L = cT$ along magnetic flux proportional to the transverse area S of the flux tube $L \propto S$ tubes codes for the temporal distance to the geometric past by transforming it to cyclotron frequency scale.

2.2 A General View About Quantum Control, Coordination And Communication Inspired By Dark Matter Hierarchy

The following general overview about quantum communication and control emerges from the model for EEG hierarchy as correlate for dark matter hierarchy discussed in detail in [K14].

1. Cyclotron frequencies relate to the control of the biological body by the magnetic body and could be assigned with the magnetic flux sheets going through DNA since it is genome where protein synthesis is initiated and is thus the optimal intermediate step in the cellular control.

2. One of the basic functions of cell membranes is to perceive the chemical environment using various kinds of receptors as sensors. Neurons have specialized to receive symbolic representations of the sensory data of primary sensory organs about the situation in the external world. A good guess is that in this case magnetic flux quanta are hollow cylindrical structures serving as templates for axons and possibly other similar structures and define the communication lines connecting cell membranes to the magnetic body.

3. This picture would explain why the temperature of brain must be in the narrow range 36-37 K to guarantee optimal functionality of the organism. If interior superconductivity is lost, magnetic body receives sensory data but is paralyzed since its desires cannot be realized. If boundary superconductivity is lost, magnetic body can move but is blind.

4. In the length scales below the weak length scale L_w also charged weak bosons behave as massless particles and the exchange of virtual W bosons makes possible a non-local charge transfer. Dark quark-antiquark pairs associated with the color bonds of the atomic nuclei can become charged via the emission of dark W boson and thus produce and exotic ion. The same can happen at the higher levels of dark matter hierarchy.

5. Massless extremals (MEs, topological light rays) serve as correlates for coherent states and Bose-Einstein condensates of dark bosons. Besides neutral massless extremals (MEs) TGD predicts also charged massless extremals obtained from their neutral counterparts by a mere color rotation (color and weak quantum numbers are not totally independent in TGD framework). The second non-local quantum control mechanism is based on em charge entanglement involving a superposition of ordinary ions/atoms and exotic ions connected by a W massless extremal joining magnetic body and biological body. In quantum jump this state would be reduced to exotic charge state with some probability increasing with the strength of the classical W field. Charged massless extremals could be seen as correlates for non-local quantum control by affecting charge equilibria whereas neutral MEs would serve as correlates for coordination and communication. Color charged MEs could also induce color charge polarization and flows of color charges and thus generate visual color qualia by the capacitor mechanism discussed in [K17].

6. It has become clear that the most plausible model for nerve pulse generation is as a phase transition changing the value of h_{eff} at the flux tube portion at either or both sides of the cell membrane. In the modification of the thermodynamical model of cell membrane based on "square root" of thermodynamics forced by ZEO, this would induce a change of ionic equilibrium distributions and generation of nerve pulse.

7. These non-local quantal mechanisms can induce or change electromagnetic polarization in turn inducing ordinary charge flows and thus making possible quantum control of nervous system by magnetic body. The generation of nerve pulse could rely on the spontaneous state function reduction occurring for charge entangled state reducing the resting potential below the critical value by this kind of mechanism inducing charge transfer between cell interior and exterior. Also remote mental interactions, in particular telekinesis, might rely on this mechanism.

2.3 The Role Of Electronic Super-Conductivity

2.3.1 General mechanisms of bio-superconductivity

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

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

A crucial element is quantum criticality predicting that new kind of superconductivity, "boundary superconductivity", appears at the fluctuating boundaries of competing ordinary and large $\hbar$ phases for nuclei besides large $\hbar$ variant of ordinary superconductivity in the interior. The Cooper pairs of interior and boundary supra currents are different with interior Cooper pairs being BCS

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

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

This mechanism is extremely general and works for electrons, protons, ions, charged molecules and even exotic neutrinos and an entire zoo of high T_c bio-superconductors, super-fluids and Bose-Einstein condensates is predicted. Of course, there are restrictions due to the thermal stability it room temperature and it seems that only electron, neutrino, and possibly proton Cooper pairs are possible at room temperature. The effects of ELF em fields on vertebrates suggest that Bose-Einstein condensates of all bosonic ions and their exotic counterparts resulting when some nuclear color bonds become charged [L4], [L4] are there but the model of high T_c super-conductivity does not favor them. It is of course possible that the temperature at dark magnetic space-time sheets is lower than at the visible space-time sheets.

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

The new model for the topological condensation at magnetic flux quanta of endogenous magnetic field $B = .2$ Gauss is based on the dark matter hierarchy with levels characterized by the values of $\hbar r\hbar_0$ of Planck constant.

1. TGD inspired quantum biology and number theoretical considerations suggest preferred values for $r = \hbar/\hbar_0$. For the most general option the values of $\hbar$ are products and ratios of two integers n_a and n_b. Ruler and compass integers defined by the products of distinct Fermat primes and power of two are number theoretically favored values for these integers because the phases $exp(i2\pi/n_i)$, $i \in \{a, b\}$, in this case are number theoretically very simple and should have emerged first in the number theoretical evolution via algebraic extensions of p-adics and of rationals. p-Adic length scale hypothesis favors powers of two as values of r.

   The hypothesis that Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1 + i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241..\}$ (the number theoretical miracle is that all the four 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 [K14]. This hypothesis - to be referred to as Mersenne hypothesis - replaces the earlier rather ad hoc proposal $r = \hbar/\hbar_0 = 2^{11k}$ for the preferred values of Planck constant.

2. There are several levels of dynamics. In topological condensation the internal dynamics of ions is unaffected and $\hbar$ has the ordinary value. The formation of Cooper pairs involves dynamics at lowest levels of dark matter hierarchy. Also the dynamics of ionic Cooper pairs remains unaffected in the topological condensation to magnetic flux quanta obeying dark dynamics with large value of Planck constant.

3. Cyclotron energies scale as as $r = 2^{k_d}$ so that for a sufficiently high value of k_d thermal stability of cyclotron states at room temperature is achieved. Spin interaction energy $\mu \cdot B \propto S \cdot B$ scales as $1/\hbar$ since four-momentum and angular momentum are by Poincare symmetry invariant under the scaling of $\hbar$ (the highly non-trivial implications of the invariance of angular momentum are discussed in [K38]). Hence spin interaction energy has the ordinary value. Unless thermal isolation is assumed, spin degrees of freedom are thermalized, and

only cyclotron degrees of freedom can be quantum coherent. This is a testable prediction distinguishing between the new and old model.

4. If the flux quanta of $B = .2$ Gauss correspond to $k_d = 44$ level of dark matter hierarchy, cyclotron energies $E = (\hbar/2\pi) \times ZeB/Am_p$ are scaled up by a factor $2^{k_d} \simeq 2^{44}$ from their ordinary values and are above thermal energy at room temperature for $A \leq 233Z$, where Z is the charge of the ion. Even for $Z = 1$ this includes all stable nuclei. Bose-Einstein condensates of bosonic ions are thus possible at room temperatures at Earth's surface.

2.3.3 Experimental evidence for bio-superconductivity

From the beginning it has been obvious that super-conductivity serves some important function in nerve pulse conduction. For instance, Josephson currents are optimal for quantal alarm clocks [K34]. Already before the ideas inspired by the dark matter hierarchy the contact by Hafedh Abdelmelek and his group [J18] led to a crucial step of progress in the understanding of this function. It became clear that genuine or effective electronic super-conductivity (in the sense that Cooper pairs are dropped temporarily to larger space-time sheets implying dissipation) is most probably involved with the propagation of the nerve signal through the myelin sheathed portions of the axon [K31].

The resulting simple model explained the experimental findings at quantitative level correctly and makes several predictions. In particular, one can understand why physiological temperature can have only a rather restricted range. The breaking of the electronic super-conductivity is an essential aspect of the ordinary nerve pulse conduction in this model. Also the distinction between poikilotherms (such as frog) and endotherms (such as rabbit) can be understood. As it often happens, the most recent model is not consistent with this model but is preferred by its simplicity.

2.3.4 Strange findings about cell membrane

There are very strange findings challenging the notions of ionic pumps and channels [I13, I15, I18, I11], and suggesting a mechanism dramatically reducing the metabolic costs involved with the ionic pumping. Second finding is that ionic currents seem to be quantal and are same for polymer membrane than for cell membrane! A further strange finding [J5] is that the propagation of nerve pulse does not cause heating of the cell membrane implied by the model of nerve pulse based on chemistry. This suggests that dissipation is absent also during nerve pulse propagation and that the process might not be chemical as assumed hitherto.

One can imagine two explanations.

1. The first explanation would be that ionic currents are actually dark supra currents flowing along larger space-time sheet connecting cell interior and exterior. The model of high T_c super conductivity favors only electronic and protonic super conductivity at room temperature [K7] whereas the model for EEG favors the presence of Bose-Einstein condensates of ions. Bosonic ions are required: the new nuclear physics predicted by TGD [L4], [L4] allows to assign to fermionic ions their bosonic chemical equivalents. Even permanent connections with the cell exterior (by magnetic flux tubes, say) are possible since Josephson currents oscillate. One can of course consider the possibility that dissipation rate is small due to the large value of Planck constant even in the absence of super conductivity. Also the temperature could be lower at the magnetic flux tubes containing dark ions but this assumption will not be made.

2. Second model that one can imagine relies on the exotic nuclear physics predicted by nuclear string model [L4] , [L4] and the predicted hierarchy of fractally scaled up variants of weak interaction physics. If weak interactions can be present in cell length scales, the exchange of virtual or real $W^{\pm}$ bosons between nuclei could induce purely quantal and non-dissipative charge transfer between cell interior and exterior. Also charge entanglement becomes possible. The emission of $W^{\pm}$ would modify the nucleus to an exotic charged state in which one of the neutral color bonds connecting nucleons is charged. Since W exchange does not depend on cell membrane at all, the prediction would indeed be that ionic currents do not depend at all on the membrane in question. The model of nerve pulse however suggests that W exchange can have only a role of a control signal.

One can argue that pumps in case of basic ions are needed only when the cell interior and exterior are connected by join along boundaries bonds/flux tubes 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.

2.4 The Role Of MEs And Magnetic Flux Tube Circuitry

The developments in the understanding of the role of MEs and magnetic flux tube circuitry have repeatedly forced to rethink the model of nerve pulse and EEG.

2.4.1 Universe as a conscious hologram

1. The notion of conscious hologram means that Universe is an extremely complex fractal Feynman diagram with lines replaced by 4-dimensional space-time sheets and MEs are particular kinds of lines analogous to photon lines. These lines are like laser beams, which interfere in the vertices of the Feynman diagram: vertices correspond to material space-time sheets, atoms, molecules, ..., cells, ... Super-conducting magnetic flux tubes are also important and act effectively as wave guides along which MEs propagate.

2. Topological field quantization allows to assign to any material system a field (magnetic) body. The view that "me" corresponds to the personal magnetic body of an astrophysical size receiving information from the material body by both classical communications and by sharing of the mental images realized in terms of bound state entanglement having negative energy MEs as a space-time correlate, has become a key hypothesis in the attempts to understand the functions of nerve pulse and EEG. The idea about brain as the sole seat of consciousness is deeply rooted in scientific thinking, and it took some time before I was able to take really seriously the idea about magnetic body as an intentional agent controlling the material body serving as its sensory and motor organ. In this respect the latest developments occurred while writing this article.

3. MEs, in particular, the topological field quanta of ELF fields are in a crucial role as far as the understanding of EEG (and the predicted ZEG and WEG) is involved. After dark matter revolution it became clear that MEs are the natural correlates for coherent states and Bose-Einstein condensates of dark matter bosons. It is still an open question whether ordinary laser light might be regarded as a special case of dark photons. Certainly the transformation of dark bosons to ordinary ones would occur through a de-coherence phase transition just like the transformation of laser light to ordinary photons.

2.4.2 Various kinds of MEs

One can imagine many kinds of MEs.

1. Interior MEs correspond to what might be called ELF MEs but they form only a small portion of the spectrum of MEs characterized by the fundamental frequencies defined by their lengths $f = c/L$ extended to ULF frequencies which correspond to length scales of order light lifetime. Also MEs in time scales at least down to 10^{14} Hz corresponding to visible photons are predicted be important.

2. Also boundary MEs identified as MEs attached to the boundaries of matter carrying space-time sheet and drifting along it quantum jump by quantum jump by a velocity $v < c$ can be considered and MEs of this kind were in a key role in the previous model for nerve pulse generation. In the case of boundary MEs, which are assumed to be positive energy MEs, the effective phase velocity satisfies $v << c$, and from $f = v/L$ the sizes of the structures associated with a given frequency are smaller by a factor v/c.

3. Negative energy MEs, which correspond to phase conjugate laser light, make possible intentional action at the micro-tubular level, they are crucial for the understanding of the macro-temporal quantum coherence, and have also inspired the notions of remote metabolism and quantum credit card. The newest discovery along this line is what might be called seesaw mechanism of energy metabolism (see the article "Time, Space-time and Consciousness" in [L2]). Phase conjugate laser beams [D3, D2] seem to be the standard physics counterpart of negative energy em MEs and negative energy photons accompanying them.

4. Fractality implies that MEs contain MEs within MEs: this conforms with the general ideas about dark matter hierarchy and p-adic length scale hierarchy. MEs within MEs is the topological correlate for de-coherence of Fourier components of classical field. In the simplest situation MEs appear as pairs of high frequency and low frequency MEs. The scaling law of homeopathy [I8] states that low frequencies are accompanied by high frequencies such that the frequency ratio has preferred predictable values identifiable as characteristic velocities in the system (such as EEG phase velocity): $f_{low}/f_{high} = v/c$. The most general assumption about the spectrum of high frequency MEs inside low energy MEs is that it is scale invariant in the sense that the intensity satisfies $I(f_{high}, f_{low}) = I(f_{high}/f_{low})$.

   Low frequency negative energy MEs could serve as correlates for remote quantum entanglement in cyclotron degrees of freedom. W MEs would make possible charged entanglement. High frequency MEs travel effectively like massless particles along the bridges defined by the low frequency MEs and can transform to boundary MEs serving as bridges between different space-time sheets at the receiving end, in which case their effective phase velocity is reduced to $v << c$. These MEs could induce a leakage of ions between different space-time sheets, breaking of super-conductivity and dissipative self-organization. This process which is analogous to the formation of hologram, is responsible for homeostasis and metabolism and gives rise to many-sheeted ionic flow equilibrium. Also many-sheeted lasers acting in a very wide range of frequencies become possible. The frequencies correspond to differences for the energies of ions at the space-time sheets involved. MEs parallel to axons can also act as Josephson junctions connecting space-time sheets which can correspond to different p-adic primes.

2.4.3 The strange effects of ELF em fields on vertebrates as a key to the model for hierarchy of EEGs

The experimental findings of the pioneers of bio-electromagnetism [J34] demonstrate that electromagnetic radiation at the harmonics of cyclotron frequencies of various ions in magnetic field $B = .2$ Gauss, in particular Ca^{+2} ion, are somehow involved with the bio-control. The dropping of ions from smaller space-time sheets to the super-conducting magnetic flux tubes of B indeed generates cyclotron radiation. The generalization of this [I9] [L1] explains the findings of Gariaev [I10] about radio waves induced by laser irradiation of DNA. The detailed model explaining various aspects of these findings on basis of TGD inspired model of high T_c superconductivity led to a detailed model for the hierarchy of EEGs (or EWEGS, with EW for electro-weak) generated by Josephson junctions as Josephson and by cyclotron transitions of Bose-Einstein condensates of bosonic ions.

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.

3 TGD Based Model For The Generation Of Nerve Pulse

The general vision about living system as a conscious hologram and the view about how "topological light rays" (massless extremals, MEs) serve as remote entanglers and induce self-organization via

the leakage of ionic currents between various space-time sheets implies that several space-time sheet pairs are involved with the bio-control. Perhaps the most radical deviation from the standard neuroscience thinking came with the realization that in TGD Universe every physical system has also magnetic/field body of size much larger than the material body and that material bodies can be seen as motor and sensor organs of the personal magnetic body. This counter intuitive conclusion is unavoidable if one accepts many-sheeted macroscopic quantum coherence, Uncertainty Principle and topological field quantization. p-Adic physics as physics of intention and cognition provides an additional support for this view: the smaller the space-time sheet is p-adically, the larger it is in the real sense so that cognition and intentionality are predicted to be astrophysical phenomena and evolve from long to short length and time scales just as it indeed occurs when motor activity is learned.

The TGD based view about dark matter hierarchy involving a hierarchy of values of Planck constant provides a justification for this picture. Dark matter hierarchy corresponds to the hierarchy of moments of consciousness with increasingly long duration with respect to geometric time and defines a hierarchy of conscious entities and reflective levels of consciousness.

Dark matter hierarchy provides a mechanism for the formation of macroscopic and macro-temporal quantum phases in all length scales. The earlier assumption about thermal isolation of space-time sheets corresponding to different p-adic length scales can be given up and thermal stability condition becomes an additional strong constraint allowing to eliminate various options very effectively. Since cyclotron energies scale like $\hbar$, thermal stability is possible to achieve for them.

The quantum model of nerve pulse requires answer to several questions. Some of them are following.

1. Are various charged currents quantal or ohmic currents? For electrons and even protons an attractive answer is that they are quantal currents. The effects of ELF em fields on vertebrate brain suggest that also ionic currents are quantal and that Cooper pairs of ions might be involved. Hodkin-Huxley model assumes ohmic currents but the observations about cell membrane do not support this view.

2. If the ionic currents are quantal, are they oscillating Josephson currents or direct currents? For the direct quantal currents a model was constructed in previous section. If the thickness of Josephson junction is not much larger than Compton length then all Josephson currents in cell membrane length require non-standard value of Planck constant. For electron it would be about 2^{11} and for proton about 2^{22} using the standard value of $\hbar$ as unit. For ions even large Planck constant would be required (its value scales like mass). The hierarchy of preferred values of Planck constant given by powers $m_p/me \simeq 2^{11}$ is suggestive. DNa as TQC suggests that also quarks are involved in this case the low masses would suggest Josephson currents.

3. Already the visible cell membrane is a highly structured object and many-sheetedness of space-time could play a key role. This could mean the presence of magnetic flux tubes with many values of Planck constant. Magnetic flux tubes would be natural models for the ionic channels and pumps. Note that DNA as TQC model involves flux tubes connecting DNA nucleotides and lipids. One can quite well consider the presence of both Josephson currents and direct quantal currents except perhaps for electron Cooper pairs and possibly they protonic counter parts.

4. In the case of fermionic Cooper pairs one can consider Cooper pairs as building bricks of Bose-Einstein condensate. Also exotic nuclei which are bosons but chemically equivalent with fermionic ions can be considered. The argument of previous section favors Cooper pair option and direct ionic currents.

5. One can consider two kinds of basic extremals. Near vacuum extremals for which classical Z^0 fields are important and far from vacuum extremals for which they are small. The latter extremals would correspond naturally magnetic flux tubes carrying monopole Kähler magnetic flux. Both of them might be involved with the ionic channels and pumps. As extreme situations one can consider two models of cell membrane assuming only near to or far from vacuum extremals.

6. What is the mechanism generating the nerve pulse? This mechanism should change the stationary situation in which only oscillatory Josephson currents are present and generation of quantal direct current is suggestive. Does this current consist of electron Cooper pairs or possibly ions of their Cooper pairs? Is there a primary wave - say Ca^{++} wave - involved. Why de-polarization instabilizes the situation? As found in previous section, the model for ionic direct currents suggest a possible explanation for this.

In this section TGD based model of nerve pulse and EEG inspired by the soliton model of Danish researchers and the model of Pollack is discussed. Also a model for the action of anesthetics is proposed.

3.1 Soliton Model Of Nerve Pulse

Let us first briefly summarize soliton model of nerve pulse proposed by Danish researchers [J9, J26, J27, J29].

1. The temperature of the axon is slightly above the critical temperature T_c for the phase transition leading from crystal like state of the lipid layers to a liquid crystal state. Near criticality the elastic constants and heat capacity of the membrane vary strongly and have maxima at criticality so that also sound velocity varies strongly near criticality. Also the relaxation times are long. There is also dispersion present meaning that the frequency of sound wave depends nonlinearly on wave vector. Non-linearity and dispersion are prerequisites for the presence of solitons which by definition do not dissipate energy.

2. Variations of temperature, volume, area, and thickness and also other mechanical effects are known to accompany nerve pulse propagation. It is also known that the heat density and temperature of the cell membrane increases slightly first and is then reduced. This suggests adiabaticity in average sense. These findings motivate the assumption that nerve pulse actually corresponds to acoustic soliton [J26, J27].

3. Soliton model reproduces correctly the velocity of nerve pulse inside myelin sheaths but it is not clear to me how well the much lower conduction velocity in non-myelin sheathed regions is reproduced. It is not clear how the lower values of the conduction velocity and its proportionality to the axonal radius in non-myelinated regions can be understood. Intuitively it however seems clear that the lower velocity is due to the feedback from the interaction of ions with the region exterior to cell membrane. In the case of myelin sheaths the conduction of nerve pulse is usually believed to take place via saltation [J8]: the de-polarization induced at Ranvier node is believed to be enough to take the membrane potential below critical value in the next node so that nerve pulse hops between the nodes. Insulation would improve the insulation and make this process possible. The reversible heat transfer process is however known to be present also in the myelinated portions of axon so that there must be a pulse propagating also in these regions [J27]. It is not clear how the myelin sheet can increase the velocity in the soliton model but the reduction of the feedback inducing friction suggests itself.

4. Soliton property predicts adiabaticity. Ordinary ionic currents however dissipate so that adiabaticity assumption is questionable in standard physics context. The model does not predict the growth of entropy followed by its reduction. This behavior is consistent with adiabaticity in a time resolution of order millisecond.

5. The estimate for the capacitor energy density during the nerve pulse is considerably smaller than the energy density is many times magnitude smaller than that of the acoustic wave. This might allow to demonstrate that Hodgkin-Huxley model is not a complete description of the situation.

6. Authors notice [J26, J27] that the shapes curves representing solitonic energy density and the capacitor energy density as a function of time are essentially identical. Same applies to the experimentally deduced heat change release curve and capacitor energy density for garfish axon. Also heat release and the deviation of the membrane potential from its resting

value are in exact phase. These similarities could reflect a control signal responsible for the nerve pulse originating somewhere else, perhaps at micro-tubules. This could explain why secondary nerve pulse is not generated immediately after the first one although the temperature is slightly lower after the pulse than before it. This could of course be also due to the exhaustion of the metabolic resources.

3.2 TGD Based Model Of Nerve Pulse Assuming Far From Vacuum Extremals

The model of nerve pulse described below can be motivated by the observed adiabaticity of the nerve pulse and by the strange findings about ionic currents associated with the cell membrane and by the model of Danish researchers for the nerve pulse [J5, J9, J26, J27]. The model involves also a fusion of various ideas of earlier models. In particular, Josephson currents and solitons are in a key role in the model but with the necessary flexibility brought in by the hierarchy of Planck constants. The model of nerve pulse by Pollack [I13] discussed at the end of previous section allows to understand the behavior of ionic currents quantitatively. In this subsection a model of nerve pulse based on the assumption that cell membrane represents far from vacuum extremals so that classical Z^0 field is very small will be discussed. In subsequent subsections the model for which cell membrane is almost vacuum extremal will be developed with main motivation coming from the observation that the model predicts correctly the frequencies of peak sensitivity for the four photoreceptors.

3.2.1 Consistency with the absence of dissipative currents through the axonal membrane

The basic inputs of the TGD based model are following.

1. The presence of acoustic soliton or density pulse proposed by Danish researchers [J27] looks plausible but a a more fundamental quantum control mechanism inducing the acoustic soliton cannot be excluded. Among other things this should explain why acoustic solitons propagate always in the same direction. In particular, one can consider a soliton like excitation (say breather for Sine-Gordon equation) associated with the electronic or ionic Josephson currents running along magnetic flux tubes. The strange effects associated with the ionic currents through the cell membrane suggest quite generally that at least weak ionic currents through normal cell membrane are non-dissipative quantal currents. The adiabaticity of the nerve pulse suggests that also strong ionic currents are quantal. This suggests identification as either Josephson currents or direct quantal currents discussed in previous section. In stationary situation direct currents would vanish by boundary conditions whereas Josephson currents would be oscillating. Direct currents as generator of nerve pulse would allow to understand why de-polarization induces nerve pulse.

2. Strong ionic currents generating nerve pulse through axonal membrane are absent in the resting state. The naïve explanation is simple: the life time of the magnetic flux tubes connecting the axonal interior to the exterior is short or the flux tubes are altogether absent. The observation that Josephson currents in constant voltage are automatically periodic suggests a less naïve explanation allowing the flux tubes to be present all the time. The presence of ionic Josephson currents predicts a small amplitude oscillation of membrane potential for which 1 kHz synchronous oscillation is a natural identification. Josephson oscillation correspond naturally to propagating soliton sequences for Sine-Gordon equation. The dynamics of the simplest modes is equivalent to the rotational motion of gravitational pendulum: the oscillation of membrane potential corresponds to the variation of $d\Phi/dt \propto V$. Note that if axon is above the melting temperature, the lipid layer is in gel phase and fluid motion is impossible. The surface density of lipids is dramatically reduced at criticality so that lipid layers behave like fluids [J27]. This means that TQC is not possible by the braiding of lipids.

3. Nerve pulse is generated when the magnitude of the negative membrane potential is reduced below the critical value. Generation of the nerve pulse is like a kick to a rotating gravitational pendulum changing the sign of $\Omega = d\Phi/dt$ so that rotational motion is transformed to

oscillatory motion lasting for about the period of rotation. An opposite but slightly stronger kick must reduce the situation to the original one but with a slightly higher value of Ω. These kicks could correspond to voltage pulse between micro-tubules and inner lipid layer of cell membrane induced by the addition of small positive (negative) charge on lipid layer. This pulse would induce electronic DC Josephson current inducing the kick and thus reducing V. For instance, the exchange of scaled variants of W bosons (assignable to W MEs) could mediate the transfer of charge through the cell membrane and reduce the membrane potential below the critical value but one can consider also other mechanisms. Another possibility is generation of direct ionic currents of Ca^{++} and Cooper pairs of Na^{+} ions. This in turn could be induced by a perturbation of electronic (and perhaps protonic) Josephson current. The analog for the stationary situation is a sequence rotating penduli with constant phase difference along axonal membrane. Nerve pulse corresponds to a propagation along the axon of a wave in which some penduli oscillate rather than rotate.

4. The conservative option would be that ordinary ionic currents take care of the rest and Hogkin-Huxley model applies. This was assumed in the earliest model in which soliton sequence for Josephson current was assumed to induce nerve pulse sequence: in the recent model this assumption does not make sense. The findings of Danish researchers do not however support the conservative option [J27] . Nerve pulse could be due to dark ionic (possibly supra -) currents with large $\hbar$ with a low dissipation rate. Their flow would be made possible by the presence of magnetic flux tubes connecting cell interior and exterior.

3.2.2 The relationship with the model of Pollack

In the model of Pollack [I13] for the action potential gel-sol-gel phase transition for the peripheral cytoskeleton accompanies the generation of the action potential. The model allows to understand reasonably well the behavior and the physical role of the ionic currents and explains various anomalies. Using pendulum analogy, the kick to the rotating pendulum representing Josephson junction would force it to an oscillatory motion inducing a gel-sol-gel phase transition propagating along the peripheral cytoskeleton.

The challenge is to understand how quantum criticality making possible the phase transition is induced.

1. The primary Josephson currents from the micro-tubuli to the axonal membrane would reduce the magnitude of the cell potential below the critical value (slowing down of the pendulum rotation). This should somehow take the peripheral cytoskeleton near to quantum criticality and induce the increase of Planck constant for the flux tubes connecting peripheral cytoskeleton to the axonal membrane and increasing their length so that they would extend to axonal exterior. This would make possible the flow of Cooper pairs of monovalent dark ions (say Na^{+}) from the axonal exterior replacing Ca^{+2} acting as cross links between negatively charged proteins and in this manner induce gel-sol phase transition. The reverse phase transition would reduce Planck constant. If ionic currents are non-dissipative they flow back automatically much like oscillating Josephson currents.

2. Gel-sol phase transition can be compared to melting since in the gel phase the hydrogen bonds induce effective freezing of various globular proteins to their folded configuration and naturally unfolded proteins to their unfolded configurations. This melting quite generally induces protein aggregation. Melting requires energy to destroy the hydrogen bonds and during action potential the system receives this energy somehow. One could even imagine that action potential generates both positive energy Josephson radiation inducing melting and phase conjugate Josephson radiation inducing freezing again and that these two steps correspond to an increase of Planck constant and its reduction back to the original value. Josephson radiation could quite generally control biological functions by inducing protein aggregation.

3. There are two forms of quantum criticality corresponding to critical sub-manifolds $M^2 \times CP_2$ and $M^4 \times S^2$, where $M^2 \subset M^4$ has interpretation as plane of non-physical polarizations and $S^2 \subset CP_2$ is a homologically trivial geodesic sphere of CP_2 with vanishing induced Kähler

form (see the Appendix of [K1]). The latter kind of quantum criticality corresponds to very weak induced Kähler fields and thus to almost vacuum extremals. Given electromagnetic field can be imbedded as a 4-surface in many ways: as a vacuum extremal, as a surface maximizing Kähler electric energy, or something between them.

4. Quantum criticality suggests that em fields in the cell interior correspond to non-vanishing but not too large induced Kähler fields in the resting state. The magnitude of the cell potential in the absence of the membrane is about -50 mV and slightly below the magnitude of the critical potential of -55 mV [I13]. Hence the reduction of the magnitude of the em (-or more precisely- Kähler-) voltage between the inner boundary of the peripheral cytoskeleton and cell exterior to a small enough value could induce almost vacuum extremal property and quantum criticality making $\hbar$ increasing phase transition for the magnetic flux tubes connecting peripheral cytoskeleton to the axonal membrane possible. This framework would also allow to understand the paradoxical fact that a reduction of the magnitude of the cell potential induces the action potential rather than its increase as the naïve idea about dielectric breakdown would suggest.

5. Action potential should induce gel-to-sol phase transition somehow and Josephson radiation generated during the action potential could be responsible for this. During action potential the energy of Josephson covers a wide range so that it could couple to metabolic energy quanta. If the frequency of Josephson radiation is considerably higher than the rate of variation of the action potential the situation is adiabatic in the sense that the energy of Josephson radiation is effectively constant. The situation is optimal during the maximum +40 mV of the action potential. Josephson radiation could couple resonantly to the gel defined by the peripheral cytoskeleton and induce fast transfer of protons from large to small space-time sheets and generate metabolic energy quanta helping to destroying the hydrogen bonds. This should somehow induce the increase of Planck constant for the magnetic flux tubes responsible for the gel-to-sol phase transition. This admittedly speculative and somewhat misty idea has been discussed already earlier and will reconsidered in the section where the relationship of the model with microtubular level is discussed.

6. The value of the membrane potential is -55 meV at criticality for the generation of the action potential and +40 meV at the maximum [J1]. All the values between them could correspond to energies of Josephson radiation, which for certain values of membrane potential correspond to metabolic energy quanta. The range of variation for membrane voltage allows all Josephson energies down to cutoff energy for which the frequency of Josephson radiation is of same order than the rate of relative variation of the membrane potential. Explicitly this condition reads as

$$\frac{\frac{dV}{dt}}{V} \ll \frac{f_0}{r}\frac{V}{V_0} \quad , \quad r = \frac{\hbar}{\hbar_0} \quad .$$

Here f_0 is the the Josephson frequency for $r = 1$ and for the resting potential V_0 and is of order 10^{14} Hz for almost vacuum extremals and 10^{13} Hz for far from vacuum extremals. Josephson frequency must be considerably above kHz frequency defined by the duration of the action potential. Therefore Josephson radiations below *resp.* above kHz frequency must relate to resting state *resp.* action potential and must correspond to different biological functions. For $r = 2^{k_d}$ the kHz frequency correspond roughly to $k_d = 36$ for almost vacuum extremals and to $k_d = 33$ for far from vacua. Note that the p-adic length scale determined by the wave length of Josephson radiation for $k_d = 36$ is 16 cm - the size scale scale of brain.

7. There are two options depending on whether the cell membrane is assumed to correspond to almost vacuum extremal or not.

   (a) For far from vacuum extremal option the energies of Josephson photons in the case of proton are 55 meV and 40 meV for the mentioned values of membrane potential and corresponds to IR radiation. The Josephson energies in case of proton and electron are by an order of magnitude smaller than the nominal energy.5 eV for standard metabolic energy quantum. The metabolic energy quantum liberated in the dropping of proton

Cooper pair from $k = 139$ atomic space-time sheet or of electron Cooper pair from $k = 151$ cell membrane space-time sheet to a much larger space-time sheet is $\simeq .62$ eV for the nominal value of.5 eV for the dropping of proton from $k = 137$ space-time sheet to much larger space-time sheet. Note however that $E = E_0(1 - 2^{-k})$ spectrum for metabolic energy quanta gives energy $E = 47$ meV for $k = 2$. One can criticize this option because one must assume non-standard metabolic energy quanta and there must be a separate control mechanism inducing their generation.

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.

(b) The cutoff frequency is certainly considerably higher than kHz. For almost vacuum extremal the Josephson energy is

$$E = Q_{eff}(p)e \times V \quad , \quad Q_{eff}(p) = 3 - \frac{1}{2p} \quad , \quad p = sin^2(\theta_W) = .029 \quad .$$

One has $E = .7$ eV for V=-55 mV and $E = .56$ eV for V=+40 meV. The latter value is not too far from the nominal value.5 eV for the basic metabolic energy quantum. Note that during nerve pulse Josephson radiation in a wide range of energies is emitted. Besides this there is energy spectrum associated with ions. The energies for $(Na^+.Cl^-, K^+, Ca^{+2})$ are (2.2, 2.74, 3.07, 2.31) eV for -55 mV and (1.60, 2.00, 2.23, 1.68) eV for +40 mV (Table 3). Note that at maximum of V 2.00 eV metabolic energy quantum is associated with Cl^-.

3.2.3 What the replacement of Ohmic ionic currents with quantal currents means?

Before the replacement of Hodgkin-Huxley model with a genuinely quantal model can be taken seriously, one must answer many difficult questions which also Hodgkin and Huxley must have faced as they developed their own model. It is best to proceed by making questions and answers.

Q: In the resting state membrane potential is negative and cell has a negative net charge. What stabilizes the cell against the leakage of the negative charge if pumps and channels are not responsible for this?

A: The findings about the strange behavior of cell membrane inspire TGD based answer. Cell membrane space-time sheet is its own quantum world and the flow of ions occurs only in the presence of magnetic flux tubes connecting it to the external world. These currents a however oscillatory Josephson currents if dissipation is absent. Hence there is no need to cut completely the connections to the external world.

Q: How the resting state can result spontaneously if pumps are absent?

A: If ionic currents are Josephson currents, they are automatically oscillating and the return to the original state is guaranteed. The flux tubes carrying the ionic currents will be assumed to connect axonal micro-tubules to the space-time sheet of the cell interior. Consider first the most obvious objections.

1. Dark ions cannot transform to ordinary ones in the exterior of the cell membrane. This might indeed kill the model.

2. The second objection is that all biologically important ions are not bosons and the model for high T_c super-conductor in its recent form allows only electronic and protonic Cooper pairs at room temperature [K7]. TGD based nuclear physics however predicts the possibility of exotic nuclei for which one or more color bonds connecting nucleons to the nuclear string are charged. These exotic nuclei with electronic states identical to those of genuine ions could save the situation.

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

(3.1)

Table 1: The modification of cyclotron frequencies of most important ions are modified by simplest replacements with exotic ions

Table 1 describes how cyclotron frequencies for $B = .2$ Gauss of the most important ions are modified in the simplest replacements with exotic ions. For instance, the notation Mg_-^{+2} tells that there is double electronic ionization and electron shell of Argon as usual but that one color bond is negatively charged.
$f_c(K+)$ and $f_c(Cl^-)$ are replaced with the frequency 7.5 Hz and one can do only using the cyclotron frequencies $f(Ca^{+2})/2 = 7.5$ Hz, $f_c(Mg^{+2}) = 12.5$ Hz, and $f(Ca^{+2}) = 15$ Hz. The nominal values of the lowest Schumann frequencies are 7.8 Hz and 14.3 Hz. All ions with relevance for nerve pulse and EEG could be bosonic ions or bosonic pseudo-ions. I do not know how well the needed ionization mechanisms are understood in the standard framework.

For small oscillations the maximal charge transfer ΔQ generated by an oscillating ionic Josephson current during the cycle is proportional to $\hbar/f_J \propto \hbar^2$ and $\hbar/\Omega \propto \hbar$ for solitonic situation. ΔQ is very small for the ordinary value of $\hbar$: also the oscillation period is very small. For large values of $\hbar$ situation changes and large maximal ion transfers are possible. An $\hbar$ increasing phase transition could be involved with the generation of the nerve pulse. Quantum criticality during nerve pulse generation indeed suggest the presence of flux tubes with varying values of $\hbar$. The lifetimes of the connected flux tubes could be proportional to $\hbar$ at criticality. A fractal hierarchy of pulses and EEG like oscillations of the membrane potential corresponding to various values of $\hbar$ is suggestive.

Q: Can one make this more quantitative?

A: One can construct a model based on Sine-Gordon wave equation for the phase difference Φ between the superconductors connected by Josephson junction sequences defined by magnetic flux tubes and idealizable as a continuous Josephson junction.

1. For a Josephson junction idealizable as a hollow cylinder with radius R and thickness d the expression of the Josephson current reads as

$$J = J_0 sin(Ze \int V dt/\hbar) \ .$$

J_0 is in case of cell membrane given by

$$J_0 = \frac{Ze2\pi dR}{\Lambda^2}\frac{\hbar}{m} \ ,$$

where R and d would be now the radius and thickness of the axon, Λ is the magnetic peneration length, and m is the mass of the charge carrier. Although this expression does not hold true as such when Josephson junctions are replaced by magnetic flux tubes connecting micro-tubules and axon, one can can safely make some qualitative conclusions. The amplitude of the Josephson current increases with $\hbar$. For electron the value of the amplitude is by a factor $x \simeq Am_p/m_e \simeq 2^{11}A$ larger than for ion with a mass number A. This gives for electron Cooper pairs a unique role as an initiator of the nerve pulse. Note that the amplitudes of the Josephson currents of electron and ions are quite near to each other if one has $\hbar(ion) = 2^{11}A\hbar e$.

2. Electronic Josephson current dominates and makes it ideal for the generation of nerve pulse (kick to gravitational pendulum). This is possible if the net amount of electronic charge is so small that it flows out during the generation of flux tubes. For ions this need not occur even if ion densities are of same order of magnitude. Constant voltage V creates an oscillating current and no catastrophic leakage takes place and the resting state results automatically. The ionic Josephson currents assignable to the magnetic flux tubes connecting micro-tubules through the cell membrane to the external world could be responsible for the nerve pulse.

3. The mechanical analog for Sine-Gordon system [B1] assignable to Josephson junction is rotating pendulum but one must be cautious in applying this analogy. There are two options concerning the modelling of the situation.

   (a) Membrane potential represents an external voltage $V(t)$ and one has $\Phi_i = Z_i e \int V dt/\hbar$, where Φ is the phase difference between Bose-Einstein condensates.

   (b) System is autonomous and membrane potential $V(t) = \hbar(d\Phi_i/dt)/Z_i e$ is completely determined by the dynamics of any phase Φ_i. This option is highly predictive and discussed in the sequel.

4. The analogy with gravitational pendulum allows to identify the phase angle Φ as the counterpart of angle Θ characterizing angular position of mathematical pendulum (note that this analogy can be misleading since it implicitly brings in 3-D thinking).

   (a) In this picture rotating pendulum corresponds to a soliton sequence containing infinite number of solitons: both stationary and moving soliton sequences are obtained. The sign of $\Omega = d\Phi/dt$ is fixed and approximately constant for large values of Ω. Resting potential could correspond to this kind of situation and $\Omega \simeq 2\pi$ kHz is suggested by kHz synchrony. A mechanism of this synchrony will be discussed below. For large values of $\hbar$ even values of Ω in EEG range could correspond to membrane potential. For large values of Ω one as $V \simeq \hbar\Omega_i/Z_i e$. If also EEG rhythms correspond to Ω they must correspond to different values of $\hbar$ and $f \propto 1/\hbar$ would hold true. Changes in the dominating EEG rhythm (40 Hz, 10 Hz, 5 Hz, ..) could correspond to phase transitions changing $\hbar$ to given value for a large number of axons. The maximal charge transfer during single period is proportional to $\Delta Q \propto 1/\Omega$.

   (b) Hyper-polarization/depolarization would mean fastening/slowing down of the pendulum rotation and slowing down would make the system unstable. Near criticality against the generation of nerve pulse would mean that pendulum is rotating rather slowly ($\Omega \ll f_J$) so that a small kick can transform rotation to oscillation. The sign of $V \propto d\Phi/dt$ would change and large amplitude oscillatory motion would result for single period only after which a kick in opposite direction would lead back to the resting state. Membrane potential varies between the resting potential $V_0 = -75$ mV and $V_1 = +40$ mV during nerve pulse: $V_1 > |V_0|$ would have killed the model. Note that $V_1 = 40$ mV is rather near to the critical potential about $V_1 = 50$ mV: ideally these potentials should be identical.

   (c) The so called breathers -both stationary and moving- correspond to soliton-antisoliton bound state (see the visualization in [B1]). Breathers could be identified as large amplitude oscillations around $\Phi = 0$ ground state. Physical intuition suggests that breathers are possible also for a ground state corresponding to a rotating pendulum (representing moving or stationary waves). They would correspond to kicking of one pendulum in a sequence of penduli along z-axis rotating in phase at the initial moment. The kick could correspond to a genuine external perturbation generated by a pair electronic supra current pulses of opposite sign giving constant velocity increments $\Delta\Omega$ initiating and halting the nerve pulse just like they would do in the case of TQC but in opposite time order. If the background corresponds to a propagating EEG wave, also nerve pulse is expected to propagate with same velocity. The propagation direction of EEG wave would also explain why nerve pulses propagate only in single direction.

5. For the ordinary value of $\hbar$, the frequency Ω of the Josephson current corresponds to that assignable to energy.07 eV being around $f = 1.6 \times 10^{13}$ Hz and quite high. One can look

at the situation in light of $r \equiv \hbar/\hbar_0 = 2^{11k}$ hypothesis, which has however turned out to be quite too restrictive. For $r \equiv \hbar/\hbar_0 = 2^{44}$ the frequency would be near to cyclotron frequency of about 1 Hz assignable to DNA strands. For $x = 3 \times 2^{3\times 13}$ f would be near to the fundamental 10 Hz frequency which is secondary p-adic time scale associated with electron and correspond to the temporal duration of negative energy space-time sheet assignable to electron. For $r = 3 \times 2^{3\times 11}$ one would obtain a 640 Hz frequency which corresponds to the time scale of nerve pulse. It seems clear that the original hypothesis that only powers of 2^{11} define the spectrum of Planck constant is too restrictive and Mersenne hypothesis introduced in the introduction seems more plausible hypothesis although even this hypothesis is too too restrictive [K14]. The requirement that cyclotron frequencies and Josephson frequencies are proportional to each other for small oscillations would guarantee resonant behavior for common strength of the magnetic field would give $\hbar \propto A$. This would require that each ion species lives at its own flux tubes.

6. The realization that cell membrane could correspond to almost vacuum extremal [K14] changed the situation completely. For vacuum extremals Z^0 and em fields are proportional and if one assumes that almost vacuum extremals define a phase in which the Z^0 charges of quarks are fed to almost vacuum extremal unlike electrons, one must replace ionic charges with effective charges proportional to the nuclear charge. This raises the energy scale defined by the resting potential to visible and UV range.Note that also neutral atoms are Z^0 ions in this phase. Otherwise the model for cell membrane as Josephson junction remains the same. This hypothesis can be defended by its success: it predicts correctly the values of frequencies of maximum sensitivity for photoreceptors in terms of Josephson energies of various ions and almost vacuum extremal property conforms also with the quantum criticality of living matter. This model will be be discussed in detail in the sequel.

Q: What instabilizes the axon? Why the reduction rather than increase of the magnitude of the membrane potential induces the instability? Why the reduction of the resting potential below the critical value induces nerve pulse?

A: Large enough voltage pulse between micro-tubules and membrane could generate electronic DC supra current. The introduction of a small amount of positive charge to the inner lipid layer and staying there for some time would generate the voltage pulse between micro-tubules and lipid layer so that DC electronic supra current would be induced, and induce the reduction $\Delta V \simeq .02$ eV of the magnitude of the membrane potential. A similar introduction of negative charge would induce hyper-polarization and the direction of the current would be opposite if it is generated at all. The proposed model for direct current explains why de-polarization induces instability. Ionic direct quantum currents could thus be the generators of nerve pulse as in Hodkin-Huxley model and Ca^{++} ions and Na^{+} Cooper pairs are in preferred position. The mechanism generating the small positive charge to the inner lipid layer could be based on the exchange of exotic W bosons between pairs of exotic nuclei at opposite sides of the cell membrane so that the negative charge of the inner lipid layer would be reduced.

Q: Can one understand the observed radial force, the increase of the radius of axons and the reduction of its thickness, and heating followed by cooling?

A: The observed outward force acting on a test system might be due to quantum currents. Josephson currents are oscillatory and are not expected to cause any force. Ionic direct currents could induce the force. The pressure caused by the ionic direct current pulse might relate to the increase of the radius of the axonal membrane and with the reduction of its thickness as well as the slight increase of its temperature as being due to the ions which heat the lipid layer as they collide with it and are transferred to smaller space-time sheets if they energy is large enough.

1. This hypothesis combined with the model for direct quantal currents allows to express the momentum flux as product of ionic particle current $n_I v = n_I p/m$ and momentum of charged current carrier equal to $p = \sqrt{2mE_n}$ at the plate of the analog of capacitor. This gives the estimate for the contribution of given bosonic ion or Cooper pair of fermionic ions to the force f per unit area as

$$\begin{aligned} f_I &= n_I \times 2E_n \ , \ , \\ E_n &= sin(2\delta)(\frac{nqE\hbar}{r\sqrt{m}})^{2/3} \ , \ r == \frac{2}{3} \ , \\ \Psi &= Rcos(U+\delta)exp(-iE_n t) \ . \end{aligned} \tag{3.2}$$

The representation of Ψ was introduced in previous section. Here δ parametrizes the current, which vanishes for $\delta = 0, \pi/2$. This gives

$$f_I(t) = n_I \times (\frac{nqE\hbar}{r\sqrt{m_I}})^{2/3} \ , \ r = \frac{2}{3} \ . \tag{3.3}$$

The force is proportional to $E^{2/3}$ rather than $E = V/d$ (electric field). There is proportionality to $m^{-1/3}$ so that lightest charges give the dominating contribution if their densities are small for some reason.

2. The force caused by ionic Josephson currents on a small piston of area S parallel to the membrane is given by

$$F = \sum_I n_I \times (\frac{nqE\hbar}{r\sqrt{m_I}})^{2/3} S \ . \tag{3.4}$$

The comparison with the observed force gives estimate for the densities n_I of ions at the flux tubes.

3. According to [J27] in one particular experiment the force on piston of area $S = .01$ cm^2 at the maximum of voltage is $F = 2$ nN. This gives for proton mass the rough estimate $n_I \sim 2/L_e(151)^3$, where $L_e(151) = 10$ nm is the p-adic length scale defining cell membrane thickness. For heavier ions large densities of super-conducting ions or their pairs would be required. Perhaps the simplest option is that the direct current pulse of dark proton Cooper pairs induces the force whereas the Josephson currents of electrons give rise to negligibly weak force.

Q: Where the primary wave propagates: along axon or along micro-tubules?

A: This question need not make sense if micro-tubules and axon are connected by magnetic flux tubes to form single quantum coherent system. That axonal micro-tubules have constant electric field which is always in same direction could explain why the background soliton sequences and nerve pulses propagate always in the same direction and suggests that the primary wave propagates along micro-tubules. On the other hand, if W exchange between cell exterior and exterior reduces the negative charge of the inner lipid layer then axon could be seen as initiator. This could induce conformational or gel-sol phase transition propagating along micro-tubule and inducing the pair of voltage pulses in turn inducing the fusion of flux tubes at cell membrane which in turn would induce criticality of the axonal membrane. For this option axonal soliton would be a shadow of the micro-tubular soliton rather than completely independent dynamical process.

Q: How nerve pulse velocities are determined?

A: At first glance it seems nerve pulse velocity v could be determined by boundary conditions guaranteeing synchronization of neuronal activity rather than by dissipation as in Hodgkin-Huxley model. As a matter fact, dissipation turns out to affect also v just because it is determined by boundary conditions!

1. Hodgkin-Huxley model would suggest that nerve pulse velocity is dictated by frictional effects as an analog of a drift velocity. The rough order of magnitude estimates for the velocities of conformational waves along micro-tubuli are consistent with the velocities of nerve pulses.

The proportionality $v \propto d$ of nerve pulse velocity to nerve axonal radius might be understood as resulting on the dependence on the length of flux tubes connecting axon and micro-tubules and mediating a frictional feedback interaction from axon. Feedback would be naturally reduced as d increases. Feedback interaction could explain also the sensitivity of the thermal parameters of the axonal membrane to the proteins in its vicinity. If the frictional feedback is due to the environmental noise at the axon amplified at quantum criticality this is what one expects. Quite generally, quantum criticality would explain the high sensitivity of the thermal parameters on noise. Saltation cannot be responsible for the higher conduction velocity in myelin sheathed portions of axon. The insulation would reduce the environmental noise at the level of axons and thus reduce the frictional feedback from axon to the micro-tubules.

2. The introduction of friction is however problematic in the recent situation. In absence of boundary conditions Sine-Gordon equation predicts for the propagating soliton sequences a continuous velocity spectrum and friction should affect Ω and V rather than phase velocity v but it is not clear whether it can affect v.

   (a) In this framework the boundary boundary conditions at the ends of the axon or some subunit of axon would dictate the values of v: $\gamma\Omega L/v = n2\pi$ corresponds to periodic boundary conditions (note that $\gamma = \sqrt{1-(v/c)^2} \simeq 1$ holds true). $v = \Omega L/n2\pi$ implies that friction indeed affects also v.

   (b) The relationship states that the time taken by the nerve pulse propagate through the axon is always $T = L/v = n2\pi/\Omega$: this would synchronize neurons and $\Omega \simeq 2\pi$ kHz is suggested by the well-known 1 kHz synchrony difficult to understand in the standard framework where v would be determined by chemistry rather than geometry. Myelin shielding could in this picture guarantee that coherent wave propagation is possible over the entire axon so that boundary conditions can be applied.

   (c) This would give $v \simeq \Omega L/n2\pi < \Omega L/2\pi$. $\Omega = 2\pi$ kHz and $n = 1$ would give for $L \in$ [1 cm -10 cm] $v \in$ 10 m/s-100 m/s corresponding roughly to the observed range of values. For short axons velocity would be lower: for $L = 10$ μm one would have $v = .01$ m/s. For longer axons the value of n could be higher or the axon would decompose into structural units for which periodic boundary conditions are satisfied. The sections between Ranvier nodes have length measured in millimeters as are also the lengths of axonal micro-tubules and 1 mm would correspond to a velocity of 1 m/s. The actual velocity for the myelinated sections varies between 18-100 m/s so that basic structural units should be longer. The proportionality of v to the radius of axon would follow from the proportionality of the length of the axon or its basic sub-unit (not longer than ~ 10 cm) to its radius: the simplest geometric explanation for this would be in terms of scaling invariance of the axonal geometry consistent with fractality of TGD Universe. In the standard framework this proportionality would be explained by the minimization of dissipative losses in the case of long axons: one cannot exclude some variant of this explanation also now since friction indeed reduces v.

   (d) There is an electric field associated with micro-tubules (always in same direction). Could this electric field play the role of external force feeding energy and momentum to the moving soliton sequence to compensate dissipation so that v would have interpretation as a drift velocity?

Q: Can one understand EEG in this framework?

A: Just like kHz waves also EEG generating waves could correspond to propagating soliton sequences. Since V is not affected, the value of $\hbar$ must be much larger and one must have $\hbar \propto f$, where f defines the EEG rhythm. It is known that EEG amplitudes associated with EEG rhythms behave roughly like $1/f$. This can be understood. By Maxwell's equation the divergence of electromagnetic field tensor is proportional to 4-current implying the amplitude of EEG identified as Josephson radiation is proportional J_0/Ω and therefore to $\hbar$. The propagation velocity $v = \Omega L/2\pi n$ of EEG generating waves is rather slow as compared to kHz waves: for $f = 10$ Hz one would have 10 cm long axon $v = 1$m /s. Synchronization results automatically from periodic boundary conditions at the ends of the axons.

Nerve pulses during EEG rhythms would have much slower velocity of propagation and the duration of nerve pulse would be much longer. The maximal charge transfer would be proportional to $1/\hbar$. It would thus seem that EEG and nerve pulse activity should exclude each other for a given axon. Ω is however smaller so that the generation of nerve pulse is easier unless also ion densities are lower so that J_0 (analogous to gravitational acceleration g in pendulum analogy) is reduced. Perhaps this takes place. The consistency with the propagation velocity of microtubular conformational (or even gel-sol-gel) waves might pose additional constraints on v and thus on frequencies Ω for which nerve pulses are possible. That ordinary EEG is not associated with ordinary cells might be due to the fact that $\hbar$ is much smaller: the fractal analog of EEG generating waves could be present but these EEG waves would correspond to faster oscillations in accordance with the view about evolution as an increase of $\hbar$.

3.2.4 Could Hodgkin-Huxley model provide a phenomenological description?

It is now clear that the physics behind Hodgkin-Huxley model is not consistent with the physics behind the TGD based model of nerve pulse. The cell as gel hypothesis excludes Hodkin-Huxley model even without any TGD based physics. If ionic currents were ordinary Ohmic currents as in the case of soliton model and Pollack's model, Hodgkin-Huxley model might be interpreted as a phenomenological description. In TGD framework the dark currents do not dissipate and the model can serve only a recipe to mimic the time evolution of the ionic currents by a judicious tailoring of the time dependence of ionic conductances.

The current associated with a given ion would be proportional to the sum of the electric forces experienced by the particle:

$$I_X = g_X \left[Q_X e(V_{em} - V_X)\right] \quad .$$

In the catastrophe theoretic variant of the Hodgkin-Huxley model [A2], which assumes a wave (Ca^{+2} now) triggering the nerve pulse, the values of the ionic conductivities g_{Na}, g_{Cl} and g_K at resting state are $g_{Na} = 0$, $g_{Cl} = .15\ mmho/cm^2$ and $g_K = .24\ mmho/cm^2$ The values of V_X are $V_K = -77$, $v_{Na} = +50$, $v_{Cl} = -46$, when millivolt is used as unit. The value of the resting potential is $v_R = -65$ mV. The vanishing of g_{Na} at the resting value and down to the point, when nerve pulse is triggered, is assumed in Hodgkin-Huxley model and in the catastrophe theoretic model of the nerve pulse [A2]. The vanishing of g_{Na} codes for the absence of magnetic flux tubes in TGD framework.

3.3 Model Of Nerve Pulse Assuming Almost Vacuum Extremal

Both near to and far from vacuum extremals might be important in living matter. Near to vacuum extremals are favored by quantum criticality reflecting as a large degeneracy of ground states assignable to small deformations of vacuum extremals. Also the vision about living matter as 4-D spin glass phase favors almost vacuum extremals. Magnetic flux tubes would in turn be more naturally far from vacua. Also the hierarchy of Planck constants can be associated with the deformations of vacuum extremals so that one would expect them to be important.

At this stage one can make only guesses and it is interesting to consider also the possibility that near to vacuum extremals are more appropriate for the modelling of cell membrane and perhaps even nerve pulse. It is also possible that both kinds of extremals are involved. One must also remember that cells are at different evolutionary levels and the effects of ELF em fields have been observed for vertebrate brain so that ionic Bose-Einstein condensates might appear only in vertebrate neurons. Also vacuum extremals might become increasingly vacuum like as the evolutionary level becomes higher.

3.3.1 Cell as almost vacuum extremal

Although the possible 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 [I16] 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 [L3], [L3] 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 significance 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 [L3] , [L3]

$$\gamma = 3J - \frac{p}{2}Z^0 \quad , \quad Q_Z = I_L^3 - pQ_{em} \quad , \quad p = sin^2(\theta_W) \tag{3.5}$$

it follows that for the vacuum extremals the part of the classical electro-weak force proportional to the electromagnetic charge vanishes for $p = 0$ so that only the left-handed couplings to the weak gauge bosons remain. The absence of electroweak symmetry breaking and vanishing or at least smallness of p would make sense below the Compton length of dark weak bosons. If this picture makes sense it has also implications for astrophysics and cosmology since small deformations of vacuum extremals are assumed to define the interesting extremals. Dark matter hierarchy might explain the presence of unavoidable long ranged Z^0 fields as being due to dark matter with arbitrarily large values of Planck constant so that various elementary particle Compton lengths are very long.

6. The simplest option is that the dark matter - say quarks with Compton lengths of order cell size and Planck constant of order $10^7\hbar_0$ - are responsible for dark weak fields making almost vacuum extremal property possible. The condition that Josephson photons correspond to EEG frequencies implies $\hbar \sim 10^{13}\hbar_0$ and would mean the scaling of intermediate gauge boson Compton length to that corresponding to the size scale of a large neuron. The quarks involved with with DNA as topological quantum computer model could be in question and membrane potential might be assignable to the magnetic flux tubes. The ordinary ionic currents through cell membrane -having no coupling to classical Z^0 fields and not acting as its source- would be accompanied by compensating currents of dark fermions taking care that the almost vacuum extremal property is preserved. The outcome would be large parity breaking effects in cell scale from the left handed couplings of dark quarks and leptons to the

classical Z^0 field. The flow of Na^+ ions during nerve pulse could take along same dark flux tube as the flow of dark quarks and leptons. This near vacuum extremal property might be fundamental property of living matter at dark space-time sheets at least.

3.3.2 Are photoreceptors nearly vacuum extremals?

The surprising outcome of following considerations is that one could understand the preferred frequencies for photo-receptors [J4] 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 $\hbar$.

In Hodgkin-Huxley model ionic currents are Ohmic currents. If one accepts the idea that the cell membrane acts as a Josephson junction, there are also non-dissipative oscillatory Josephson currents of ions present, which run also during flow equilibrium for the ionic parts of the currents. A more radical possibility is that the dominating parts of the ionic currents are oscillatory Josephson currents so that no metabolic energy would be needed to take care that density gradients for ions are preserved. Also in this case both nearly vacuum extremals and extremals with nearly vanishing Z^0 field can be considered. Since sensory receptors must be highly critical the natural question is whether they could correspond to nearly vacuum extremals. The quantitative success of the following model for photoreceptors supports this idea.

Photoreceptors can be classified to three kinds of cones responsible for color vision and rods responsible for black-white vision. The peak sensitivities of cones correspond to wavelengths (405, 535, 565) nm and energies (3.06, 2.32, 2.19) eV. The maximum absorption occurs in the wave length range 420-440 nm, 534-545 nm, 564-580 nm for cones responsible for color vision and 498 nm for rods responsible black-white vision [J2, J4]. The corresponding photon energies are (2.95, 2.32, 2.20) eV for color vision and to 2.49 eV for black-white vision. For frequency distribution the maxima are shifted from these since the maximum condition becomes $dI/d\lambda + 2I/\lambda = 0$, which means a shift to a larger value of λ, which is largest for smallest λ. Hence the energies for maximum absorbance are actually lower and the downwards shift is largest for the highest energy.

From **Table 3** it is clear that the energies of Josephson photons are in visible range for reasonable values of membrane voltages, which raises the question whether Josephson currents of nuclei in the classical em and Z^0 fields of the cell membrane could relate to vision.

Consider first the construction of the model.

1. Na^+ and Ca^{+2} currents are known to present during the activation of the photoreceptors. Na^+ current defines the so called dark current [J4] 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. Interestingly, currents of Ca^{+2} ions and Na^+ Cooper pairs are also in special role that they would give rise to initiation of nerve pulse with values of Planck constant which can be same for both options (near vacuum extremal or far from vacuum extremal). This is seen by studying the expression of the parameter $x = r^2/A(A-Z)$, $r = \hbar/\hbar_0$, appearing in the amplitude of the direct current: the ratio of these parameters is 1.4 in good approximation for same value of Planck constant (see previous section about quantum model for Becker's direct currents). Does this mean that Josephson currents of Ca^{+2} ions and Na^+ Cooper pairs appear in photoreceptors and for ordinary neurons the currents are direct currents? This would require that photoreceptors have higher value of Planck constant so that the Compton length of ion is of order cell membrane thickness.

2. One ends up with the model in the following manner. For Ca^{+2} the Josephson frequency does not depend on p and requiring that this energy corresponds to the energy 2.32 eV of maximal sensitivity for cones sensitive to green light fixes the value of the membrane potential during 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 3 below.

1. The resting potential for photoreceptors is $V = -40$ mV [J7]. 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^{+2} the wave length is below the visible range. Na^+ Josephson energy is below visible range. This conforms with the interpretation of Na^+ current as a counterpart for the sensation of darkness.

3. For $V = -55$ mV - the threshold for the nerve pulse generation- and for $p = .0295$ the Josephson energies of Na^+, Ca^{+2}, and K^+ a correspond to the peak energies for cones sensitive to red, green, and blue respectively. Also Cl^- is in the blue region. Ca^{+2} Josephson energy can be identified as the peak energy for rods. The increase of the 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 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 [J7], which the normal value of resting potential. For this voltage Josephson energies are predicted to be in UV region except in case of Ca^{+2}. This would suggests that only the quale "white" is generated at the level of sensory receptor: very intense light is indeed experienced as white.

The model reproduces basic facts about vision assuming that one accepts the small value of Weinberg angle, which is indeed a natural assumption since vacuum extremals are analogous to the unstable extrema of Higgs potential and should correspond to small Weinberg angle. It deserves to be noticed that neutrino Josephson energy is 2 eV for $V = -50$ mV, which correspond to color red. 2 eV energy defines an important metabolic quantum.

It interesting to try to interpret the resting potentials of various cells in this framework in terms of the Josephson frequencies of various ions.

1. The maximum value of the action potential is +40 mV so that Josephson frequencies are same as for the resting state of photoreceptor. Note that the time scale for nerve pulse is so slow as compared to the frequency of visible photons that one can consider that the neuronal membrane is in a state analogous to that of a photoreceptor.

2. For neurons the value of the resting potential is -70 mV. Na^+ and Ca^{+2} Josephson energies 2.80 eV and 2.94 eV are in the visible range in this case and correspond to blue light. This does not mean that Ca^{+2} Josephson currents are present and generate sensation of blue at neuronal level: the quale possibly generated should depend on sensory pathway. During the 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^{+2} Josephson frequency corresponds to 4 eV metabolic energy quantum as the **Table 3** 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.

Ion	Na^+	Cl^-	K^+	Ca^{+2}
$E_J(.04\ \ mV, p = .23)/eV$	1.01	1.40	1.51	1.76
$E_J(.065\ \ V, p = .23)/eV$	1.64	2.29	2.69	2.73
$E_J(40\ \ mV, p = .0295)/eV$	1.60	2.00	2.23	1.68
$E_J(50\ \ mV, p = .0295)/eV$	2.00	2.49	2.79	2.10
$E_J(55\ \ mV, p = .0295)/eV$	2.20	2.74	3.07	2.31
$E_J(65\ \ mV, p = .0295)/eV$	2.60	3.25	3.64	2.73
$E_J(70\ \ mV, p = .0295)/eV$	2.80	3.50	3.92	2.94
$E_J(75\ \ mV, p = .0295)/eV$	3.00	3.75	4.20	3.15
$E_J(80\ \ mV, p = .0295)/eV$	3.20	4.00	4.48	3.36
$E_J(90\ \ mV, p = .0295)/eV$	3.60	4.50	5.04	3.78
$E_J(95\ \ mV, p = .0295)/eV$	3.80	4.75	5.32	3.99
Color	R	G	B	W
E_{max}	2.19	2.32	3.06	2.49
energy-interval/eV	1.77-2.48	1.97-2.76	2.48-3.10	

Table 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.

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.

3.3.3 Could nuclei and neutrinos couple to light variants of weak gauge fields in the critical phase?

One of the hard-to-kill ideas of quantum TGD inspired model of quantum biology is that neutrinos might have something do with hearing and cognition. This proposal looks however unrealistic in the recent vision. I would be more than happy to get rid of bio-neutrinos but the following intriguing finding does not allow me to have this luxury.

1. Assume that the endogenous magnetic field $B_{end} = .2$ Gauss is associated with s nearly vacuum extremal and therefore accompanied by $B_Z = 2B_{end}/p$. Assume for definiteness $m_\nu = .3$ eV and $p = sin^2(\theta_W) = .23$. The neutrino cyclotron frequency is given by the following expression

$$f_\nu = \frac{m_e}{m_\nu}\frac{1}{2sin^2(\theta_W)}f_e \ .$$

   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 MEs in the phase near vacuum extremals.

3. Josephson frequency is proportional to $1/\hbar$, whereas neutrino cyclotron frequency does not depend on $\hbar$ at non-relativistic energies. For larger values of $\hbar$ the neutrino becomes relativistic so that the mass in the formula for cyclotron frequency must be replaced with energy. This gives

$$E = \sqrt{n} r^{1/2} \sqrt{g_Z Q_Z B_Z 2\pi} \simeq r^{1/2} \times .48 \ \ eV \ \ , \ \ r = \sqrt{\hbar/\hbar_0} \ \ .$$

Here n refers to the cyclotron harmonic.

These observations raise the question whether the three frequencies with maximum response assignable to the three different types of receptors of visible light in retina could correspond to the three cyclotron frequencies assignable to the three neutrinos with different mass scales? The first objection is that the dependence on mass disappears completely at the relativistic limit. The second objection is that the required value value of Planck constant is rather small and far from being enough to have electroweak boson Compton length of order cell size. One can of course ask whether the electroweak gauge bosons are actually massless inside almost vacuum extremals. If fermions -including neutrino- receive their masses from p-adic thermodynamics then massless electroweak gauge bosons would be consistent with massive fermions. Vacuum extremals are indeed analogous to the unstable extrema of Higgs potential at which the Higgs vacuum expecation vanishes so that this interpretation might make sense.

It is easy to test whether Hodgkin-Huxley model tolerates the inclusion of Z^0 field and the assumption that nuclei and neutrinos or antineutrinos serve as its sources. In the cell scale neutrinos would indeed serve as a natural source of classical Z^0 fields. The simplest assumption is that neutrino current guarantees that the almomst acuum extremal property prevails during the nerve pulse.

3.3.4 Goldman equation in Hodgkin-Huxley model

Consider first Hodgkin-Huxley model in order to understand how to generalize it to take into account the couplings of nuclei and neutrinos to the classical Z^0 field. In Hodkin-Huxley model the basic equations state flow equilibrium. The basic equation is so called Goldman equation [J3].

1. Ion current j_A is a sum of two terms:

$$j_A \ \ = \ \ D_A(\frac{dn_A}{dz} - b_A n_A) \ \ , \ \ b_A = \frac{q_A e E}{k_B T} \ \ , \ \ E = \frac{V}{d} \ \ . \tag{3.6}$$

The first term is a diffusion term proportional to concentration gradient of ion and second term a drift term proportional to ion concentration n_A and the electric field E assignable to cell membrane and defined as membrane potential V divivided by the thickness of cell membrane d. Stokes-Einstein equation implies that the coefficient of electric force in drift velocity is expressible in terms of the diffusion constant D_A defining ionic permeability as $P_A = D_A/d$.

2. The equations for the ion currents can be integrated with respect to the coordinate z orthogonal to the cell membrane and give the currents in terms of differences of concentrations outside and inside membrane. The outcome is

$$j_A \ \ = \ \ D_A b_A \frac{n_A(in) exp(b_A d) + n_A(out)}{1 - exp(b_A d)} \ \ . \tag{3.7}$$

The change of the sign of the charge changes the sign of b and implies only the replacement in↔out and changes of the sign in the above formula. The explicit expression reads as

$$j_A = \mu q_A P_A \frac{n_A)(out) - n_A(in)exp(q_A\mu)}{1 - exp(q_A\mu)} \ , \ \mu = \frac{eV}{kT} \ . \tag{3.8}$$

Note that the multiplication by q_A compensates the change of sign in j_A.

3. The condition that total electric current vanishes reads as

$$j_{tot} = \sum q_A j_A = 0 \tag{3.9}$$

It gives Goldman equation [J3]. If the charges have same magnitude ($q_A = \pm 1$) the equation can be solved as

$$\begin{aligned} \mu &= log(\frac{w}{v}) \ , \\ w &= \sum_C P_C n_C(out) + \sum_A P_A n_A(int) \ , \\ v &= \sum_C P_C n_C(in) + \sum_A P_A n_A(out) \ . \end{aligned} \tag{3.10}$$

Here C refers to positively charged ions (cations) and A to negatively charged ones (anions). In the physical situation only K_+, Na_+, and Cl_- are the interesting ions and only K_+ conductivity differs considerably from zero due to the continual pumping of K_+ ions against the concentration gradient. This gives a more explicit formula

$$eV = k_B T \times log(\frac{P_{K^+} n_{K^+}(out) + P_{Na^+} n_{Na^+}(out) + P_{Cl^-} n_{Cl^-}(in)}{P_{K^+} n_{K^+}(in) + P_{Na^+} n_{Na^+}(in) + P_{Cl^-} n_{Cl^-}(out)}) \ . \tag{3.11}$$

relating the resting potential to the ratios of ionic concentrations outside and inside membrane and ionic conductivities which are parameters, which cell is able to modify and does it during the generation of nerve pulse. During nerve pulse in practice only the flows of K_+ and Na_+ ions matter. In the beginning of nerve pulse Na_+ conductance increases and K_+ conductance is reduced. This changes the sign of potential and after that the situation returns to the original one.

3.3.5 Hodgkin-Huxley model for the resting potential for nearly vacuum extremals

One can formulate Hodgkin-Huxley model for the resting potential for exact vacuum extremals by replacing the membrane potential with its Z^0 counterpart since the couplings to em charge vanish assuming that Weinberg angle vanishes for vacuum extremals

1. One must assume that the interior of the cell corresponds to many fermion state -either a state filled with neutrinos up to Fermi energy or Bose-Einstein condensate of neutrino Cooper pairs creating a harmonic oscillator potential. The generalization of nuclear harmonic oscillator model so that it applies to multi-neutrino state looks natural. Also neutrino conductance could be added as a parameter to the model.

$E(Ion)/eV$	$V = -40\ mV$	$V = -60\ mV$	$V = -70\ mV$
Na^+	1.01	1.51	1.76
Cl^-	1.40	2.11	2.46
K^+	1.64	2.47	2.88
Ca^{+2}	1.68	2.52	2.94

Table 3: Values of the Josephson energy of cell membrane for some values of the membrane voltage for $p = .23$. The value $V = -40$ mV corresponds to the resting state for photoreceptors and $V = -70$ mV to the resting state of a typical neuron.

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 [J1]. These time scales might relate to the time scales of CDs associated with quarks and electron.

3. The basic question is whether only nuclei couple to the classical Z^0 field or whether also electrons do so. If not, then nuclei have a large effective vector coupling to em field coming from Z^0 coupling proportional to the nuclear charge increasing the value of effective membrane potential by a factor of order 100. If both electrons and nuclei couple to the classical Z^0 field, one ends up with difficulties with atomic physics. If only quarks couple to the Z^0 field and one has $Z^0 = -2\gamma/p$ for vacuum extremals, and one uses average vectorial coupling $\langle I_L^3 \rangle = \pm 1/4$ with + for proton and - for neutron, the resulting vecotor coupling is following

$$\begin{aligned} (\frac{Z-N}{4} - pZ)Z^0 + q_{em}\gamma &= Q_{eff}\gamma \ , \\ Q_{eff} &= -\frac{Z-N}{2p} + 2Z + q_{em} \ . \end{aligned} \tag{3.12}$$

Here γ denotes em gauge potential. For K^+, Cl^-, Na^+, Ca^{+2} one has $Z = (19, 17, 11, 20)$, $Z - N = (-1, -1, -1, 0)$, and $q_{em} = (1, -1, 1, 2)$. **Table 3** gives the values of Josephson energies for some values of resting potential for $p = .23$. Rather remarkably, they are in IR or visible range.

Consider now Hodgkin-Huxley model with the resting potential replaced with an effective resting potential due to the classical Z^0 field and the couplings of nuclei to it.

1. The flow equilibrium condition for the Hodgkin-Huxley model changes since the charges (1, -1, 1) for K^+, Cl^- and Na^+ are replaced with the ratios $Q_{eff}(I)/Q_{eff}(K^+) = E(I)/E(K^+)$ giving ratios $(1, E(Cl^-/E(K^+), E(Na^+)/E(K^+)$, which are of same sign.

$$j_{em,tot} = \sum q_{em,A} j_A = 0 \ . \tag{3.13}$$

The resulting equation for the resting potential is more complex and can be solved only numerically. The facts that the charges are of same sign and the conductivity of Cl^- is small, means however that the situation need not change too much qualitatively. Of course, all cell membranes need not be near to vacuum extremal. It could be that only neuronal membranes or only sensory receptor membranes ready to respond rapidly could satisfy this condition.

2. Also neutrino current would contribute to the ionic currents in the modification of the Hodgkin-Huxley model. If the near vacuum extremal property is preserved during the nerve pulse, neutrino current is fixed from the condition that it compensates the ionic contributions to Z^0 current in flow equilbrium. Since nuclei tend to have more neutrons than neutrinos, antineutrino background should more or less compensate the nuclear Z^0 charge so that the antineutrino current should be equal to the total ionic current. The condition that totalZ^0 current vanishes reads as

$$j_{Z^0,tot} = \sum q_{Z^0,A} j_A = 0 \ . \tag{3.14}$$

Here also neutrino current is included and the condition allows to solve it in terms of other currents.

3.4 Pollack's Findings And Nerve Pulse

The discovery of negatively charged exclusion zone formed in water bounded by gel phase [I3, L7] (`http://tinyurl.com/ycqtuchp`) has led Pollack to propose the notion of gel like fourth phase of water. In chapters [K32, K14] 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 [K14]. Dark protons are proposed to fork 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.

Pollack's findings have powerful implications concerning the model of the cell membrane, ionic pumps and channels and various receptors. The basic implication is the receptors can be regarded as generalized Josephson junctions with Josephson energy replaced with the sum of Coulomb contribution and difference of cyclotron energies of charged bosonic particle at the two side of the membrane. In accordance with ZEO, the thermodynamical description of cel membrane is replaced with its "square root" inand therefore also the model of EEG and nerve pulse. The implications of the model of EEG were discussed in chapter [K14]. The equilibrium distributions of ions are determined by Schrödinger amplitudes proportional to the square root of Boltzmann weight determined by the generalized Josephson energy.

In this framework the general mechanism of nerve pulse generation can be identified as a phase transition changing the value of effective Planck constant at either or both sides of the membrane inducing a change of equilibrium ionic distributions.

3.5 Zero energy ontology and quantum model for nerve pulse

In TGD based model of nerve pulse axonal membrane is generalized cylindrical Josephson junction defined by axonal membrane consisting of smaller Josephson junctions defined by membrane proteins.

1. A sequence of mathematical penduli along axon in rotation in the same direction is the mechanical analog. Oscillation frequency Ω transforming to a rotation frequency above critical value is proportional to the resting potential V. When V is overcritical, the pendulum starts to rotate instead of oscillating. The system should be near quantum criticality for the transformation of rotation to oscillation or vice versa.

2. During nerve pulse membrane potential and therefore also rotation frequency is reduced and changes sign and then returns back to the original value. The first guess is that at criticality there is a kick reducing the rotation frequency Ω and continuing to change its sign and then return it to original.

The basic condition is that resting state becomes critical at critical hyper-polarization. There are two options for the resting state.

1. According to the original model [K33], resting state can be regarded as a soliton sequence associated with the phase difference over the membrane. More concretely, the mathematical penduli rotate in same direction with phase difference between determining the propagation velocity of solitons. The rotation frequency is slightly above that for oscillation. There is a preferred direction along axon. This conforms with the reduction and change of sign of potential and thus of Ω.

   Problem: Hypo- rather than hyper-polarization should cause the nerve pulse as a transformation of rotation to oscillation. Something goes wrong.

2. Alternatively, the penduli almost rotate being near criticality for the rotation: the penduli almost reaches the vertical position at each oscillation as required by criticality. That hyper-polarization would cause the nerve pulse as propagating soliton conforms with this idea.

   Problem: Ω and thus V should increase rather than reduce and even change sign temporarily.

Neither option seems to work as such but the first option is more plausible as a starting point of an improved model.

The membrane potential changes sign suggesting quantum jump. Could zero energy ontology (ZEO) based view about quantum jump as "big" (ordinary) state function reduction (BSFR) help? Could nerve pulse correspond to BSFR?

1. Could BSFR occur changing temporarily the arrow of time in ZEO and induce nerve pulse. Could opposite BSFR take place after this in millisecond scale and establish the original arrow of time. Using the language of TGD inspired theory of consciousness [L23], a conscious entity, sub-self or mental image, would die and reincarnate with an opposite arrow of time, live for the duration of nerve pulse and then die and reincarnate with the original arrow of time. Nerve pulse would be a propagation of a temporary neuron death along the axon and would occur as neuron becomes hyper-polarized.

2. In the article [L28] about the recent findings of Minev *et al* [L28] related to quantum jump in atomic physics are discussed. ZEO predicting that the arrow of time is changed in BSFR. This would create the illusion that discontinuous quantum jumps correspond to a classical time evolution leading smoothly and deterministically to the final state.

   This because BSFR leads to a state with reversed arrow of time, which corresponds to a superposition of classical time evolutions leading from the final state to the geometric past and it this, which is observed. This would also explain why the removal of the irradiation inducing quantum jumps has no effect during the transition process and why a stimulation inducing opposite quantum jump can stop the process. Also the findings of Libet related to the active aspects of consciousness [J13] showing that neural activity seems to preceded volitional act can be understood in this framework without giving up the notion of free will.

   The first half of the nerve pulse would correspond to this apparent evolution to the time reversed final state with opposite membrane potential but actually being time reversed evolution from the final state. The second half of nerve pulse would correspond to opposite state function reduction establishing the original arrow of time. This model looks attractive but many details remain to be checked.

Why hyper-polarization should cause the temporary death of neuron or its subself?

1. Metabolic energy feed is needed to preserve the polarization of neuron since membrane potential tends to get reduced by second law stating that all gradients are bound to decrease. There should be some maximal polarization possible to preserve using the existing metabolic energy resources.

2. Does quantum jump to a state with opposite arrow of time happen as this limit is reached? Why? Could the metabolic energy feed stop causing the neuron to die to starvation? Why the death of neuron should happen so fast? Could the quantum criticality against the change of rotation to oscillation be the reason. When neuron cannot rotate anymore it would die immediately: the mental image "I am rotating" would die and reincarnate as its time reversal. Does the neuron feeded by metabolic energy become a provider metabolic energy during this period somewhat like dead organisms after their death. Can one conclude that this energy goes to some purpose inside neuron?

3.6 TGD based model of nerve pulse and superconducting, possibly conscious computers

The recent dramatic progress in AI has inspired speculation about the possibility of at least rudimentary computer consciousness. I have also written some articles [L44, **?**, **?**, **?**] related to the question whether TGD based new physics could make conscious computers possible. Although the notion of a magnetic body (MB) carrying dark matter in TGD sense of the word does not distinguish between living and inanimate matter, one might argue that the transistor based technology cannot allow conscious computers with a high level of intelligence. Quantum criticality should be realized as criticality at the level of ordinary matter and transistors. Superconducting computing based on superconductivity and Josephson junctions look more promising and here the connection with TGD based view of nerve pulse might provide guidelines.

Superconducting computing, which could be involved with both classical and quantum computation, is a technology, which might provide at least a starting point in attempts to understand how conscious computers might be created in the TGD Universe [L43, L44]. Rapid single flux quantum (RSFQ) is the basic active element in the circuitry and corresponds to single Josephson junction. The presence/absence of quantized magnetic flux defines the bit. SFQ voltage pulses of duration about picosend are produced by switching of bits in this way. This would allow THz clock frequency f_{cl}.

If f_{cl} corresponds to Josephson frequency $f_J = ZeV/h$, where Z is the charge of the superconducting charge carrier, one obtains an estimate for the voltage as $ZeV \sim .05$ eV. For the cell membrane one has $eV \sim .05$ eV, which is near the thermal threshold at room temperature. The superconducting computations require a temperature of order 10 K so that the value of frequency does not seem to emerge from thermal considerations. The thermal criterion is expected to be satisfied at physiological temperatures for the TGD based generalization of superconducting computers if realized using the same principles as in living matter.

So: could the neuronal and perhaps also cell membranes in general act as analogs of superconducting computers sending sensory information to the magnetic body as Josephson radiation and receiving control commands cyclotron radiation with resonance serving as the basic communication mechanism?

Somewhat surprisingly, the detailed consideration of this question led to an identification of a topological mechanism for how nerve pulses are generated. The counterparts of nerve pulses would be the signalling mechanism also in the case of superconducting computers.

3.6.1 How electromagnetic fields in the TGD Universe different from their Maxwellian counterparts?

One must first clarify how the TGD view of electromagnetic fields differs from the Maxwellian picture.

1. Quantum criticality is essential for the appearance of large values of h_{eff} labelling the scales of long length scale quantum fluctuations. Quantum criticality combined with ZEO would make possible the emergence of life-like features.

2. The gravitational Planck constants $\hbar_{gr} = GMm/\beta_0$ assignable to the gravitational flux tubes of the Earth and Sun are excellent candidates in this respect. The value of $\hbar_{gr}/\hbar$ is $GM_Em/\hbar\beta_0 = (r_S(E)/2L_m)$, r_s denotes the Schwartschild radius of Earth about 1 cm and L_m denotes Compton length of particle with mass m $\beta_0 \simeq 1$.

   The value of $\hbar_{gr}$ depends on particle mass m considered unlike the gravitational Compton length $r_S(E)/2$ (Equivalence Principle). For the Earth, the gravitational Compton frequency is 67 GHz. For the Sun it is about 50 Hz, and is in the EEG range and corresponds to a gravitational Compton length of one half of the Earth radius.

3. In TGD, two kinds of magnetic fields are possible. Monopole flux tubes are something new and rather remarkably, can exist in absence of currents: this makes them ideal for computation. Monopole flux tubes have closed 2-surfaces as cross sections. Flux quantization follows from the homology of CP_2. Monopole flux tubes explain the presence of long range magnetic fields appearing in even cosmological scales [L45, L46] and also the stability of the Earth's magnetic field [L8].

   The magnetic flux tubes having an open cross section with boundary (say disk), correspond to Maxwellian magnetic fields and require the presence of currents (carried by a coil around the flux tubes). For them the flux is conserved but not necessarily quantized.

4. Also in TGD, the topological half of Maxwell's equations, that is Faraday law and the vanishing of the divergence of magnetic field, hold true. Therefore the basic argument for the outcome of the switching of the flux is not affected when ordinary flux tubes are replaced with monopole flux tubes.

3.6.2 Some details of the model of the cell membrane as a Josephson junction

The relation of this picture to the TGD inspired model of nerve pulse [K33] has been already considered in [L44]?

1. The original model of the nerve pulse idealizes the sequence of discrete membrane protein Josephson junctions with a 2-D continuous Josephson junction formed by the lipid layers (or interior and exterior) of the axonal membrane. The mathematical model relies on the Sine-Gordon equation. The key idea is that one can regard the system as analogous to a collection (continuous distribution in the proposed idealization) of gravitational penduli satisfying d'Alembert type wave equation.

   One can consider two kinds of ground states:

   (a) All penduli oscillate in the same phase and with the same amplitude.

   (b) All penduli rotate with the same frequency and in the same phase so that one has a static soliton sequence.

   Lorentz transformations give rise to propagating patterns of this kind.

   For option a), the nerve pulse would correspond to a propagating soliton or a multisoliton in the oscillating background, i.e. a propagating rotational mode of some penduli. For option b), the nerve pulse would correspond to an opposite direction of rotation for some penduli. The fact that the voltage changes its sign during the nerve pulse is consistent with option b).

2. Also the possible role of the axonal microtubules in the conduction of nerve pulse is discussed in [L44]. The transfer of the charges from the microtubule to very long gravitational flux tubes affects the effective charge of the microtubule and therefore membrane potential. This could play an important role in the conduction of nerve pulse.

3.6.3 How could RSFQ generalize in the TGD framework?

How could the notion of RSFQ generalize in the TGD framework? The hint comes from the TGD based model of cell membrane and nerve pulse assigning to the ionic channels of the cell membrane dark Josephson junctions with a large value of h_{eff} making possible high T_c superconductivity.

Consider first the flux quantization in Josephson junctions from the TGD point view.

1. The presence/absence of flux quantum through the junction represents a bit. Switching of the bit in RSFQ means that the flux changes by the unit Φ_0 of magnetic flux. In the simplest situation, the value of flux through the Josephson junction connecting the super conductors, which could have planar or cylindrical geometry, is equal to 0 or Φ_0.

2. When the flux through junction is changed by one unit, Faraday law $\Delta\Phi = \pm\Phi_0 = Ze\int Vdt$ implies a generation of voltage pulse propagating along the superconducting wire formed by the coupled cylindrical superconductors. For a constant voltage $V = V_0$, this condition fixes the duration $T = \Phi_0/ZeV$ of the process and this defines Josephson frequency, in turn defining the clock frequency.

The following arguments raise optimism concerning the realization of conscious computers as superconducting computers.

1. Concerning the numbers assigned to RSFQ, the cell membrane looks ideal for the seat of analogues of RSFQs. I have proposed that the cell membrane acts as a sequence of dark Josephson junctions associated with membrane proteins acting as channels and pumps [K33] [L44]. The membrane resting potential $\sim$ .05 eV corresponds to the frequency of 5 THz and is in the same range as the Josephson frequencies assigned with RSFQs. The large value of h_{eff} makes possible high temperature superconductivity and scales up the value of Josephson frequency to $f_J = ZeV/h_{eff}$ so that Josephson frequencies even in EEG scales would be made possible by quantum gravitation in TGD sense.

2. No currents are needed to maintain monopole magnetic fields so that they are ideal for technological purposes. Cell membrane would be a superconductor and membrane proteins would define Josephson junctions. Membrane potential could realize the Josephson frequency $f_J = ZeV/h_{eff}$.

   The TGD view of quantum gravitation would suggest that the Earth's gravitational Compton frequency of f_{gr} = 67 GHz=.067 THz is important in quantum biology. This frequency is considerably lower than THz and I have proposed it as a clock frequency below with the statistical determinism could fail and make the computer analogous to a life-form.

The TGD view of the basic active unit would differ from RSFR.

1. In TGD, the absence of flux quantum in RSFQ corresponds to two U-shaped monopole flux tubes at opposite sides of the junction associated with the counterpart of the cell membrane and transversal to it. The U-shaped monopole flux tubes can reconnect to form a pair of flux tubes with opposite magnetic fluxes.

   This topological process is fundamental in the TGD inspired view of biocatalysis and water memory [L40]. By the fractality of the TGD Universe, it applies in all scales including, besides cosmological and astrophysical scales [L45, L46], also the scales relevant to atomic, nuclear and hadron physics as has become clear quite recently [L42].

2. What is the effect of the generation/disappearance of a pair of opposite flux tubes? Do both fluxes go through a single junction or does only one of them traverse the junction? In the latter case, the junction would act like RSFQ after reconnection. This is a natural looking working hypothesis. The difference comes from the presence of the flux tube with opposite flux.

   Here one must be very cautious. Flux tubes could make possible the flow of either Ohmic or Josephson current (the more plausible option). If the Josephson currents reside at the flux tubes, the Josephson junction ceases to exist during the nerve pulse. Can one say that the Josephson junction exists also after the splitting of the flux tube pair?

   The fact that ohmic currents flow during the nerve pulse motivates the assumption that the splitting of the pair of flux tubes makes Josephson current impossible and Ohmic currents associated with the nerve pulse appear.

3. Faraday's law should apply to both flux tubes. The appearance of flux tubes would correspond to a generation of opposite fluxes $\Delta\Phi = \Phi_0 = \int Vdt$. In the simplest situation the

voltage values associated with the flux quanta have opposite values $\pm V_0$. This is very much like in the case of nerve pulse in which the resting potential changes its sign during the first half of the nerve pulse. When the reconnection disappears, the situation would become "normal". The analog of nerve pulse would be generated and propagate along the counterpart of the axon and induce a similar process in all membrane proteins defining Josephson junction.

4. In zero energy ontology (ZEO), the identification of the generation of nerve pulse as a pair of "big" state function reductions (BSFRs) changing the arrow of time temporarily is attractive and would correspond to quantum tunnelling in standard quantum theory.

   An interesting question is whether pump proteins act as channel proteins in reversed time direction and whether the flux tube pairs are associated with pairs of channel and pump proteins.

3.6.4 Critical questions

The first critical question is is how the very low Josephson frequencies ZeV/h_{eff} associated with the large values of h_{eff}, say $h_{eff} = h_{gr}$, can be consistent with the very large values of clock frequency $f_{cl} = f_J = ZeV/h$ needed by a fast operation. It would seem that both h_{eff} and h are needed. Is this possible or are these computers doomed to be very slow?

Should one widen the perspective and take into account the many-sheeted structure of TGD space-time? Is the scale hierarchy of space-time sheets having various values of h_{eff} involved and could it correspond to the onion-like hierarchical structure of the magnetic body (MB) involving increasing time scales as Josephson frequencies? This would give rise to a cognitive hierarchy of MBs serving as "bosses" for lower level MBs and the ordinary Josephson junction would be at the bottom.Could the fast Josephson frequencies define a hierarchy of computer clocks? Could the pulses of short duration induced by RSFQs induce a hierarchy of frequency modulations of scaled up Josephson oscillations for various values of h_{eff}? This could also make the computer conscious by bringing in the hierarchy of time scales. These levels could correspond to a cognitive hierarchy corresponding to increasing values of $n = h_{eff}/h_0$ identifiable as the dimension of extension of rationals assignable to the space-time sheet considered.

The following simple estimates allow to gain some quantitative perspective concerning the proposal that quantum gravitation could play a decisive role.

1. It is instructive to look at the energy equivalents of the gravitational Compton frequencies for Earth, Moon and Mars for $h_{eff} = h$ (energy is conserved in the the transformation of gravitationally dark photons to ordinary photons).

2. The gravitational Compton frequency $f_{gr} = 67$ GHz of Earth corresponds to the energy $E \simeq .04$ eV near to the energy assignable to the membrane potential.

3. The mass of the Moon is $M_{Moon} = .012M_E$ and scales and correspond to $.56 \times 10^{14}$ Hz, which corresponds to the energy $E \simeq .43$ eV consistent with the size of metabolic energy quantum.

4. The mass of Mars is $.11M_E$ and the corresponding Compton frequency is .67 THz and energy $E = 2.7$ meV which correspond to the mV scale of miniature potentials.

The experimental work of the group of Anirban Bandyopadhyay [J24] has inspired a proposal of a hierarchy in which the frequency scales come as powers of 10^3. This hierarchy could correspond to a hierarchy of p-adic primes $p \propto 2^{10k}$ and/or hierarchy of effective Planck constants $h_{eff} \propto 2^{10k}$. One cannot associate with it a hierarchy of large masses M appearing in gravitational Compton frequencies. The scale ratio 2^{11} could relate to the ratio $L(127)/L(107) \simeq 2^{10}$ of the p-adic length scales of electron and proton.

The second critical question concerns the temperature needed. Technologically high temperature superconductors are highly favored.

1. In the TGD framework, the cell membrane is assumed to act as a high temperature superconductor at quantum criticality making it an ideal sensory receptor and motor instrument. Biosystems are open systems and a metabolic energy feed would take care that the distribution for the values of h_{eff} is preserved.

2. The fact that the dark matter as $h_{eff} \geq h$ phases of ordinary matter at the space-time sheets of the flux tubes has very weak interactions with the other sheets, in particular the sheet of the ordinary matter, would be decisive.

3. Also zero energy ontology (ZEO) would be highly relevant for maintaining the quantum criticality by making possible homeostasis in which time reversal changes attractor to repulsor and vice versa. When the system begins to roll down from the top of the hill, the arrow of time brings it back.

The key question is whether it is possible to realize the counterparts of bio-superconductors without using organic living matter.

3.7 Do neuron groups define homologies of higher-D spaces

Shamoon Ahmed gave a link to a popular article (see this) claiming that the brain is in some sense 11-dimensional. Probably the only thing that M-theory predicts is that the target space of strings is 11-D so that this finding might provide some confirmation of faith for frustrated M-theorists.

In the sequel I will discuss this finding from TGD viewpoint and propose a modified interpretation based on the geometry of icosahedron, one of the 5 platonic solids, which play a key role in TGD, and TGD inspired quantum biology and theory of consciousness.

The dimension 11 in this context looked to me a rather formal notion but one could give it a mathematical meaning.

1. In 3-D one can take tetrahedra, 4-simplexes as building bricks of a discretized manifold. In dimension 11 one has 12-simplexes. These are glued together, which means that n-faces with n varying from 1 to 11 are glued together along $n-1$-D faces.

2. In the case of the brain, one would have groups of neurons, with 12 neurons connected in such a way that one has a connectedness of a 12-simplex. There would be 11- edges meeting at each 12 vertices. Each neuron would be connected to all the other 11 neutrons and would have maximal connectedness, which is very natural if one wants a maximally coherent functional unit.

   The notion of orientation is essential: axons are oriented by the direction of nerve signals which is always the same. The orientation of axons could induce orientations of n-faces. 2-face would correspond to a loop in which signals can rotate in a single direction.

3. Since axons must be present, each neuron must be connected with every other neuron. The geometric connectedness possible in the case of neurons since the axon from a given neuron can branch and have a synaptic contact with the dendrites of several neurons: for n=11-simplex with all other (11) neurons (see this). Note that also a synaptic contact with the neuron itself (autapse) is possible.

   Could one consider also a generalization of this geometric view of a simplex. Could functional coherence of the neuron group serve as a criterion for whether neurons form an n-face? Here the definition of orientation without the notion of axon is the challenge.

4. The interpretation in terms of 11 real dimensions might assume too much and I am reluctant to believe that it has anything to do with M-theory. However, one could realize n-simplexes in this way in 3-space and the orientation of the axon, determined by the preferred directions of signals, would define orientations of higher level simplexes. The idea that these structures could have something to do with geometric cognition allowing us to imagine higher dimensional geometric structures is attractive.

Can TGD add anything interesting to this picture? The appearance of number 12 creates an overwhelming temptation to associate this finding with one particular Platonic solid, icosahedron, having triangular faces. I am not claiming that the proposed interpretation of the findings is wrong but asking whether Platonic solids could add something interesting to the proposal.

1. The 12 vertices of the argued 11-simplex could be also identified as vertices of icosahedron, one particular Platonic solid appearing repeatedly in molecular biology. For an icosahedron, the Hamilton cycle, going through all vertices just once, has 12 vertices and edges [?] It would connect each vertex to all other vertices by a unique path having a varying number of edges: 1,2,... The selection of this Hamilton cycle could raise one particular edge path among all possible closed edge paths possible in the maximally connected 12-neutron network in a special position.

2. This icosahedron need not correspond to an ordinary Platonic solid in the Euclidean 3-space. The definition of nearness can be defined also in terms of functional nearness. Indeed, hyperbolic 3-space has been suggested to play a role in neuroscience for neutrons: neurons resembling each other functionally would be near to each other in the hyperbolic metric and in TGD framework this metric is assigned with hyperbolic 3-space H^3 as Lorentz invariant light-cone proper time = constant surface to which the magnetic body (MB) of the brain is assigned as 3-D surface [L34, L39] (see `https://zpr.io/7Bzbagjrk7LE`). The signals from neurons, which are near each other in functional sense, would be sent to nearby points of the MB so that functional nearness would be geometric nearness at the level of MB.

3. Also tetrahedron with 4 vertices and faces and octahedron with 6 vertices and and 8 faces are Platonic solids which have triangular faces representing 2-simplex and could correspond to dimensions d=3 and d=5. Cube with 6 square faces and d=8 vertices is the dual of octahedron and dodecahedron with d=20 vertices and 12 pentagonal faces is the dual of icosahedron. It might be also possible to assign to them a dimension as the number of vertices by using maximal axonal connectedness of vertex neurons as a criterion.

   Platonic solids and Hamiltonian cycles as paths going once through each vertex of the Platonic solid and identified as nuclear strings play a key role in the "Platonization" of nuclear and atomic physics [L42] leading to quite precise quantitative vision about basic numbers of nuclear and atomic physics and even hadron physics. The key observation is that the states of $j = l \pm 1/2$-blocks of atoms and nuclei correspond to Platonic solids for $l \leq 6$ (a highly non-trivial fact), which therefore provide geometric representation for the j-block.

Icosahedron is a very special Platonic solid and deserves a separate discussion.

1. Icosahedron is unique among Platonic solids in the sense that it allows a large number of Hamiltonian cycles. Icosahedron, tetrahedron and their Hamiltonian cycles play a fundamental role in the TGD inspired model of genetic code [L6, L27, L35, L38, L41] involving the notion of icosa-tetrahedral tessellation of hyperbolic 3-space involving all 3 Platonic solids with triangular faces.

   Each combination of 3 icosahedral Hamiltonian cycles with symmetries Z_n, $n = 6, 4, 2$ defines a particular realization of the genetic code predicting correctly the number of DNA codons coding for a given amino acid.

2. The model of the genetic code emerged originally as a model of musical harmony. The faces of icosahedron are triangles and would define 3-chords realized as cyclotron frequencies assignable to the vertices of the triangle. Each Hamiltonian cycle would define 20 chords defining a particular harmony whereas the 12 vertices along Hamiltonian cycles would define a 12-note scale, with neighboring vertices representing frequencies related by scaling by 3/2 (quint) modulo octave equivalence.

   One could speak of music of light and since music creates and expresses emotions, the proposal is that different bio-harmonies correspond to different emotional states, moods, realized already at DNA and RNA level. Could these 12 neuron units and possible tessellations (hyperbolic crystals) associated with them relate to the realization of emotions at the level of the brain?

Physically, the Hamiltonian cycle as a representation of 12-note scale is an analog of a closed string made of flux tubes representing the edges (pipes of organ!)

3. What is fascinating is that hyperbolic 3-space (mass shell in particle physics), playing a key role in TGD, has a unique tessellation/lattice involving all Platonic solids, whose faces are triangles (icosahedron, octahedron, tetrahedron) and also provides a model of DNA making quantitatively correct predictions. I have proposed that this tessellation defines a universal realization of the genetic code realized in all scales at the level of the MB of the system. Could the 12-neuron unit interpreted as 11-simplex relate to one particular realization of this tessellation.

4. Also cubic, icosahedral, and dodecahedral regular tessellations are possible in hyperbolic space (Euclidean 3-space allows only cubic regular tessellation) and they would define the analog of a homology of dimension $n = 7, 11$ or 19 space at neuronal level.

4 TGD Based Model For Anesthetic Action

The mechanism of anesthetic action [J29] (`http://tinyurl.com/yb9pauld`) has remained mystery although a lot of data exist.

Typically anesthetes induce analgesia, amnesia, and immobility. Some anesthetes cause amnesia (brain) but no immobility (spinal cord). I have heard also about anecdotal evidence that anesthetes do not always cause amnesia nor even analgesia.

The first question what comes in mind is whether anesthetes indeed cause a loss of consciousness? In TGD framework self dies when the first state function reduction to the opposite boundary of CD occurs and time reversed self is generated [K37, K3]. Could also anesthetes have the same effect? If so, anesthesia would be like sleep, which need not be unconscious state but could represent time reversed self at "our" level of self hierarchy. This would explain also why we do not have memories about the period during sleep.

The Meyer-Overton correlation suggests that the changes occurring at lipid layers of are responsible for anesthesia but this model fails. Another model assumes that the binding of anesthetes to membrane proteins is responsible for anesthetic effects but also this model has problems. The hypothesis that the anesthetes bind to the hydrophobic pockets of microtubules looks more promising.

The model should also explain the hyperpolarization of neuronal membranes taking also place when consciousness is lost. The old finding of Becker is that the reduction or reversal of voltage between frontal brain and occipital regions correlates with the loss of consciousness. Microtubules and DNA are negatively charged and the discovery of Pollack that so called fourth phase of water involves generation of negatively charged regions could play a role in the model.

Cell memrane can be also seen as a battery and quite recently (towards end of 2016) I learned about battery that after 175 years is still working [L12] [K9]. The explanation would be in terms of Pollacks effect providing also a possible explanation for the production of nuclei and energy in an effect christened originally as cold fusion and later low energy nuclear physics effect (LENR). This battery - as also cell membrane - could be self-loading battery using dark and possibly also ordinary nuclear energy. Combining these inputs with TGD inspired theory of consciousness and quantum biology one ends up to a microtubule based model explaining the basic aspects of anaestesia. The possible loss of consciousness at our level of hierarchy (more precisely, the loss of sensory-motor activity) could be understood as the stabilization of the membrane potential implying that nerve pulses are not generated and sensory input and motor output ceases.

4.1 Background

4.1.1 Some facts about anesthetes

To begin with, it is could to list some facts about anaeshtetes.

1. Very wide variety of substances act as anesthetes and there is no clear correlation with the chemical properties of substance. Even noble gases can affect anesthetes. Short range van der Waals interaction involving induction of electric dipoles is a natural candidate for

the interaction in question. The increase of atmospheric pressure is known to reduce the anesthetic effect.

2. The anesthetic potency correlation (the Mayer-Overton correlation, see `http://tinyurl.com/ycch96kb`) serves as a valuable guideline as one tries to imagine mechanisms of anesthetic action. The potency of anesthete is proportional to the solubility to lipids. Several mechanisms along these lines have been proposed (see `http://tinyurl.com/yb9pauld`).

   The most obvious guess is that anesthetes are dissolved into lipids and induce perturbation of lipid layer and that the change of properties of lipid layer is responsible for the anesthetic action.

   There are objections against this idea. Anesthetes cause also a fluidization of membrane but so does also a slight temperature increase but is not followed by anesthesia. Further objection is that stereoisomers of anesthetes have very different anesthetic effects. Some drugs highly soluble to lipids have a convulsive effect instead (they are called non-immobilizers). Polar anesthetes are less effective: the reason is that they have to cross blood-brain barrier. The effect of anesthete also vanishes above certain chain length in the case of homologous series of any general anesthetic. For instance, for n-alcoholes carbon chain length of 13 units serves as a cutoff raising whereas the solubility to lipids does not display this kind of effect. Note that t microtubular surface has also this kind of periodicity.

   The conclusion is that lipid solubility is only a necessary condition (allowing the anesthete to get through the membrane) and the lipids in question need not be associated with cell membrane but be hydrophobic pockets of proteins.

3. Second proposal is that anesthetes could bind to membrane proteins. Some anesthetes are indeed stereospecific. The study of this hypothesis led to the observation that general anesthetics can also interact with the hydrophobic protein sites of certain proteins. It is known that lock-key mechanism is not the general mechanism. Rather, it seems that anesthetes affect protein dynamics in microsecond-millisecond time scale. This suggests that the primary action of anesthetes is at higher level.

What one can conclude?

1. Effects on lipid layers do not explain the findings. Anesthete must be able to go through neuronal membrane. High solubility to lipids certainly helps here. Different anesthetic effect of stereoisomers suggests that the process involves several steps.

2. Lock-key mechanism does not explain all findings: noble gases is a good example and suggests that also van der Waals interactions are important in some cases at least. The ability of anesthetes to bind to hydrophobic pi rings might be important. This kind of rings are associated with tubulin dimers, which suggests that the action of anesthete takes place at the level of microtubules.

4.1.2 Some basic facts about microtubules

1. Microtubules have been proposed to be central for consciousness [J25]. In [J6] `http://tinyurl.com/ybdy6lw3` Stuart Hameroff discusses this hypothesis in this commentary of the recent findings of Stuart Kauffmann, Gabor Vattay [J21] supporting the view that quantum criticality is a general property of biomolecules. Quantum criticality is the key notion of not only TGD inspired view about life [**?**] but of entire TGD and realized in terms of hierarchy of sub-algebras of super-symplectic algebra represented as conformal gauge transformations [K11].

   Hameroff argues that the hydrophobic regions of microtubules involving pi rings serve as seats of consciousness and the interaction of anesthetes with them leads to an un-conscious state. The TGD view discussed below is not so simple but assumes that this interaction is central in the process leading to a loss of consciousness. Notice that aromatic rings associated with basic bio-polymers and hallucinogens are examples of these regions highly relevant for consciousness.

2. A related proposal [J39, J36] is that in the case of microtubules ferro-electric phase explaining the polarization of microtubules makes possible signalling along microtubule highly relevant to consciousness. Also this view is in accord with TGD based vision, where resonant communications using dark photons with large Planck constant and having universal energy spectrum in the range of visible and UV energies is central. This gives connection also with quantum gravitation but in a way very different from that in the model of Penrose and Hameroff [J25]. Quantum coherence in even astrophysical scales is essential.

The stabilization of microtubules is due to the negative charge density along them.

1. Microtubular carry negative charge density due to the binding of two GTP molecules to each tubulin dimer (`http://tinyurl.com/y8s3yes5`. The article of Jack Tuszynski [J36] provides a good view about non-linear liquid crystal model for ferro-electric phase of microtubules and also contains illustration about the average negative charge density of tubulin dimer.

2. Where does the positive charge reside? TGD interpretation for the fourth phase of water suggests that it resides outside microtubules at magnetic flux tubes as dark protons with large value of h_{eff} [K28, K23]. Hu and Wu [J28] have observed that proton pairs with members at opposite sides of cell membrane have spin-spin interaction frequencies in ELF scale, I have proposed that these protons are dark: TGD inspired model of super-conductivity suggests that they form a super-conducting phase. Also electrons and fermionic ions could be superconducting with same binding energies for Cooper pairs and this is essential for the TGD based model of cell membrane [K31]. On basis of a model for dark protons I have proposed that they give rise to a representations of DNA, RNA, amino-acids and perhaps even tRNA and that also genetic is naturally realized [K19] and that dark proton sequences accompany DNA: this might make sense since also DNA is negatively charged with 2 negative charges per nucleotide.

3. The empirical rule for the direction of electric polarization is that the neuronal ends of axonal microtubules correspond to minus ends of the microtubule. Remarkably, in the case of dendrites there is fifty-fifty distribution in polarity in the case of vertebrates but for invertebrates the dendrites have positive neuronal end [J23] (`http://tinyurl.com/y8e7y55f`). This could tell something very deep about consciousness.

   In TGD selves has time reversed variants born when self dies as the first state function reduction to the opposite boundary of CD takes place. Since electric potential changes sign in time reversal, the presence of two kinds of dendrites could relate to memory. Electric voltage changes its sign in time reversal and indeed leads to a loss of consciousness in the scales studied by Becker [J14]. Could the dendrites correspond to sensory dendrites and memory dendrites? Memories would involve signalling in reversed time direction and memory dendrites. Note that invertebrates would not have memory at this level of self hierarchy.

4.2 Earlier TGD Based Model For Anesthetic Action

The molecular mechanism of the anesthetic action is a fascinating unsolved problem of neurophysiology. Noble gases have very weak chemical interactions. Despite this many noble gas such as Xe, Kr, Ar but to my best knowledge not Ne and He, act as anaesthetics. Also chemically non-inert molecules have quite similar narcotic effect so that chemistry does not seem to matter as Hodgkin-Huxley model would predict.

4.2.1 Simplest model for the anesthetic action

It is known that the narcotic efficiency of anesthetics correlates with their solubility in lipids [J32]. Anesthetics also reduce the melting temperature of the lipid layer. Strong pressure increases the melting temperature and it is known that high pressure brings consciousness back. Thus anesthetic molecules dissolved into the lipid membrane should hinder the generation of the nerve pulse somehow and liquid state of the axonal membrane could be the reason for this. The explanation of the soliton model for the anesthetic action [J27, J29] is that the metabolic energy needed to generate an acoustic soliton becomes too high when axon is too high above the critical temperature.

To get a useful perspective note that also the problem why ordinary cell and neuronal soma outside axonal hillock do not allow action potentials is poorly understood. The fact that anesthetes interact so weakly is the basic problem which could be solved by the almost vacuum extremal property predicting that also noble gas atoms are highly charged Z^0 ions so that they are expected to behave very much like ordinary ions in the cell membrane.

1. Pollack's model [I13] suggests that anesthetics could hinder the occurrence of the gel-sol phase transition for the peripheral cytoskeleton. Suppose that $\hbar$ increasing phase transition for the magnetic flux tubes connecting peripheral cytoskeleton to the axon extends them to the axonal exterior and makes possible the influx of monovalent ions inducing gel-sol phase transition. Perhaps anesthetics prevent this phase transition somehow.

2. The obvious idea is that anesthetized axonal membrane (or at least axonal hillock) is just like the ordinary cell membrane. The model for DNA-cell membrane system as a topological quantum computer requires the liquid-crystal property of the lipid layers of the ordinary cell membrane and neuronal membrane outside axonal hillock. If this is the case, then liquid phase for axonal membrane implied by the anesthetic action would indeed make it more or less equivalent with the ordinary cell membrane. Therefore the question is why the liquid-crystal property of the ordinary cell membrane prevents the generation of the action potential. naïvely one could think that the freezing of the membrane means that the mechanical deformation of the membrane occurring during nerve pulse becomes impossible. The presence of noble gas Z^0 ions could induced the freezing. Perhaps they induce a phase transition taking the cell membrane space-time sheet to far from vacuum extremal.

3. Suppose that the phase transition increasing $\hbar$ is induced by the reduction of the voltage over the axonal membrane (assume to be much smaller than cell potential) inducing almost vacuum property and quantum criticality. Somehow the presence of anesthetics would prevent this. Either the voltage over the membrane is increased in magnitude so that the flow of dark ionic currents to the membrane is not enough to induce quantum criticality or the flow of dark currents is completely prevented by the presence of noble gas Z^0 ions. The first option is more economical and could be tested by finding whether the voltage over the axonal membrane (membrane in a solid state) is considerably smaller than that over the ordinary cell membrane (membrane in liquid-crystal state). The first option also predicts that during sleep the increase of cell potential (hyper-polarization) actually corresponds to the increase of the membrane potential.

4.2.2 Could cyclotron transitions of noble exotic ions in theta and delta bands induce lullaby effect?

Just for fun can consider also more exotic explanation for the anesthetic action. If dark weak force is to have any biological role, the cellular environment should induce a generation of anomalous weak isospin due to the charged color bonds inside nuclei of noble gas. This would obviously relate closely to the anomalous properties of water explained in terms of dark matter hierarchy in [K15, K13]. The color bonds carry also em charge so that noble gas atom with single charged color bond would behave like an ion with nuclear charge Z+1 or Z-1 and electronically like ion with full electronic shell due to ionization (say Cl^- or K^+ in the case of Argon). An important point is that the exotic ions are bosons and can form thermally stable Bose-Einstein cyclotron condensates at $k_d = 47$ flux sheets unlike ordinary ion with mass number differing by one unit.

An interesting question is whether some fraction of Cl^- and K^+ ions are actually exotic Argon ions. Also the long ranged color force and dark weak force with range associated with noble gas nuclei in dark phase could be part of the solution of the mystery.

EEG and ZEG bands above theta band correlate with consciousness. The cyclotron frequencies of ions of anaesthetic noble gases are in theta and delta band as are also EEG frequencies during various stages of sleep but for Ne and He this is not the case. This might not be a mere accident. For instance, one could imagine that the strong resonances in theta and delta bands in EEG induced by Xe, Kr, or A could steal the power otherwise going to higher EEG bands and induce a lullaby effect leading to anaesthesia. This effect of course does not exclude the proposed effect reducing the nerve pulse activity.

According to the general model of EEG [K14], the magnetic flux sheets traversing DNA double strands in cell nuclei come in two varieties corresponding to the two possible quantization of magnetic flux as $Z \int BdS = n\hbar(4)$. For $Z = 1$ the field strength is very near to B_E and for $Z = 2$ to $B_E/2$, with $B_E = .2$ Gauss, the strength of endogenous magnetic field explaining the findings of Blackman and others. For instance, left and right brain hemispheres might correspond to $Z = 1$ and $Z = 2$ and the scale for cyclotron frequencies for right hemisphere would be half of that for left hemisphere. During sleep $Z = 2$ cyclotron frequencies are responsible for EEG via the interaction with Josephson junctions generating the satellites $f_c \pm f_J$ of these frequencies, $f_J = 5$ Hz for $Z = 2$ and $f_J = 2.5$ Hz for $Z = 1$.

The cyclotron frequencies of exotic ions $(Xe^+, Kr^+, Ar^+, Ne^+, He^+)$ are (2.15, 3.57, 7.5, 15, 75) Hz for $B = B_E$ and (1.08, 1.78, 3.75, 7.5, 37.5) Hz for $B = B_E/2$. It would be interesting to check whether EEG contains narrow bands around these frequencies during anesthesia. Also the satellites $f_\pm = f_c \pm f_J$, $f_J = 5$ Hz, could be present. For all noble gas anaesthetics Xe, Kr, and Ar both frequencies are below 7.5 Hz and thus in theta and delta bands. This would encourage to think that the presence of these bosonic exotic ions amplifies the EEG frequencies usually assigned with the theta and delta bands and in this manner induces anaesthesia.

If this is a correct interpretation then it would be essential that K^+ and Cl^- are fermionic ions: otherwise a lullaby effect would result. Note that the exotic ions of Argon can mimic either Cl^- and K^+. Besides producing the lullaby effect, this mimicry could change the effective concentrations of various ions so that large enough reduction of the resting potential could become impossible.

4.3 Second TGD Based Model For Anesthesia

In TGD based model for anesthesia magnetic body, supra currents [K30, K31], and dark matter [K16, ?] should be involved. Besides this the findings of Pollack [L7], Becker's discoveries [J14], and microtubules, in particular the latest findings of Bandyopadhyay *et al* [J11, J24] are expected to be in a central role in the model.

1. The fourth phase of water discovered by Pollack [L7] involving charge separation creating negatively charged regions with sizes up to 100 μm and $H_{1.5}O$ stoichiometry inside negatively charged regions might be involved. Negatively charged linear structures populate living matter. For instance, DNA has 2 negative charges per nucleotide and tubulin dimers have 2 negative charge per nucleotide. Cell interior is also negatively charged. TGD based model [K28, K23] assumes that part of protons go to the magnetic flux tubes and become dark having large non-standard value of effective Planck constant $h_{eff} = n \times h$.

2. Becker's electronic DC currents directed to the wound induce the healing of the wound. Wound develops a negative potential with respect to environment. For instance, frontal lobes are in negative potential with respect to the occipital regions and brain injury generates positive polarization. This means the presence of longitudinal electric fields and ferro-electric phase is a good guess. Becker's discoveries are discussed in TGD framework in [K31, K29]. I have also proposed that Becker currents are supra currents and assignable to microtubules: this assumption is not necessary but possible. Closed circuit must be formed and the return currents could flow as dark supra-currents. Also the currents inside microtubules could be supra-currents, and the ohmic portions of current circuit could fore the semiconductor property.

3. Microtubular ferro-electric property could be the mechanism generating the electric potentials and the action of anesthetes could weaken or destroy these potentials. There is an old discussion of TGD inspired ideas ideas related to microtubules in [K27], and the latest findings of Bandyopadhyay *et al* [J11, J24] are modelled in in [K29].

4.3.1 Mostly questions

To end up with TGD based model it is could to start with questions.

1. Could the mechanisms inducing anesthesia and sleep have something in common? Could also anesthetes induce hyperpolarization so that nerve pulses are not generated so much? How the hyperpolarization could be induced?

2. Could there be a connection with DC currents of Becker [J14]? Could anesthesia reduce the strengths of electric fields of Becker or maybe even reverse their direction. For instance, the electric field between frontal lobes and occipital lobes could change its direction or get weaker.

3. Healing by DC currents means that the damaged body part generates negative potential. DC currents of Becker consisting of electrons make this possible. Could one say that the damaged body part becomes conscious? Could also cell interior, DNA, microtubules negatively charged be conscious.

4. Could there be a connection with microtubules and their ferroelectric phase transition? Could the microtubular longitudinal electric fields be responsible for these electric fields and could DC currents of Becker be associated with microtubules? Is the phase transition destroying microtubular ferro-electricity responsible for the loss of consciousness induced by anesthetes? Could the phase transition change the direction of the electric field? Could this mean change of the arrow of time generating time reversed mental images?

   If the answer to these questions is positive, one might be able to perform reduction of the control of neural activity to microtubular level. Nerve pulses might be induced by a primary wave propagating along microtubules changing locally the direction of the microtubular electric field during the nerve pulse. Temporary time reversal of a microtubular sub-self (mental image) is highly suggestive.

5. Could anesthetes act on microtubules and induce a phase transition destroying their ferroelectric character? Could Becker's DC currents [J14] flow along microtubules as proposed [K31, K29]? Consciousness would be lost, when ferroelectricity of microtubules is reduced or disappears. Longitudinal electric field of microtubule associated with its negative charge density would become radial and would induce hyperpolarization.

6. Is there a connection with TGD view about self? Could the change of the sign of voltage be a space-time correlate for time reversal for self [K26] - in the usual interpretation loss of consciousness? Could amnesia about period of "non-consciousness" be due to time reversal changing the sign of the potential.

4.3.2 What could happen in the ferro-electric phase transition?

What could happen in the phase transition making microtubule ferro-electric and in the reverse phase transition leading to a loss of consciousness?

1. Coherent orientation of the microtubular dipoles in longitudinal direction can generate a longitudinal electric field which for long enough microtubules is proportional to the electric charge at the second end. If the orientations of tubulin dipoles are random, the net electric field is also random. The effect of anesthete would be to randomize the directions of dipoles so that the potential between the ends of microtubule would be random. One can wonder whether this field is really strong enough to explain the experimental findings [**?**].

2. Microtubule carries non-vanishing constant negative charge density due to the presence of two GTPs differing from ATPs only in that A is replaced with G attached to the tubulin dimer and stabilizing it.

   The non-topological half of Maxwell's equations also in TGD framework at the level of space-time surfaces. One can however assume it at QFT limit. Consider first the solutions to the Maxwell equation $\nabla^2\Phi = -\rho_q$ for constant charge density ρ_q concentrated on long linear structure, say microtubule. The standard ansatz is that outside of a very long microtubule the potential depends on the radial coordinate ρ only. Φ satisfies Laplace equation $\partial_\rho^2\Phi + \partial_\rho\Phi/\rho = 0$ giving a potential of form $\Phi = klog(\rho/\rho_0)$ creating a slowly varying radial electric field. For this option microtubule would be analogous to a conductor for which the tangential electric field at microtubular surface vanishes. The value of k is proportional to the surface charge density.

3. In the article of Tuzcinsky *et al* [**?**] it is assumed that inside microtubular surface the potential restricted to the microtubular surface satisfies the equation $\partial_z^2\Phi = \rho_q$). A more general ansatz reads as $\Phi = az + bz^2 + c\rho^2$ with $2b + 3c = \rho_q$. The electric field increases along the microtubule and voltage between the ends can be higher than the voltage solely due to a coherent polarization. One can indeed pose this kind of condition as a boundary condition in Maxwell's theory although it makes solution numerically complex.

   The physical picture would be that the electric decomposes to two parts. The first part flows along the microtubule and second part flows in good approximation in the radial direction. The electric field generated by microtubule would be at large distances that of a point like charge but nearby radial field would be weaker than for the solution carrying maximal radial flux and there would be longitudinal electric field carrying part of flux.

   If a phase transition to a situation in which the electric field is radial occurs, the value of the radial flux becomes maximal and could lead to a hyperpolarization of the cell membrane and reduce neural activity. Also the longitudinal electric field would be reduced and would accompany the loss of consciousness in accordance with the findings of Becker. Becker's findings and a basic fact from neuroscience would be understood as aspects of one and same phenomenon.

4. Can one imagine a phase transition changing the sign of the longitudinal electric field of the microtubule. Could this occur for the dendritic microtubules of vertebrates for which both directions of electric field are present? The direction of electric field correlates with the structure of the microtubule so that the reversal very probably cannot occur for an existing microtubule.

5. How the anesthete bound to hydrophobic pi resonance rings generates the phase transition from ferro-electret to non-ferro-electric phase or to a phase with weaker longitudinal electric field? anesthete should induce a phase transition in which the electric field transforms from longitudinal to radial. The interaction with the pi rings defining hydrophobic pockets should somehow redirect the electric flux to radial direction. The simplest possibility is that the anesthete increases the resistance in the longitudinal direction and reduces the current and therefor also the voltage. Also super-conductivity might be destroyed locally.

6. Situation would be also quantum critical. Quantum criticality of TGD Universe is basically due to the huge vacuum degeneracy of Kähler action inducing 4-dimensional spin glass degeneracy, which predicts that a given induced Kähler field allows all symplectic transforms of the space-time surface as its representations. Only classical gravitational fields differ for these representations. Hierarchy Planck constants is one manifestation of the hierarchy of quantum criticalities.

   Also classical gravitation would be relevant and assuming the condition $\hbar_{eff} = \hbar_{gr} = GMm/V_0$, where v_0 is some characteristic velocity in 2-body system involving large mass M and mass m of electron, proton, or heavier particle. TGD predicts macroscopic quantum gravitational coherence [**?**] and universal energy spectrum for cyclotron photons (no dependence on the mass m of charged particle mass) highly relevant for the model of bio-photons as decay products of dark photons serving as key tool of quantum control also at the microtubular level. By universality also bio-super-conductivity is universal- that is possible for all charged fermions involved being characterized by same binding energies of Cooper pairs associated with pairs of flux tubes. Also bosonic analogs of supra-currents acting also as spin currents and associated with single flux tube are predicted [K31].

One can relate this model to the TGD based model for the findings of the group led by Anirban Bandyonophyay [J11, J24].

1. Microtubules allow two kinds of conformations. For type B microtubules helical symmetry is broken and their is kind of a gap along microtubule. In this phase classical signalling is expected to be possible but macroscopic quantum coherence is restricted to single portion of microtubule helix consisting of 13 tubulins. Also super-conductivity is expected to fail and the conductivity of microtubule is expected to be low. Type A microtubules have helical

symmetry since gap is absent. They might be ideal for quantum computation and consciousness since quantum coherence scale would increase from a length of single helical twist to the length scale of entire tubule.

2. There is however a problem: microtubules of type A appear in neither vivo or vitro! This problem can be solved in TGD inspired model [K29].

   The group of Anirban Bandyonophyay [J11, J24] have found highly interesting effects of AC electric fields on microtubules at frequency ranges about kHz, MHz, and GHz. The TGD inspired proposal is that the external AC signal can induce a phase transition transforming microtubules of type B to microtubules of type A, and in this manner can make possible quantum computation and consciousness. Dark photons at these frequencies but with energies above thermal threshold - perhaps in the energy range of bio-photons in visible and UV range - would serve as a control tool inducing this phase transition increasing the value of h_{eff}. The generation of the gap would also break the long superconducting wire to pieces and super-conductivity inside microtubule would become super-conductivity in much shorter scale and therefore reduces microtubular conductivity. This implies the reduction of longitudinal electric field and explains the other signatures for the loss of consciousness (reduction of Becker's DC voltage and hyperpolarization).

3. This transition has analog also in TGD based description of both bio-super-conductivity and ordinary high T_c super-conductivity [K31]. There are 2 critical temperatures. At higher critical temperature Cooper pairs are formed at flux tubes carrying antiparallel magnetic field but supra-currents flow in rather short length scale (the analog of B phase for microtubules). At lower critical temperature the flux tube pairs reconnect to from much longer flux tube pairs (microtubules of type A) and give rise to macroscopic super-conductivity. The process is percolation type process. In the recent case the external AC frequency has the same effect as lowering of temperature.

The model could generalize to other important biopolymers.

1. The presence of negative charge density due to GTP and ATP could provide biopolymers with negative charged density generating the stabilizing electric fields. The negative charge could be due to the generation of fourth phase of water discovered by Pollack [L7] transforming part of protons to dark protons and providing the ionizing electron for GTP or ATP. This suggests a very close connection with metabolism.

2. Also the denaturation of basic biopolymers such as DNA and proteins could rely on a phase transition reducing the longitudinal electric fields made possible by GTP or ATP generated in Pollack's phase transition. In TGD framework one could say that biopolymer loses consciousness.

3. The two strands of DNA could represent sub-selves with opposite time directions. Also brain hemispheres could have opposite arrow of time at some level of self-hierarchy. The other hemisphere would remember and the other hemisphere would pre-cognize (remember in reverse time direction).

4.3.3 Aromatic rings as the lowest level in the molecular self hierarchy?

Of special interest from TGD point of view were the talks of Hameroff and Bandyopadphyay, who talked about aromatic rings (ARs, `http://tinyurl.com/yb492da6`) (`p://tinyurl.com/nrntzs5`).

I have also wondered whether ARs might play key role with motivations coming from several observations.

1. In photosynthesis ARs are a central element in the energy harvesting system , and it is now known that quantum effects in longer length and time scales than expected are involved. This suggests that the ARs involved fuse to form a larger quantum system connected by flux tubes, and that electron pair currents follow along the flux tubes as supra currents.

DNA codons involve ARs with delocalized pi electrons (http://tinyurl.com/jqj56wz), neurotransmitters and psychoactive drugs involve them, 4 amino-acids Phe, trp, tyr and his involve them and they are all hydrophobic and tend to be associated with hydrophobic pockets. Phe and trp appear in hydrophobic pockets of microtubules.

2. The notion of self hierarchy suggests that at molecular level ARs represent the basic selves. ARs would integrate to larger conscious entities by a reconnection of the flux tubes of their magnetic bodies (directing attention to each other!). One would obtain also linear structures such as DNA sequence in this manner. In proteins the four aromatic amino-acids would represent subselves possibly connected by flux tubes. In this manner one would obtain a concrete molecular realization of self hierarchy allowing precise identification of the basic conscious entities as aromatic rings lurking in hydrophobic pockets.

3. Given AR would be accompanied by a magnetic flux tube and the current around it would generate magnetic field. The direction of the current would represent a bit (or perhaps even qbit). In the case of microtubules the phe-trp dichotomy and direction of current would give rise to 4 states identifiable as a representation for four genetic letters A,T,C,G. The current pathways proposed by Hameroff *et al* consisting of sequences of current rings (http://tinyurl.com/j9pgm6q) could define the counterparts of DNA sequences at microtubule level.

   For B type microtubules 13 tubulins, which correspond to single 2π rotation, would represent basic unit followed by a gap. This unit could represent a pair of helical strands formed by flux tubes and ARs along them completely analogous to DNA double strand. This longitudinal strand would be formed by a reconnection of magnetic flux tubes of the magnetic fields of ARs and reconnection occurring in two different ways at each step could give rise to braiding.

4. The magnetic flux tubes associated with the magnetic fields of nearby aromatic rings could suffer reconnection and in this manner a longitudinal flux tubes pair carrying supra current could be generated by the mechanism of bio-superconductivity discussed in [K31] and working also for the ordinary high T_c super conductivity. The interaction of microtubule with frequencies in the scales kHz, GHz, and THz scales would induce longitudinal superconductivity as a transition to phase A from phase B meaning generation of long super-conducting wires.

   This view suggests that also DNA is superconductor in longitudinal direction and that oscillating AC voltage induces the superconductivity also now. Bandyopadphyay indeed observed the 8 AC resonance frequencies first for DNA with frequency scales of GHz, THz, PHz, which suggests that dark photon signals or AC voltages at these frequencies induce DNA superconductivity. According to the model of DNA as topological quantum computer DNA is superconductor also in the transversal degrees of freedom meaning that there are flux tubes connecting DNA to a lipid layer of the nuclear or cell membrane [K1, K36].

5. Interestingly, the model of Hameroff *et al* for the helical pathway (http://tinyurl.com/j9pgm6q) assumes that there are three aromatic rings per $d = 1$ nm length along microtubule. This number is same as the number of DNA codons per unit length. It is however mentioned that the distance between aromatic rings trp and phe in MT is about $d = 2$ nm. Does this refer to average distance or is $d = 1$ nm just an assumption. In TGD framework the distance would scale as h_{eff} so that also scaling of DNA pathway by a factor 6 could be considered. In this case single tubulin could correspond to genetic codon.

   If $d = 1$ nm is correct, these helical pathways might give rise to a representation of memetic codons representable as sequences of 21 genetic codons meaning that there are 2^{126} different memetic codons [K18]. DNA would represent the lowest level of hierarchy of consciousness and microtubules the next level. Note that each analog of DNA sequences corresponds to different current pathway.

6. What is especially interesting, that codon and its conjugate have always altogether 3 aromatic cycles. Also phe and trp appearing in MTs have this property as also tyr and his. Could these 3 cycles give rise to 3-braid? The braid group B_3 which is covering of permutation group of

3 objects (http://tinyurl.com/ycnar9sa). Since B_2 is Abelian group of integers, 3-braid is the smallest braid, which can give rise to interesting topological quantum computation.

B_3 is also the knot group of trefoil knot (http://tinyurl.com/of6t3sw), and the universal central extension of the modular group PSL(2,Z) (a discrete subgroup of Lorentz group playing a key role in TGD since it defines part of the discrete moduli space for the CDs with other boundary fixed [K25]). Quite generally, $B(n)$ is the mapping class group of a disk with n punctures fundamental both in string model: in TGD where disk is replaced with partonic 2-surface.

4.3.4 Why some anesthetes do not prevent motor activity?

Some anesthetes (non-immobilizers (http://tinyurl.com/jqlncvn)) do not prevent motor activity and thus break the Meyer-Overton rule. This piece of data could provide a test for the model.

The two kinds of dendrites giving rise to sub-selves with possibly different arrows of time are expected to be similar. Suppose sensory-motor duality realized as dendrites-axon dichotomy. Suppose that the two kinds of dendrites correspond to sensory experience (and pre-cognition as having an idea about what will probably happen) and memories and have opposite arrows of time. If so, there would be no memories about sensory experiences - including pain. The interaction of anesthetes with axonal microtubules would prevent motor activity. If it can happen that an anesthete can bind only to dendrites or to microtubules inside them, one could understand the finding.

What could distinguish between dendrites and motor axons? Size scale is different and could prevent the interaction of some anesthetes with the microtubules of motor axons. Also the microtubules inside dendrites and axons could differ.

4.4 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.

4.4.1 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?

4.4.2 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.

4.4.3 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.

4.4.4 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 [K29] [L9]. 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 [K33]. 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.

It is interesting to compare this Hameroff's vision with TGD view about the roles of microtubules and cell membrane already discussed in [L9]. The new elements are cell membrane as self-loading battery based on the TGD based model for the exclusion zones (EZ) of Pollack [L7] in terms of $h_{eff}/h = n$ phases.

4.5 Anesthetes again

The writing of the summary about SSE-2016 conference forced to think again the model for anesthetes in light of the vision about cell membrane as sel-loading battery relying on TGD based model for Pollack's exclusion zones (EZ) [L7] in terms of $h_{eff}/h = n$ phases.

First however a philosophical remark.

1. According to the behavioristic definition of consciousness, the ability to respond to sensory input and perform motor actions are essential aspects of consciousness. To my opinion these abilities correspond to only particular type of consciousness and consciousness might be possible even without neural activities (OBEs and NDEs). In any case, the inability to generate nerve pulse patterns would be an essential aspect for what we call loss of consciousness. This happens if there is hyperpolarization of neuronal membrane.

2. Hyperpolarization means reduced rate of spontaneous nerve pulse generation. This would be achieved if microtubules gain additional negatively charge so that the radial component of microtubule electric field increases. Hence the interaction of anesthetes with the microtubuli should generate this negative charge. One possibility is that Pollack effect [L7] generates in the presence of anesthete negatively charged exclusion zone (EZs) [L7]. The TGD based model assumes that the protons are transferred to the magnetic flux tubes as dark protons and perhaps end up to the exterior of cell membrane and transform to ordinary protons. This would induce hyperpolarization. The neutral anesthete atoms or molecules in turn could be transferred to the microtubules along flux tubes.

Consider next a model for the cell membrane.

1. In TGD Universe cell membranes could be generalized Josephson junctions. The energy of generalized Josephson photons (dark with energies in bio-photon range) would be the difference of cyclotron energies for flux tubes at the two sides of the membrane plus the ordinary Josephson energy. Generalized Josephson photons would take care of communications of sensory data to MB.

   Unless the cyclotron energies at the two sides of the membrane are same, the new contribution would dominate in the communications to MB for large values of h_{eff} since cyclotron energy is proportional to h_{eff}, and neuronal contribution would represent frequency modulation allowing to code nerve pulse patterns to kind of "whale's song". For smaller value of h_{eff} ordinary Josephson energy would dominate.

   There is a temptation to assume that the value of h_{eff} serves as a kind of intelligence quotient of cell. Frequency scale and energy scale for the analog of EEG would serve for the same purpose. For instance, pyramidal neurons responsible for EEG would represent the intellectual elite of brain and ordinary cells could have much smaller value of h_{eff} being say by factor 2^{-10} smaller than for pyramidal cells so that generalized Josephson energy would be of the same order of magnitude as ordinary Josephsone energy and in IR range.

2. Generalized Josephson photons with biophoton energies would also generate Pollack's EZs [L7] by ionizing one proton from hydrogen bonded pair of water molecules. The reduction of the membrane potential below the threshold for nerve pulse generation could reduce the energy of Josephson photons below threshold for generating Pollack's EZs and neuronal membrane would cease to be self-loading battery: this would replace ionic Josephson currents with ohmic currents through cell membrane and generate nerve pulse.

   The objection is that for low values of h_{eff} generalized Josephson energy reduces to ordinary one in IR range and for high values to cyclotron energy in visible-UV range. It is known that IR photons generate EZs in the experiments of Pollack. The process could occur in two steps involving cyclotron radiation - perhaps from MB - kicking of hydrogen bonded water molecules to a state, where proton is almost ionized so that the IR radiation would take care of the ionization. The mechanism generating EZs cannot be different for ordinary cells and neurons. Either the notion of generalized Josephson junction must be given up or in the case of neurons glial cells accompanying also axons generate the IR radiation giving rise to EZs inside axons.

3. It is also attractive to see at least ordinary cell membrane as a self-loading battery [L12]. The generation of Pollack's EZs with negative charge and dark proton charge at magnetic flux tubes of the associated MB could make cell a self-loading battery [L12].

   Generalized Josephson photons from cell membrane or cyclotron photons could generate EZs by kicking protons to dark protons at flux tubes of MB of the cell. The energy must be in some critical range in order that this can happen. For too small energies the process stops. Besides ionic charge distributions EZs and the delocalized dark proton charges and the flux tubes extending beyond cell interior would be responsible for the resting potential.

   EZs are not expected to be completely stable. The $h_{eff} \to h$ phase transition would bring dark protons back as ordinary protons and destroy EZs and reduce the magnitude of membrane potential. There could be a competition between the generation and destruction of EZs by $h_{eff} \to h$ phase transition.

4. This picture is enough to explain the effect of anesthetes. Anesthetes at microtubules would generate a negative charge assignable to additional EZs thus increasing the magnitude of the membrane potential. This would imply stable hyperpolarization preventing the generation of nerve pulses.

What about generation of nerve pulses in this framework? I have suggested a TGD based model for nerve pulse [K33] relying on the idea about cell membrane as array of Josephson junctions consisting of membrane proteins (channel and pump proteins) but the model leaves open what exactly generates the nerve pulse. The expectation has however been that microtubules play a key role in the generation of nerve pulse. A charge wave with positive charge propagating along microtubule could induce the reduction of the membrane potential and lead to a generation of nerve pulse as a secondary wave.

1. The propagation of $h_{eff} \to h$ phase transition followed by its reversal along axon interior could serve as a weak control signal inducing the nerve pulse propagation at quantum criticality. This phase transition could be assignable to microtubules. Battery would temporarily discharge during the nerve pulse. If glial cells generate the EZs making axons glial-cell loaded batteries then the return back to the normal state after nerve pulse would be possible by the presence glial cells.

2. During nerve pulse either the generation of EZs ceases and/or the existing EZs suffer an h_{eff} reducing phase transition so that flux tubes are shortened and the positive dark charge returns to EZs and cell membrane potential is reduced. The generation of nerve pulse is usually modelled using ohmic ionic currents, which suggests that quantum coherence is lost by a reduction of h_{eff}, which is predicted to be proportional to ion mass so that cyclotron energy spectrum is universal and in visible-UV range for bio-photons.

3. Nerve pulse could be a "secondary wave" induced by a wave of positive charge propagating along microtubule. This wave of positive charge would rather naturally result from the reduction $h_{eff} \to h$ and return back to h_{eff}. A pair of phase transitions dark-ordinary-dark would propagate along the microtubule. The unidirectionality of the propagation direction would be forced by the fact that it can begin only from axonal hillock. Axonal hillock contains a large number of voltage gated ion channels, which would serve as generalized Josephson junctions in TGD framework.

4. What one can one conclude about the development of total charge during the time development of membrane potential $V(t)$? Nerve pulse corresponds to certain segment of axon and lasts for few milliseconds. The cell membrane voltage goes from resting potential $V(t = 0) = V_{rest}$ to approximately $V(t = T) = -V_{rest}$ and returns back. The total charge in cell interior defines the value of electric field E at the interior side of cell membrane and approximation interior as conductor, the value of Ein good approximation one has $V = Ed = Q_{cell}d/4\pi R^2$ in spherical geometry and $V = Ed = dQ_{tot}/dld/2\pi R$ in cylindrical geometry of axon. Here Q_{tot} is the charge of the piece of axons at which nerve pulse is located. Total charge is sum of microtubular charge Q_{mt} serving as a control parameter and the total ionic charge Q_I changing due to the presence of ohmic ionic currents during the pulse (ionic currents are Josephson currents except during nerve pulse).

   To get some quantitative grasp, let us idealize the situation by assuming that during nerve pulse the negative microtubular charge $Q_{mt}(0) < 0$ goes to $Q_{mt}(T) = 0$ for $V(T) = -V_{rest}$ (EZs disappear totally) and returns back to its original value as the phase transition returning the value of h_{eff} occurs.

   One has $Q_{tot}(0) = Q_{mt}(0) + Q_I(0)$ before the nerve pulse. At $V = -V_{rest}$ one has $Q_{tot}(T) = -Q_{tot}(0)$, which gives $-Q_{tot}(0) = Q_I(T)$. This gives $Q_{mt}(0) = Q_I(T) - Q_I(0)$.

   What can one say about the magnitude of Q_{mt}? If this charge serves control purpose and if the system is kicked off from quantum criticality, the change of Q_{mt} need not be large so that no large modifications of the ordinary model of nerve pulses are needed. The negative microtubular charge is partially due to the GTPs along microtubular to which EZs are associated. The value of resting potential of order .06 eV at threshold for nerve pulse generation and

estimates for linear ionic charge densities $dQ_I(0)/dl$ and $dQ_I(T)/dl$ and $Q_{mt}(0)/dt$ would allow to test the model. The $h_{eff} \to h$ phase transition outside quantum criticality would take place in millisecond time scale.

The distinctions between neurons and ordinary cells allow to invent objections against the proposed scenario.

1. Ordinary cell membrane should act as a self-loading battery with Josephson radiation generating Pollack's EZs. Axonal microtubules are missing but the cytoskeleton consisting also of microtubules is present. Inside the cell soma the microtubules meet the cell membrane transversally. There is also T-shaped antenna like structure involving microtubules whereas ordinary neurons have axonal microtubules. Also now a microtubular positive charge generated by $h_{eff} \to h$ phase transition could induce the reduction of membrane potential.

2. Why the analog of nerve pulse does not take place also now? In the case of cancer cells membrane potential is reduced and can become even vanishing, and one might think that the lack of recovery is due to the absence of glial cells taking care that EZs are generated. For too low Josephson energies the self-loading would stop and due to the spontaneously occurring $h_{eff} \to h$ phase transitions, the membrane potential would be gradually reduced.

   In the case of neurons the $h_{eff} \to h$ phase transition would occur fast. The transition away from quantum criticality could cause this since long range quantum fluctuations would disappear. The value of membrane potential or the difference between neuronal and glial membrane potentials could serve as a critical parameter changing as the membrane potential is reduced. The quantum criticality of ordinary cell membrane would be analogous to self-organized quantum criticality. That of neuronal axon to quantum criticality induced by glial cells.

4.6 TGD interpretation of new experimental results about the mechanism of anesthesia

I received a link to a highly interesting popular article with title "*Century-Old Scientific Debate Settled: Anesthesia's Effect on Consciousness Solved*" (`https://tinyurl.com/yd4ztmph`). The article tells about a study from Scripps Research published in the Proceedings of the National Academies of Sciences (PNAS). The paper [J31] "*Studies on the mechanism of general anesthesia*" has appeared in PNAS (`https://tinyurl.com/y8oa97eo`). In addition to Lerner and Hansen, the authors are Mahmud Arif Pavel, E. Nicholas Petersen and Hao Wang, all of Scripps Research.

I have pondered possible mechanism of anesthesia in TGD framework several times earlier [K33] [L9] and it is interesting to see whether the findings allow to make earlier insights more detailed or even develop new ones.

4.6.1 What was observed

According to the popular article the discovery by chemist Richard Lerner, MD, and molecular biologist Scott Hansen, PhD, settles a century-old scientific debate about whether anesthetics act directly on cell-membrane gates called ion channels, or do they somehow act on the membrane to signal cell changes in a new and unexpected way. The conclusion of the researcheres is that anesthetic action is a two-step process that begins in the membrane. The anesthetics perturb ordered lipid clusters within the cell membrane known as "lipid rafts" to initiate the signal. There are two kinds of clusters involved and known with names GM1 and PIP2.

What was observed was following.

- A shift in the GM1 cluster's organization, a shift from a tightly packed ball to a disrupted mess occurred first As GM1 grew disordered, it spilled its contents, among them, an enzyme called phospholipase D2 (PLD2). Melting is a good analog for what happens. Gel-to-sol transition in cytoplasm is second analogy.

- PLD2 moved like a billiard ball away from its GM1 home and over to a different, less-preferred lipid cluster called PIP2.

- This activates key molecules within PIP2 clusters, TREK1 potassium ion channels and their lipid activator, phosphatidic acid (PA) are among them. The activation of TREK1 potassium channels releases potassium hyper-polarizing the nerve and it makes it more difficult to fire. Nerve pulse generation rate becomes low and leads to a loss of consciousness - at least in clinical sense. Something analogous to this could happen when one falls in sleep.

In the sequel I try to understand in the framework provided by TGD inspired model of cell membrane and nerve pulse [K33], compare these findings to TGD inspired views about anesthesia based on hyperpolarization, and also try to build a bridge from TGD description provided by a generalization of thermodynamics forced by zero energy ontology (ZEO) predicting that in ordinary state function reduction the arrow of time changes [L31, L37].

4.6.2 TGD background

In the following Pollack effect and its generalization are discussed, ZEO based view about self-organization involving time reversal as key element is compared to the non-equilibrium thermodynamics (NET) based approach, and the TGD based view about nerve pulse generation and EEG is discussed.

1. Pollack effect as starting point

The generalization of Pollack effect [I14, L7, I20, I17] plays a key role in TGD inspired biology.

1. TGD based model of cell membrane relies on a generalizaton of Pollack effect so that it would allow also to other ions - at least positively charged ions inside neuronal (cell) membrane. Pollack effect occurs in presence of energy feed such as IR photons, and means charge separation in water bounded by gel so that negatively charged exclusion zone (EZ) is formed. TGD interpretation is that part of protons goes outside EZ to magnetic flux tubes and form dark proton sequences having effective Planck constant $h_{eff} = nh_0 > h$ and forming macroscopic quantum phase. Dark particles at magnetic flux tubes of magnetic body of system (MB) would control its dynamics like master and induce coherence as forced coherence.

   EZ has the strange property that it drives out impurities. The interpretation is that the arrow of time is change at MB controlling EZ and induces effective change of the arrow of time at EZ differing from the standard arrow of time of observer. DNA nucleotides involve negatively charged phosphate ion, which leads to the proposal that they are accompanied by magnetic flux tubes parallel to them carrying dark proton triplets as a representation of genetic codons [L10, L27].

   Negatively charge entities appear abundant in biology.

   (a) Cell interior is negatively charged, which suggests similar charge separation with positive charge assignable to dark ions at the magnetic flux tubes outside cell. Fermionic ions such as K^+, Na^+,.. could form Bose-Einstein (B-E) condensates of Cooper pairs whereas bosonic ions like such as Ca^{2+}, Mg^{2+}, Fe^{2+} could as such form B-E condensates. It is not clear whether also negatively charged ions like Cl^- form B-E condensates at flux tubes and whether they are in the interior or exterior of cell.

   (b) Microtubules carry constant negative charge density per unit length realized in terms of GTP molecules suggesting that they are accompanied by parallel flux tubes carrying say dark protons. Microtubules could be partially responsible for the negative charge of cell and could be related to the control of membrane potential.

   (c) ATP has charge -3. This forces to ask whether there is charge +3 of 3 protons associated with a magnetic flux tube accompanying ATP. Could the 3 protons form the analog of genetic codon so that information processing might take place already at this level?

2. Pollack effect would basically transform part of ordinary ions in cell interior to dark ions or their Cooper pairs outside cell at flux tubes. Note that also the analogs of 3-proton units can be considered for positive ions. This would require energy feed, which need not come from metabolic energy. Integral proteins acting as ion channels do not require ATP to function and are a good candidate in this respect. Their opening could make possible Pollack effect

for ion. Ion pumps are also integral proteins and could transfer the ions produced in the decay of Cooper pairs to ordinary ions back to cell interior.

2. ZEO based thermodynamical description of self-organizing cell

TGD leads to a new kind of thermodynamical description of cell as an open self-organizing system. Cell is indeed an open self-organizing system requiring metabolic energy feed. The standard description would be using non-equilibrium thermodynamics (NET). ZEO allows both arrows of time and and the arrow of time changes in ordinary ("big") state function reductions (BSFRs) possible in arbitrary long scales. This forces a generalization of thermodynamics allowing a new kind of description.

Dissipation with reversed arrow of time corresponds to generation of gradients and gradients as seen by observer with standard time direction, and energy feed needed by self-organization corresponds to dissipation of energy by self-organizing system in reverse time direction. The arrow of time could be different from standard one in long time scales only at the level of MB carrying dark matter and can induce its effective change at the level of ordinary matter.

The energy of particle increases with h_{eff} so that generation of dark phases and the preservation of h_{eff} distribution requires energy feed. Hence one can see self-organization as a direct evidence for the notions of MB and ZEO.

How does TGD description relate to the standard description of cell in terms of NET differing from the ordinary thermodynamics by the presence of energy feed?

1. In standard thermodynamical description the presence of dark matter is not assumed. Therefore the description takes into account only the ordinary matter. For living cell the differences between ion concentrations are in sharp conflict with naïve expectations for ions like K^+ (concentration is considerably higher in the cell interior). They are explained by using chemical potentials μ as parameters. Their values are determined experimentally from measured ion concentrations. Their values would be basically determined by the metabolic energy feed: here NET enters the picture.

2. The basic quantity is Gibbs energy $G = E - TS$, whose minimization corresponds to second law of thermodynamics. The energy minimization and entropy maximization compete and there is a competition between energy and entropy. Giggs energy for single particle corresponds to chemical potential $\mu = e - Ts$ at single particle level. Given process is thermodynamically favored at single particle level if μ decreases in it.

3. For instance, the measured density of K^+ ions is much higher inside cell than exterior - this corresponds to the fact that dark K^+ ions or of their Cooper pairs at flux tubes are not observed. When channel is opened the K^+ ions flow to the exterior of the membrane provided this corresponds to a decrease of μ. For given ion there is also a certain value of membrane potential for which there is no flow.

   In TGD framework Pollack effect transforming K^+ ions to their dark variants transferred to the flux tubes outside cell and possibly forming Cooper pairs would be the description. The safest assumption is that ions are at flux tubes at both sides but that at either side the value of h_{eff} is minimal. Also phase transitions changing h_{eff} for flux tubes are expected to occur and play a key role in TGD based model for bio-catalysis.

4. An open problem is whether the phenomenological description of ordinary matter in terms of NET is equivalent with the ZEO based description in which also dark matter is taken into account. For instance, Pollack effect for protons requires energy feed. It generates charge separation, which generates negative Coulomb energy. The Coulomb repulsion between charged protons at flux tube generates positive energy. The model as dark nuclei implies that there is also scaled dow nuclear binding energy involved. The value of entropy generated in this manner depends on the scale of de-localization at MB. If macroscopic quantum phase is generated, one expects that the generated entropy is actually small.

5. It would seem that ion channels, which do not require ATP, involve the transfer of ordinary matter to dark matter at magnetic flux tubes. Could ion pumps requiring ATP be responsible

for the transfer of ordinary ions between cell interior and exterior against gradient of chemical potential? Could they correspond to standard arrow of time?

3. EEG and nerve pulse generation in ZEO

TGD leads to a model of nerve pulse and EEG [K33, K14, K34].

1. Cell membrane is a generalized Josephson junction in the sense that there are flux tubes at both sides of the membrane connected by a flux tubes through cell membrane. The energy assignable to the ion in junction is sum of two terms. The first term is the ordinary Josephson energy given by Coulomb energy. Second terms is the difference of the cyclotron energies of ion associated with the flux tubes at the two sides of the membrane. The generalized Josephson radiation generated by this system consists of dark photons travelling along magnetic flux tubes to the part of MB much larger than the system. The Compton length of EEG radiation at Schumann frequency 7.8 Hz gives an estimate of order Earth circumference for the size scale of MB.

2. The sensory part of EEG mediating sensory information to MB would be assigned with the generalized Josephson frequencies modulated by the variation of membrane potential and in this manner coding the sensory data. If the signal is received at certain resonance frequencies it corresponds to a sequence of peaks corresponding to critical values of membrane potential.

   MB containing cyclotron B-E condensates would receive this radiation resonantly and respond by control signal consisting of dark cyclotron radiation possibly mediated through genome (and possibly also microtubuli) and inducing biological effects. They would emerge by a transition $\hbar_{eff} = h\hbar_0 = h_{gr} = GMm/v_0 \rightarrow h$ producing ordinary photons identifiable as bio-photons in visible and UV range [K5, K10]. These would induce molecular transitions.

3. h_{eff} hierarchy allows to interpret the generation of nerve pulse as a quantum jump in neuronal scale. The change of the arrow of time correspond to the change of the sign of the membrane potential temporarily. This process would liberate energy needed to preserve the thermodynamical non-equilibrium state but regeneration of standard arrow of time would require metabolic energy so that energy would be lost. For instance, generalized Josephson radiation would use part of the energy.

   Neural membrane is quantum critical against generation of nerve pulses by macroscopic quantum jump changing the arrow of time (automatically) - as a matter of fact, the Josephson energy for ion Cooper pairs is near to thermal energy. This makes cell membrane an ideal sensory receptor.

4. Quite generally motor actions correspond in TGD framework BSFRs whereas sensory perception corresponds to a sequences of "small" state function reductions (SSFRs). This would suggest that the EEG waves from the cell membrane as sensory input have standard arrow of time and control signals from MB comes as EEG waves with opposite arrow of time. One might also speak of time reflection of the positive energy signal. A detailed model for the sequence of SSFRs leads also to a model for what personal memories are [L31, L37].

What happens to GM1 fart is essentially melting.

1. Melting phase transitions - analogous to gel-sol transitions for cytoplasm - occur in the lipid layer also during the propagation of nerve pulse and has been proposed to accompany a propagation of soliton [J38] (`https://www.pnas.org/content/102/28/9790`). TGD based model of nerve pulse [K33] assumes that in the resting state of axon there is a sequence of solitons propagating along the axon mathematically. The chain of the proteins representing ion channels (and possibly also pumps) as Josephson junctions would be analogous to a chain of rotating mathematical penduli with constant phase difference.

2. Nerve pulse would correspond to a propagation of a perturbation for which some penduli oscillate rather than rotate. The local transformation of rotation to oscillation would correspond to a melting phase transition propagating along axon.

3. One cannot however exclude the possibility that the Josephson penduli are not kicked to oscillation but to a rotation in opposite direction. This would conform with the proposal of [J38] that nerve pulse involves propagation of some kind of soliton.

   If this is true, the ions at two sides should be at flux tubes with different values of h_{eff} and the values of h_{eff} are effectively permuted at two sides to change the sign of membrane potential. This requires transfer of energy between interior and exterior. The change of the sign of membrane potential suggests local time reversal and if BSFR occurs, this must happen. If BSFR occurs, some self - neuronal mental image - at exterior dies and re-incarnates with opposite arrow of time in the interior. The observer with standard arrow of time would see ions to flow from the MB of the neuron to interior flux tubes for which h_{eff} is increased. The naïve expectation is that also the roles of channels and pumps are changed.

4. It would be natural to assign melting transition with the reduction of membrane potential and initiation of the time reversed period. The possible melting outside neuron would be accompanied by freezing in the interior. Gel-sol phase transitions in cytoplasm could accompany the nerve pulse propagation. Cavitational fluctuations of water and microtubule disassembly are known to be accompanied by gel-sol phase transitions and of emission of biophotons and IR light [I6] (`https://tinyurl.com/ya33kdzt`). Photons are indeed in central role also in the generation of Pollack effect as providers of metabolic energy to realize the transition.

   Gel like states would correspond in TGD picture states of water in which the value of h_{eff} for the flux tubes is increased and thus to ordered states with higher number theoretic "IQ" having interpretation as dimension of extension of rationals [L30, L36, L33]. The increase of h_{eff} requires energy and gel-sol phase transition would correspond to a reduction o h_{eff} and liberate stored metabolic energy. One expects gel-sol phase transitions for cellular water to accompany the propagation of nerve pulses. One can imagine that the energy liberated in gel-to-sol transition induces sol-to-gel transition. This would naturally allow interpretation also as information transfer too?

4.6.3 What could happen in anesthesia?

Anesthetes - often noble gases - are expected to have rather weak chemical effects. This suggests that the mechanism inducing hyperpolarization is not purely chemical.

1. It would seem that GM1 clusters and PIP2 clusters correspond to two different equilibria in which the dark K^+ concentrations at dark flux tubes are different and therefore also membrane potentials. The role of the anesthete and of the control step inducing sleep would be to replace GM1 with PIP2. The anesthete dissolving into lipid layers could induce its melting by lowering the density of lipids in lipid-crystal and in this manner induce the decay of GM1 clusters. The interpretation of lost coherence could be in terms of reduction of h_{eff}: if BSFR occurs, GM1 could be said to die. The decay of the GM1 clusters could be thus seen as analog of decay process in general liberating energy used in the next step of the process.

2. What could happen in the decay of GM1 cluster, which expands from tightly packed ball and looses is order? The twistor lift of TGD [L32, L29] predicts length scale dependent cosmological constant Λ characterizing various structures in all scales and the possibility of phase transitions reducing the value of Λ, scaling up the size of the structure in question, and liberating energy. Could also GM1 be characerized by Λ decreasing in the transition and could the liberated energy be used as metabolic energy in the transfer of K^+ ions?

3. The PLD2 molecules (containing phosphate) are said to move like billiard balls to PIP2 clusters, which suggests that they could travel along magnetic flux tubes connecting the two systems. PLD2 molecules act as catalysts and could help to activate TREK1 K^+ channels and their lipid activator, phosphatidic acid (PA) containing phosphate with charge -2.

   All these molecules involve negatively charged phosphate ions and this could relate to the generation of charge separation by Pollack effect. PIP2 involves 3 negatively charged phosphates and it binds to the TREK1. The negative charge from phosphates bound to TRKE1

could make it part of an analog of EZ. I do not know whether one has excluded the possibility of ATP $\rightarrow$ ADP type mechanism.

4. It is not clear what happens at the level of energetics. In ZEO picture the opening of K^+ ion channels would make possible a transfer of K^+ ions by Pollack effect to their dark variants possibly forming Cooper pairs at MB at the other side of neural membrane. If this requires metabolic energy, it is not provided by ATP.

   In NET picture Gibbs free energy should decrease if the process is spontaneous as suggested by the absence of ATP. This could be the case also now at least approximately. There could be quantum criticality in the sense that there is large number of states of neuron with essentially same energy or with energies differing only slightly but with different membrane potential.

   The increase of the membrane potential reduces the rate for the spontaneous generation of nerve pulses. Nerve pulse generation is expected to release energy but the regeneration of membrane potential back to its original value requires energy. Hence one expects that the anesthetic state saves metabolic energy as also sleep state is expected to do. Note that the feed of metabolic energy could corresponds quite generally to dissipation in opposite time direction. Could the MB of PIP2 cluster live in opposite time direction - as also GM1 cluster when active - and get its metabolic energy making possible the transfer of K^+ ions in this manner?

5. What is the role of the anesthete? Meyerton-Overton hypothesis states that the potency of anesthete correlates with its liquid solubility. The anesthete dissolved into the 2-D liquid-crystal formed by lipid layer should somehow induce the decay of GM1 cluster: the dissolved anesthete could force the reduction of density of 2-D liquid crystal if the total pressure is preserved. Could this decay liberate provide the metabolic energy needed in Pollack effect? Anesthete dissolves spontaneously. In standard picture the interpretation would be that this reduces Gibbs energy G. Does this liberate energy or is the increase of entropy enough to reduce G?

4.6.4 Questions

The foregoing speculative picture raises several questions.

1. The falling to sleep could involve similar transition. What happens to conscious experience in anesthesia and sleep. Sensory input from cell membranes to MB disappears and also motor control from MB becomes impossible but does this really mean loss of consciousness? Could the experience be nearer to a meditative state?

2. The arrow of time changes inside EZs assignable to negative charge in Pollack effect. Could PIP2 cluster be contained in EZ and thus have also reversed arrow of time. Could EZ property be tested? Could also the GM1 cluster have reversed arrow of time and be responsible for the transfer of different kind of ions?

   In ZEO "big" (ordinary) state function reduction (BSFR) corresponds quite universally to death and re-incarnation with opposite arrow of time for conscious entity involved. Could falling asleep be BSFR at some level of self hierarchy. Could GM1 clusters as conscious entities die and could their decay be analogous to ordinary decay process and provide both building bricks (PLD2) and metabolic energy for PIP2 clusters? Could this be interpreted as a kind of birth or wake-up for PIP2 clusters? Could the re-incarnated GM1 clusters live in opposite arrow of time?

3. K^+ channels represent only one particular kind of ion channel and there are many ways to control the ion flux. Could all ion channels rely to Pollack effect? What about on pumps. Could ion pumps be channels but with opposite arrow of time?

4. Quantum consciousness theorists like Hameroff have speculated about the role of microtubules in the action of anesthetes. The proposal is that the anesthete could bind in the hydrophobic pocket of microtubule. The recent findings seem to exclude this option.

Microtubules however carry large negative charge density due to the presence of GTP molecules (analogous to ATP molecules), which strongly suggests the existence of magnetic flux tubes parallel to them and carrying dark protons or possibly some other positive ions. Microtubules are highly dynamical in quantum critical phase. Could their varying negative charge control the membrane potential by generating opposite varying charge at MB outside cell membrane by Pollack effect (I have discussed anesthetes in several sections of [K33]). Could the transition to sleep be controlled by the microtubular level using a variant of the mechanism discussed as a tool?

Concerning the possible the source of metabolic energy, it is known that $GTP \to GDP$ cycle occurs [J20] (`https://tinyurl.com/yapdcotf`). Could this mechanism serve as an analog of $ATP \to ADP$ with metabolic energy stored in metabolites replaced with the metabolic energy carried by dark photons transforming to bio-photons?

5. What is interesting is that at the endogoneous magnetic field with value $B_{end} = .2$ Gauss assigned with monopole flux tube part of Earth's magnetic field with nominal value of $B_E = .5$ Gauss the cyclotron frequency of K^+ ion (and Cooper pair) is 7.5 Hz. Could dark Schumann resonance photons induce cyclotron transition of B-E condensate of K^+ Cooper pairs? A magnetic field oscillating frequency of with 7 Hz frequency not too far from the lowest Schumann resonance frequency and cyclotron frequency of K^+ ions appears also in the experiment of Montagnier *et al* [L24] strongly suggesting remote replication of DNA.

5 Many-Sheeted Neuron

TGD approach allows to make educated guesses concerning the interpretation of various phenomena in neuronal level. This section has been written much before the input from DNA as TQC and the realization that microtubule-cell membrane braids could serve as quantal sensory memory storage based on the braiding of the magnetic flux tubes emanating from the amino-acids of tubulin molecules. This implies obvious updatings of the text of this section left to the reader.

5.1 Neuronal Consciousness

The fractality of consciousness encourages the view that neurons and corresponding magnetic bodies are conscious organisms having receiving sensory input and forming sensory representations at their magnetic bodies, and generating motor actions. One can see associations at neuronal level as a process in which neuronal sub-self induces mental images inside the postsynaptic neuronal self. Neuron could be seen as a fractally scaled down version of a sensory pathway.

The sensory input of a neuron is determined by the inputs from active pre-synaptic neurons. Postsynaptic receptors are analogs of ordinary sensory receptors and they determine the sensory qualia and primary sensory mental images of the neuron about external world (also ordinary cells have sensory receptors and sensory representations but only about nearby environment). Microtubuli inside dendrites are the analogs of sensory pathways, and cell membrane and cell nucleus could play the role of the neuronal skin and brain. Both could give rise to sensory representations. Sensory representations at the magnetic body of nucleus could be generated by DNA or directly by the communications from cell membrane. Neurons would have sensory qualia and neuronal receptors and receptors at the surface of any cell could give rise to the analogs of tastes and smells. Cells could also see and hear at some wave length ranges and the micro-tubuli associated with the cilia span a length scale range containing visible frequencies.

The general model of how cell membrane acts as a sensory receptor [K14] allows to make this vision much more detailed and also allows to understand how the qualia experienced by us emerge.

1. DNA as topological quantum computer model plus certain simplifying assumption leads to the conclusion that the spectrum of net quantum numbers of quark antiquark pair define the primary qualia assignable to a nucleotide-lipid pair connected by a magnetic flux tube. The most general prediction is that the net quantum numbers of two quark pairs characterize the qualia. In the latter case the qualia would be assigned to a pair of receptor cells.

2. Composite qualia result when one allows the nucleotide-lipid pairs of the membrane to be characterized by a distribution of quark-antiquark pairs. Cell membrane -or at least the axonal parts of neurons- would define a sensory representation in which is a pair of this kind defines a pixel characterized by primary qualia. Cells would be sensory homunculi and DNA defines a sensory hologram of body of or of part of it. Among other things this would give a precise content to the notion of grandma cell.

3. Josephson frequencies of biologically important ions are in one-one correspondence with the qualia and Josephson radiation could re-generate the qualia or map them to different qualia in a one-one and synesthetic manner in the neurons of the sensory pathway. For large values of Planck constant Josephson frequencies are in EEG range so that a direct connection with EEG emerges and Josephson radiation indeed corresponds to both bio-photons and EEG. This would realize the notion of sensory pathway which originally seemed to me a highly non-realistic notion and led to the vision that sensory qualia can be realized only at the level of sensory organs in TGD framework.

4. At the level of brain motor action and sensory perception look like reversals of each other. In zero energy ontology motor action this analogy can be justified so that the model of sensory representations implies also a model for motor action. Magnetic body serves as a sensory canvas where cyclotron transitions induced by Josephson frequencies induce conscious sensory map entangling the points of the magnetic body with brain and body.

5.2 Functions Of Nerve Pulse

Nerve pulses inducing generalized motor action represent pushes and pulls in spin glass energy landscape of brain. These pushes and pulls induce motion in the spin glass landscape and generate somehow both neuronal and our emotions. Transmitters mediate nerve pulses from presynaptic neuron to postsynaptic neuron and modify the properties of the synapse and of the postsynaptic neuron. Fast neurotransmitters controlling directly ion channels are involved with the process and the relevant time scale is one millisecond. No long term change of the postsynaptic neuron is involved. Slow neurotransmitters involving second messenger action are involved with the modulation of the response of the postsynaptic neuron, and the time scales can be of order of minutes. In this case the properties of the postsynaptic neuron are changed. Emotional reactions involve typically slow transmitters and their effect can be regarded as a generalized motor action inducing motion of the neuron in the spin glass energy landscape of the neuron.

5.2.1 What the specialization of sensory pathways to sensory modalities means?

Sensory pathways are specialized to produce some specific sensory qualia. How this specialization correlates with what happens at the neuronal level?

1. If one accepts the notion of magnetic body, it is not too difficult to accept the idea that the magnetic bodies associated with the sensory organs are the seats of the sensory representations whereas higher levels of CNS are responsible for symbolic and cognitive representations accompanying sensory representations. TGD based view about long term memories makes it possible to defend this view against standard objections such as phantom limb phenomenon, projected pain, and the stimulation of sensory hallucinations electrically. One cannot exclude the possibility that even the sharing of mental images with the objects of external world contributes to the conscious experience.

2. An almost diametrically opposite view is that qualia are like colors of a map and coloring is decided at quite high level of sensory processing.

These views need not be mutually exclusive. Sensory qualia seated at sensory organs can serve as the colors of the map if sensory receptors and brain form single quantum system in which entanglement with and back projection to the structures defined by sensory receptors is essential. This back projection could transform the primary mental images. This view would also explain the rapid eye movements during REM sleep and oto-acoustic sounds.

In this picture association areas could be seen not as cognitive areas, where sensory input is transformed to cognitive output, but areas in which the mental images associated with various symbolic and cognitive pathways fuse to a single mental image. Therefore the term association would be somewhat misleading. A genuine association can be seen to result when a sub-self wakes up sub-self by nerve pulse patterns and is experienced by a higher level self as two subsequent mental images.

5.2.2 Could nerve pulse patterns realize the memetic code?

TGD based model of cognition allows to construct a model for memetic code in which sequences of 126 cognitive neutrino pairs of total duration of about .1 second correspond to Boolean statements or also integers in the range $\{1, 12^{126}\}$ in binary representation. The model for the physical realization of the memetic code is discussed in more detail in [K18] and here only the basic idea will be described.

The model for the memetic code assumes that antineutrinos resides in the strong Z^0 magnetic field associated with the cell membrane and having the direction of the axon. The antineutrinos have suffered spontaneous Z^0 magnetization. Memetic codons consisting of (almost) 127 bits are realized as temporal sequences of spontaneous Z^0 magnetization of antineutrinos at $k = 151$ cell membrane space-time sheet. The ground state with all bits in the direction of the Z^0 magnetic field does not represent consciously anything so that the number of representable bit sequences is $M_{127} = 2^{127} - 1$ which corresponds to almost 127 bits.

Memetic codons are generated by Z^0 magnetic pulses reversing the direction of local Z^0 magnetization. The magnetic transition frequency is energy difference for states $(n+1, up)$ and $(n, down)$ for cognitive antineutrinos of opposite spin in the strong Z^0 magnetic field of the axonal membrane. There is however a "miracle" involved. The magnetic transition frequencies of muonic and tau neutrinos for the transitions between states $(n + 1, up)$ and $(n, down)$, are in the range of ELF frequencies and that for the largest possible value of the axonal Z^0 magnetic field this frequency is slightly higher than the maximal frequency of nerve pulses. Hence the duration of nerve pulse implies automatically that it generates harmonic perturbation giving rise to spin flips of neutrinos [K18, K32].

The basic objections against the idea that nerve pulses generate memetic codons are following.

1. The minimum time interval between nerve pulses is slightly longer than required by memetic codon.

2. The prediction would be that high level linguistic cognition is everywhere in brain. Rather, higher level cognition should be associated with the neurons at multi-modal associative regions of cortex [K18] or with cognitive neural pathways leading to these areas. Only humans possess the parietal-occipital-temporal association region combining somatosensory-, visual- and auditory inputs into associations and giving meaning to the objects of the perceptive field. Perhaps the emergence of this associative region associating Boolean statements with sensory features has led to Homo Sapiens.

3. Ordinary nerve pulse patterns suggest strongly frequency coding rather than refined memetic code. In the case of memetic code it would mean roughly 64 nonequivalent codons. This in fact might be enough to understand the basic phonemes of language as expressions of memetic codons.

These arguments suggest that nerve pulse patterns give rise only to a frequency coding such that only the frequency of the bits differing from the standard value is of significance. The intensity of sensory input, motor output, and emotional expression could be coded in this manner. MEs can generate also oscillations of the membrane potential and it is known that this kind of oscillations accompany hearing. These oscillations could also induce reversal of Z^0 magnetization and could allow to realize memetic code in full complexity.

5.2.3 Generation of declarative long term memories at micro-tubular level

The TGD based model of declarative long term memories is based on the mirror mechanism with brain and body effectively serving as time like mirrors from which negative energy MEs are re-

flected as positive energy MEs. Long term memories would be coded to subjecto-temporal changes of the micro-tubular conformations [K20] which allow a huge number of almost degenerate configurations, and the transitions between these configurations generate MEs with ultra-low frequencies determined by the time span of the long term memory. The natural first guess is that the nerve pulse patterns accompanied by MEs are an essential part of the process of building long term memories by inducing the motion of the axonal micro-tubuli in the spin glass energy landscape. Nerve pulse could be also accompanied by a separate wave propagating along the axonal micro-tubuli and containing much more detailed information about the sensory input specifying the content of declarative long term memories. This would mean huge information storage capacity and also explain why the axonal lengths associated with the sensory pathways are maximized.

A model for the cognitive code associated with with micro-tubuli is discussed in [K26]. The model is based on $13 \times 13 = 169$ bits defined by single full turn for 13 helical tubulin strands consisting of 13 tubulins each. Since only the changes of tubulin conformations contribute to the micro-tubular conscious experience, only $2^{169}-1$ patterns code for conscious experiences. Therefore the code represent only 168 full bits and the remaining almost bit could define some kind of parity bit. The presence of a sufficiently strong external electric field along the micro-tubule would imply that the change of bit is replaced with a pattern of $b \to b+1 \to b$ transitions leading from the ground state to excited state and back to the ground state.

An interesting possibility is that micro-tubuli define a cognitive code above the memetic code in the hierarchy of cognitive codes so that biology would not reduce to neither genetic nor memetic code. The changes of the micro-tubular conformation patterns could be coded to 2^{126} memetic codons represented by field patterns associated with MEs. The $64 \to 21$ correspondence for DNAs and amino-acids would be generalized to $2^{169}-1 \to 2^{127}-1$ correspondence such that 168 full bits would be mapped to 126 full bits. The degeneracy would be $6log(2)/log(21) \simeq 1.39$ for the genetic code and $168/126 = 1.33$ for the micro-tubular code.

5.3 Functions Of Transmitters

It is an interesting challenge to try to understand the role of various information molecules, in particular neurotransmitters, in TGD inspired conceptual framework.

5.3.1 Information molecules as quantum links in quantum web?

One particular challenge is to find convincing "reason why's" for what happens in the synaptic contacts. Why myriads of neurotransmitters are needed: inhibition, excitation and neuro-modulation could indeed be carried out in much simpler manner?

1. Information transfer is certainly in question and a natural assumption is that the information is conscious quantum information. If so, it is not the transfer of the neurotransmitter molecules which is essential but the transfer of bound state entanglement of these molecules with the environment and thus of conscious information. This is in accordance with the computer metaphor: neurotransmitters would be like links to different pages in the web activated in the transfer process analogous to sending an email containing a list of links plus text. Also a transfer of usable energy could be involved: the positive energy MEs transferred could provide their energy to the postsynaptic cell unless they are used to energize the transfer process. Besides neural transmitters blood cells and various molecules transmitted by blood and lympha could be carriers of quantum links and hormonal action at the deeper level would be quantum communication in this sense.

2. When information molecules and receptors form a quantum bound state, macro-temporal quantum coherence is generated and this correspond at the level of conscious experience a multi-verse state of "one-ness" and from the point of information processing a quantum computation like process [K20]. One could also see information molecules and receptors as representative of opposite molecular sexes. The resulting non-entropic mental image corresponds to sensory qualia of the neuron analogous to smells and tastes. In principle, each neurotransmitter gives to a distinct neuronal taste or smell. Also neuronal analogs of vision and hearing are possible. Micro-tubuli indeed give rise to infrared vision in the case of bacterial cells.

3. This picture is consistent with the interpretation of neurotransmitter induced experiences as kind of chemical qualia analogous to tastes and odors and giving rise to emotions at our level of self hierarchy.

5.3.2 Excitation and inhibition

Excitation and inhibition are seen as basic functions of neurotransmitters. More precisely, the attribute excitatory/inhibitory can be assigned with a given transmitter-receptor combination. Gardener metaphor states that brain is a gardener allowing particular plants, now mental images having neural firing patterns as neurophysiological correlates, to flourish. One could argue that this kind of selection is reasonable in order to use metabolic resources optimally. One must be however very cautious here. Paradoxically, the metabolism during synchronous firing does not seem to increase [J35]. This finding has two mutually non-exclusive explanations.

a) Remote metabolism involving the generation of negative energy MEs received by glial cells serving as a storage of metabolic energy is involved.

b) Inhibition could require actually more energy than excitation: neural firing would occur spontaneously when the energy feed to the system is subcritical. At least for the inhibition caused by hyper-polarization this view might make sense. One can say that the gardener would actively prevent the growth of some plants. Inhibition would be censorship preventing a spontaneous generation of mental images in accordance with the vision of Huxley about brain as a filter which prevents conscious experience rather than creates it. The hypothesis that bio-control is quite generally based on this principle is attractive since it is easier to prevent a complex process to occur spontaneously than to force a complex process to occur in a desired manner.

Option b) would explain several paradoxical looking findings about the correlation of inhibition with the level of self control. The amount of inhibition increases and the behavior becomes more controlled and "civilized" as one climbs up in the evolutionary tree being highest for humans. Inhibition is higher for adults than for children as is also the level of self control. Inhibition is dramatically reduced during the process of physical death. In all these cases the reduced inhibition would naturally correlate with the reduction of the metabolic feed. Inhibition is also reduced during several altered states of consciousness and these states of consciousness involve also a high level of relaxation.

If the reduced inhibition means a reduction of energy feed, a depletion of energy resources is an unavoidable outcome. This leads to a spontaneous generation of negative energy MEs by starving neurons making possible remote entanglement and remote metabolism. In particular, synchronous neural firing would involve also remote metabolism so that option a) is not excluded by b). The generation of episodal long term memories and various kinds of remote mental interactions would be an automatic side product. The memory feats of synesthetics indeed correlate with a dramatic reduction of metabolism in left cortex; various remote mental interactions are reported to occur during altered states of consciousness; and there are reports about the association of telepathy, precognition and poltergeist type phenomena with the physical death of a close relative or intimate friend.

On the other hand, if inhibition means heightened metabolic energy feed, it also reduces the need to generate negative energy MEs. The reduction of entanglement with the environment means among other things fewer shared mental images. Therefore the increase of inhibition would be a correlate for the increasing privacy of conscious experience. Ironically, the physical well-being would more or less unavoidably lead to the alienation and unhappiness suffered by so many members of post-modern society.

5.4 Negentropic Entanglement And The Role Of Neurotransmitters

Soon after starting to develop TGD inspired theory of consciousness, I somehow ended up to an email correspondence with Gene Johnson who insistently emailed me links to abstracts about neuroscience. I read the classic Bible about brain by Kandel *et al* [J30] and tried to make sense of it in my own conceptual framework. This was of course hopeless task since I had only the notions of quantum jump and self. The feeling that something very simple -about which I do not and perhaps cannot ever have a slightest clue- must be behind this incredible complexity made the situation

really frustrating. The deeper meaning of EEG, nerve pulse neurotransmitters, hormones- actually of entire brain chemistry and also biochemistry- remained a total mystery.

5.4.1 Development of ideas

After the required number of years however some concrete ideas began to emerge.

1. The notion of magnetic body with fractal onion-like structure meant a decisive step of progress. Also the hierarchy of Planck constants and dark matter as controller of visible matter in living systems emerged. The function of EEG as communication and control tool of magnetic body using biological body as a motor instrument and sensory receptor looked very natural. This led also to a proposal that there is an entire hierarchy of EEGs and their variants. After several trials a vision about nerve pulses as concomitants of quantum level communications emerged as also a vision about DNA as topological quantum computer based on the flux tubes connecting DNA nucleotides with the lipid layers of cell membrane emerged and providing a function for the intronic portions of genome as carriers of quantum computer programs [K1].

2. Also a vision about the biochemical role of dark matter evolved. In particular, phase transitions reducing Planck constant for a magnetic flux tube would induce its contraction and force biomolecules near to each other. This would explain the miracles of DNA replication, translation, and transcription and quite generally the processes known as aggregation of proteins. The reconnection of magnetic flux tubes changing the topology of the biological Indra's net would be also a central mechanism.

3. The model of nerve pulse and the vision about living matter as a kind of dynamical Indra's net led to a first clear idea about the role of neural transmitters. Transmitters are classified to inhibitory or excitatory depending on whether they increase or reduce the magnitude of the membrane potential. This property is however a property of the receptor rather than that of the transmitter. The same transmitter can have both excitatory and inhibitory receptors although often either receptor type dominates. The proposal was that neural transmitters are associated with the ends of the links of the 4-dimensional web connecting neurons to each other. Neurotransmitter attaches to the plug defined by the receptor connecting the communication wire from presynaptic neuron to the flux tube leading to the passive portion of postsynpatic DNA strand acting as sensory receptor. This would make possible rapid communications to DNA. The corresponding active portion of DNA strand could then respond by generating an activity at the level of cell membrane. This conforms with the general idea that proteins represent only one particular outcome of the gene expression. This left open the question whether the excitatory-inhibitory dichotomy could have some deeper meaning.

4. Also it became clear the emotions and information are closely related and that peptides acting both as neurotransmitters and hormones are crucial for emotions [J15]. I proposed that emotions are "entropic" qualia. Although I realized the importance of negentropic entanglement I did not have time or I was not able to realize how far reaching this notion actually is.

5.4.2 Is genome a fractal counterpart of brain?

Fractality replaces standard reductionism in TGD Universe. An old idea inspired by p-adic length scale hypothesis is that the binary structures associated with p-adic scales $L(k) \propto 2^{k/2}$ and $L(k+2)$ define a fractal hierarchy. Brain hemispheres would represent one example of this kind of pair, lipid layers ofe cell membrane second one, and DNA double strand third one. Just for fun one could assume that the structure and functions of brain hemispheres have fractal analogs at the level of DNA double strand and vice versa and look what kind of questions this inspires.

1. Could the identical structures of DNA strands correspond to the anatomical similarity of right and left brain and could the functional asymmetry of the strands correspond to the laterizalization of brain function? Could the genome act as the brain of cell? Could various brain areas have counterparts at the level of DNA? Could the hydrogen bonds between

nucleotides serve as the counterpart of corpus callosum? Could the splitting of these bonds during transcription and replication correspond to what happens to a split brain patient?

2. Before continuing it must be made clear that the global identification of right-left dichotomy with holistic-reductionistic dichotomy is wrong. One can however consider its local variant with holism and reductionism assigned do the pairs of right and left brain areas. For instance, in contrast to the naïve rule the emotional right (left) brain (amygdala) would be reductionistic (holistic, negentropic) whereas the intellectual right (left) would be holistic (reductionistic, entropic). The practical reason to the division to the entropic and negentropic pieces could relate to the metabolism. The entropic regions could provide the binding energy as a usable energy to the positive energy negentropic entanglement. Good is not possible without Evil! There are no winners without losers! One must be however very cautios in making conclusions since second law might break down for dark matter.

   Right brain is specialized in spatial thinking and left brain to verbal thinking and arithmetics: the geometry-algebra division of mathematics! Right brain is not so good in motor actions as left brain as any right-handed person knows. Right brain is however better in tactile sensing: right handed persons tend to use left hand for touching objects to get an idea about their shape. Also this can be understood in holistic-reductionistic picture.

3. Apart from reflex actions almost all activities of the body seem to be controlled to a high degree by brain. Could also the activitities of cell be regarded as motor actions of the genome acting as the brain of cell receiving sensory imput from the cell membrane? Could one identify the analogs of sensory areas receiving information from cell membrane, processing, and sending it to the association areas? Could the analogs associative areas be identified as intronic portions of DNA performing topological quantum computations and communicating the outcome to the higher motor areas at the intronic portions of the of the complementary strand, wherefrom they would be communicated to the primary motor areas identifiable as the regions of DNA expressing themselves either chemically (RNA and proteins), as activities generated directly at the level of cell membrane, or electromagnetically? For instance, could neurotransmitter in the receptor generate the feed of sensory input to the genome inducing the change of the membrane potential as the counterpart of motor action. Could prokaryotes without introns be analogous to brain with only primary sensory and motor areas or to mere ladder-like nervous system?

   One could argue that the analogy between DNA are brain fails because second DNA strand is completely passive whereas both brain hemispheres express themselves via motor actions. This is not the case! Both DNA strand has regions expressing themselves but the transcription takes place in opposite directions. Hence DNA strands have motor and sensory areas as also brain does, and the natural guess is that primary motor areas correspond to the areas expressing themselves in terms of RNA, proteins, and possibly also as actions at the level of cell membrane. Primary sensory areas would correspond to to regions complementary to the primary motor regions.

4. What right brain sings-left brain talks metaphor could mean in this picture? Pitch-rhythm dichotomy is more technical expression for this dichotomy. Function providing local data and its Fourier transform providing global data is more abstract representation for this dichotomy and Uncertainty Principle for momentum and position relates closely to these two representations of information. This dichotomy could reflect the presence of two different natural time scales and millisecond time scale for nerve pulses and.1 second time scale for moments of sensory experience are the natural candidates.

   If so, this dichotomy could directly reflect the different time scales assignable to u and d type quarks (1 millisecond) and to electron (100 ms) and reduce to the level of elementary particle physics. This dichotomy would also have fractally scaled up variants made possible by the hierarchy of Planck constants. The analog of Fourier transform would be the negentropic un-entanglement of sub-CDs (assignable to quarks) to single mental image inside electron's CD. The analog of function itself would be a collection of sub-CDs representing separate unentangled mental images assignable to individual nerge pulses in millisecond time scale. Also the topological quantum computations assigned to the intronic portions correspond to

different time scales due and reflect quark-lepton dichotomy. The quarks in question could be the quarks assigned to the ends of flux tubes in the model of DNA as topological quantum computer.

5. This raises some questions. Could the gene expressions of the two strands somehow reflect this dichotomy? For instance, could the flux tube structures assignable to the amino-acid sequences correspond to the millisecond and 100 ms scales assignable to quarks and electron have the property that also the functioning of these proteins is characterized by these typical time scales? According to [I19] the time scales of protein folding vary from.1 s to 10^3s. According to Wikipedia [I4] the typical time scale is 1 millisecond which suggests that the time scales correspond to two ranges beginning from ms and 100 ms respectively. There are also short proteins for which the folding takes place in microsecond time scales which might relate to the CD of proton.

5.4.3 What can one say about the function of neurotransmitters?

Can one say anything interesting about the function of neurotransmitters if one combines this highly speculative picture- which can be defended only by the belief on fractality as universal principle- with the idea that bound state and negentropic entanglement make possible the fusion of mental images.

1. Suppose that the fusion of neuronal mental images is required to build higher level mental images that we experience. Suppose that neuronal mental images involve DNA in an essential manner. Suppose that magnetic flux tubes serve as correlates for the entanglement so that the transmission of nerve pulse from pre-synaptic neuron to post-synaptic one creates a flux tube connection between neurons possibly extending to the genome of the post-synaptic neuron. The transmitter at the end of flux tube attached to the receptor acting as a plug would build this connection to some part of DNA specialized to receive particular kind of sensory data from a particular region of cell membrane with complementary strand activating as a response a motor function inducing gene expression at cell membrane level. Gene expression as build-up of proteins would not be necessary and is also too slow for neural activities.

2. Suppose that the entanglement between neurons generated in this process is always negentropic as the interpretation as the idea about neural correlate for a conscious association suggests. One could also ask whether the neurons could entangled entropically and whether the entropic-inhibitory association could make sense. This does not lead to anything interesting and entropic entanglement between neurons should be regarded as a pathological condition. Note that neuron-neuron entanglement would be naturally time-like and in this case only negentropic entanglement might be meaningful.

   (a) To gain some perspective consider the activation of cell in general by some external perturbation from the resting state to the active state (here I have learned a lot from email correspondence with Vladimir Mateev) In the resting state the proteins inside cell are passive -or rather, forced to be passive- as one might expect on basis of the general vision about homeostasis. The unfolded proteins and unfolded portions of the folded proteins are connected by hydrogen bonds to ordered water so that the folding occurring otherwise spontaneously is prevented. One can say that the cellular winter prevails. The situation is however nearly critical and if external perturbation occurs cell liberates metabolic energy melting the ice and spring comes. Also the outer surfaces of globular proteins are hydrogen bonded and when the ordered water melts, spontaneous melting of the protein takes place leading to a partial unfolding.

   The resulting folded proteins and partially unfolded globular proteins interact by forming aggregates and this activity would naturally involve $\hbar$ reducing phase transitions and flux tube reconnections. In TGD based model the mechanism of both folding and melting would be the liberation of metabolic energy destroying the hydrogen bonds and the energy for this comes from the ATP containing positive energy negentropic bond between O=s of phosphates.

(b) Similar situation could prevail at the cell membrane. One can imagine that cell membrane is like a particle at the bottom of a small potential well. At the other side there is a deep well representing the generation of nerve pulse and at the other side a high wall corresponding to hyper-polarization requiring energy. Both polarization and hyper-polarization are prevented by the freezing of protein activities needed to induce them. The flux tubes connecting the presynaptic neuron and receptor and possibly genome are always negentropic and their formation can as such serve as the signal leading to the partial melting of the ordered water making possible to generate action leading to either de-polarization or hyper-polarization. The signal could be just the additional metabolic energy making it possible for these transitions to occur.

(c) This picture does not require any communications from the receptor to the genome and in the simplest situation the resulting action could be seen as the analog of reflex action. These communications could of course be present and the negentropic entanglement could make it easier to induce de-polarization also now. Also the question whether excitatory-inhibitory dichotomy for the receptors has some deeper meaning apart from taking the neuron nearer to or farther from criticality for firing remains unanswered.

6 Relating The Model Of Nerve Pulse With The Micro-Tubular Level

The relationship of the presumed quantum dynamics of the cell interior to the nerve pulse is the basic topic of quantum consciousness theories. Micro-tubular conformational dynamics; gel-sol phase transition of the cytoplasmic water inducing the de-polymerization of the actin polymers; the parallelization of micro-tubuli possibly making possible a coherent generation of infrared em radiation; and Mg^{+2} and Ca^{+2} ions as controllers of polymer stability, are some of the most important pieces of the jigsaw. The hierarchical model of Alex Kaivarainen emphasizing these aspects provided crucial pieces of information [J12] allowing to construct many-sheeted view about this process. The hierarchy of condensed matter excitations introduced by Kaivarainen corresponds in TGD framework to the hierarchy of space-time sheets whereas the molecular Bose-Einstein condensates of Kaivarainen correspond to BE condensates of various bosonic ions and Cooper pairs at various cold space-time sheets. The classical article of Nanopoulos summarizing basic facts and various ideas about micro-tubuli [J17] has been a continual source of information and inspiration and is warmly recommended.

One important element are negative energy IR MEs having phase conjugate laser beams [D3] as physical counterparts. First of all, they make possible intentional action at the micro-tubular level: even the TGD based model of mRNA-protein translation involves intentional aspects. Negative energy MEs are crucial for the understanding of the macro-temporal quantum coherence and have inspired the notions of remote metabolism and quantum credit card. The notion also leads to what might be called seesaw mechanism of energy metabolism, and allows to understand how micro-tubular surfaces provide dynamical records for the cellular sol-gel transitions and thus define fundamental micro-tubular representation of declarative long term memories.

The vision about dark matter hierarchy brings in perhaps the most decisive new elements.

1. Dark matter hierarchy leads to the identification of big leaps of evolution in terms of the emergence of new levels of dark matter hierarchy. Magnetic bodies are the intentional agents in this picture and it is possible to understand the control of logistics and declarative memory as basic functions associated with micro-tubules.

2. Synchronous neuron firing involves parallelization of microtubules. This coherent action can be understood in terms of macroscopic quantum coherence realized in terms of super-genes and the more general notion of multi-neuron with neurons organized to linear structures analogous to the lines of text on the pages of book defined by magnetic flux sheets.

3. Ca^{+2} and Mg^{+2} ions are known to be important for the de-polymerization of microtubules and actin molecules occurring during nerve pulse. This conforms with the central role of the Bose-Einstein condensates of dark bosonic ions Ca^{+2} and Mg^{+2} and their exotically

ionized counterparts in the generation of pulse in the proposed model, and more generally, in quantum bio-control based on charge entanglement between cell and magnetic body.

4. The ordered water associated with gel phase was earlier modelled in terms of dropping of protons to $k = 139$ space-time sheets. In the new framework this phase can be identified as a partially dark water. The response of cells to IR radiation is maximal at photon energy.1 eV. What makes bells ringing is that the model of high T_c conductivity based on dark matter hierarchy leads to the identification of the cell membrane as a Josephson junction generating ordinary IR photons with energy $2eV = .1$ eV at the membrane potential corresponding to threshold for nerve pulse generation kicking protons to $k = 139$ space-time sheet associated with ordered water.

   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 only the "dropping" option is discussed.

This section was written much before the breakthrough induced by the model of DNA as TQC and the inspiration coming from the model of nerve pulse as acoustic soliton by Danish researchers [J27]. Hence a lot is lacking and the contents of section are not necessarily completely consistent with the new vision. For instance, the phase transitions changing the value of $\hbar$ and TQC using 4-colored braids provide a general explanation for the selectivity of the catalytic action [K1]. I have however decided to leave the section as it is.

6.1 Dark Matter Hierarchy And Big Leaps In Evolution

Dark matter hierarchy leads to an amazingly concrete picture about evolutionary hierarchy allowing to identify the counterparts for concepts like mineral, plant, and animal kingdom that we learned during schooldays and ceased to take seriously as students of theoretical physics as we learned that other sciences are just taxonomy. Even more, a view about what distinguishes between prokaryotes, eukaryotes, animal cells, neurons, EEG, and even about what makes cultural evolution, becomes possible. This view is also very useful when one tries to understand the role of microtubules.

The appearance of CDs scaled up in size by $r = \hbar/\hbar_0$ and space-time sheets scaled up in size by $\sqrt{r}$ means the emergence of new levels of structure and it is natural to identify big leaps in evolution in terms of emergence of new larger matter carrying space-time sheet magnetic flux sheets and corresponding magnetic bodies. If magnetic flux quanta are scaled by r magnetic flux quantization conditions remain unaffected if magnetic field strengths scale down by $1/r$ so that the energies of cyclotron photons are not affected. The thickness of flux tubes can remain unchanged if the currents running at the boundaries of the flux quantum cancel the magnetic flux. As already found, this mechanism must be at work inside living organisms whereas in far away region flux quanta are scaled up in size.

The attractive hypothesis is that the leaps in evolution correspond to the emergence of dark variants of weak and possibly also color interactions in dark p-adic length scales which correspond to ordinary p-adic length scales characterized by Mersenne primes. These leaps would be quantum leaps but in different sense as thought usually. The emergence of higher dark matter levels would basically mean the integration of existing structures to larger structures. A good metaphor are text lines at the pages of book formed by magnetic flux sheets whose width is scaled up by r as the new level of dark matter hierarchy emerges. The big leaps can occur both at the level of organism and population and organisms with rather low individual dark matter level can form societies with high dark matter levels and high collective intelligence (honeybees and ants are good example in this respect).

Certainly also other scalings of Planck constant than those summarized in tables are possible but these scalings are of primary interest. This intuition is supported by the observation that electron is completely exceptional in this framework. Electron's dark p-adic length scales corresponds to

p-adic length scales $L(k)$, $k = 167, 169$, assignable to atomic and molecular physics and to the Gaussian Mersennes $M_{G,k} = (1+i)^k - 1$, $k \in \{151, 157, 163, 167\}$, assignable to the length scale range between cell membrane thickness 10 nm and nucleus size 2.58 μm. The corresponding p-adic length scales, the number of which is 23, are excellent candidates for the scales of basic building bricks of living matter and vary from electron's p-adic length scale up to 1.25 m ($k = 167$ defining the largest Gaussian Mersenne in cell length scale range) and defining the size scale of human body. The corresponding p-adic time scales are also highly interesting and vary from.1 seconds for electron defining the fundamental biorhythm to 9.6×10^{14} years which is by 4-5 orders longer than the age of the observed Universe. For $k = 167$ the time scale is 1.1×10^{11} years and is by one order of magnitude longer than the age of the observed Universe estimated to be 1.37×10^{10} years [E1].

This conceptual framework gives rather strong guidelines for the identification of the levels of evolutionary hierarchy in terms of dark matter hierarchy. The outcome is a more detailed vision about big evolutionary leaps. Note that in the sequel only the general option is considered: the justification for this is that for this option electron appears as a dark particle for all length scales defined by Gaussian Mersennes as well as in atomic length scales. The basic vision in nutshell is that evolution means the emergence of dark weak and gluonic physics in both dark and ordinary length scales and that the size scales of the basic biostructures correspond to Mersenne primes and their Gaussian variants.

6.1.1 A sketch about basic steps in evolution

The vision about evolution depends on what one assumes about the initial state.

1. If one assumes that weak bosons with ordinary value of Planck constant were present in the beginning, evolution would mean a steady growth of k_d. Note that the hypothesis is $h_{eff} = nh$, where n is product of distinct Fermat primes and power 2^{k_d}. The problem is that small values of $k_d = k_1 - k_2$ correspond to the Gaussian Mersennes defining cellular length scales. If these exotic weak physics were present from the beginning, large parity breaking in cellular length scales would have been present all the time.

2. An alternative and perhaps more realistic view is that the evolution means the emergence of exotic weak physics corresponding almost vacuum extremals in increasingly longer length scales. A possible mechanism could have been the induction of exotic $\hbar_0$ variant of weak physics at the nearest Mersenne length scale k_{next} by the dark variant of weak physics at level k so that one would have $k_d = k_{next} - k$. The simplest induction sequence would have been $89 \to 107 \to 113 \to 127 \to 151 \to 157 \to 163 \to 167$ corresponding to $k_d \in \{18, 6, 14, 24, 6, 6, 4\}$. A possible interpretation of exotic $\hbar_0$ physics is in terms of almost vacuum extremals and non-standard value of Weinberg angle: also weak bosons of this physics would be light. This sequence defines the minimal values for k_d but also larger values of k_d are possible and would correspond to steps between neighbours which are not nearest ones.

The following sketch about the basic steps of evolution relies on the latter option.

1. Elementary particle level

Magnetic bodies with size scale defined by the sizes of CDs assignable to quarks and leptons and possibly also weak bosons (already now the size of big neuron emerges) corresponds to the lowest level of hierarchy with the sizes of the basic material structures corresponding to the Compton lengths of elementary particles. The fundamental bio-rhythms corresponding to frequencies 10, 160, and 1280 Hz appear already at this level in zero energy ontology which suggests that elementary particles play a central and hitherto unknown role in the functioning of living matter.

2. $89 \to 107$ *step with* $k_d = 18$

The first step would have been the emergence of $k_{eff} = 107$ weak bosons inducing $\hbar_0$ weak physics in $k = 107$ length scale characterizing also ordinary hadrons. This in turn would have led to the emergence of exotic nucleons possibly corresponding to almost vacuum extremals. The reduction of the model for the vertebrate genetic code to dark hadron physics [K36] is one of the most unexpected predictions of quantum TGD and assumes the existence of exotic- possibly dark- nucleons whose states with a given charge correspond to DNA, RNA, mRNA, and tRNA.

The $\hbar_0$ variants of these nucleons would interact via weak bosons with hadronic mass scale. The exotic variants of the ordinary $k = 113$ nuclei would correspond to the nuclear strings consisting of exotic nucleons [K12, K36] and define nuclear counterparts for DNA sequences. Their dark counterparts could define counterparts of DNA sequences in atomic physics length scales. Therefore a justification for the previous observation that genetic code could be realized at the level of hadron physics and that chemical realization would be higher level realization finds justification. The anomalous properties of water could be also partly due to the presence of dark nucleons and the proposal was that the presence of exotic nuclei is involved with water memory [K19]. The possible existence of the analog of DNA-RNA transcription between ordinary DNA and its nuclear counterpart would have dramatic implications. For instance, one can imagine a mechanism of homeopathy based on this kind of transcription process which would also allow a modification of genome by using dark nuclei to communicate the DNA sequences through the cell membrane to the target nuclei.

3. $107 \to 113$ *step with* $k_d = 6$

The next step would have been the emergence of $k_{eff} = 113$ weak bosons inducing $\hbar_0$ weak physics in $k = 113$ length scale characterizing also ordinary hadrons. Exotic variants of the ordinary nuclei possibly corresponding to almost vacuum extremals could have emerged interacting weakly (or actually relatively strongly!) via the exchange of weak bosons with mass scale of order 100 MeV. Also dark variants of the exotic $k = 107$ nucleons could have have emerged and formed exotic nuclei of size scale $k = 119$.

4. $113 \to 127$ *step with* $k_d = 14$

At this step weak bosons in electron mass scale would have emerged. Whether these weak bosons could have induced large parity breakings in atomic and molecular length scales is not clear. Viruses, which do not yet possess cell membrane could correspond to this level of hierarchy.

5. $127 \to 151$ *step with* $k_d = 24$

This step would have been fundamental since weak bosons in cell membrane length scale would have appeared. Note that by $113 - 89 = 24$ this step also leads from $k = 89$ weak bosons to $k = 113$ weak bosons. The weak bosons assignal to $k = 151$ could correspond to the weak interactions associated with almost vacuum extremals and $sin^2(\theta_W) = .0295$ could correspond to the weak physics in question.

$k_d = 24$ step for $k = 113$ $\hbar_0$ weak bosons would have produced them in $k_{eff} = 137$ atomic length scale with $L(137) \simeq .78$ Angstrom This could have naturally led to large parity breaking effects and chiral selection.

Dark $k_{eff} = 151$ electrons appearing in the TGD inspired model of high T_c super-conductivity would have been a by-product of this step. Whether dark electrons could have transformed to light $\hbar_0$ electrons (of mass.25 keV) with a common mass scale of order 10^2 eV with exotic weak bosons is an interesting question. The model of high T_c super-conductivity predicts the presence of structures analogous to cell membrane. This would suggest that cell membranes emerged and chiral selection emerged at this step so that one could not distinguish the emergence of molecular life as a precedessor for the emergence of cell membrane like structures. This would conform with the fact that DNA molecules are stable only inside cell nucleus. Note that for $k_{eff} = 151$ electron's CD has time scale $2^{24} \times .1$ seconds -that is 19.419 days (day=24 hours).

The smallest nanobes [I2] appearing in rocks have size 20 nm and could have emerged at this step. The size of the viruses [I5] is between 10-300 nm covers the entire range of length scales assignable to Gaussian Mersennes, which suggests that smallest viruses could have emerged at this step. Also the smallest [I1] [I1], which by definition have size smaller than 300 nm could have appeared at this stage.

6. The remaining steps

The remaining steps $k = 151 \to 157 \to 163 \to 167$ could relate to the emergence of coiling structure DNA and other structures inside cell nucleus. $k = 167$ would correspond to $k_d = 167 - 89 = 68$ to be compared with the value $k_d = 47$ required by 5 Hz Josephson frequency for the neuronal membrane for -70 mV resting potential. Note that $k_d = 48$ (state 1-2 of deep sleep) corresponds to $k = 163$.

By their smallness also double and triple steps defined by $k_d = k_{i+n} - k_i$, $n > 1$, are expected to be probable. As a consequence, electrons can appear as dark electrons at all the Gaussian Mersenne levels. At these steps the dark electrons corresponding to primes $k_{eff} = 137, 139$ would appear. For $k = 137$ dark electron appears with CD time scale equal to 128 seconds- rather precisely two minutes. The model for EEG suggests that the exotic weak bosons appear in the scales $k_{eff} = 136, 137, 138$.

Further multisteps from the lower levels of hierarchy would give structures with size scales above the size of cell nucleus possibly assignable to organs and structural units of brain. The dark levels assignable to electron are expected to be of special interest. It is encouraging that the longest scale assignable to electron in this manner corresponds to $k = 205$ and length scale of 1.28 m defining body size. As a consequence dark electrons are predicted at levels $k = 137, 139, 141, 143, 145, 147$ coming as octaves.

Prokaryotic cells (bacteria, archea) without cell nucleus for which cell membrane is responsible for metabolic functions and genome is scattered around the cell could have emerged at this step. This would mean that the emergence of the cell membrane thickness as a fundamental scale is not enough: also the size scale of membrane must appear as p-adic length scale. The sizes of most prokaryotes vary between 1 μm and 10 μm: the lower bound would require $k = 163$. There also prokaryotes with sizes between.2 μm ($k = 157$ corresponds to.08 μm) and 750 μm. Cell nuclei, mitochondria, and other membrane bounded cell nuclei would have evolved from prokaryotes in this framework. The sizes of eukaryote cells are above 10 μm and the fact that multicellular organisms are in question strongly suggests that the higher multisteps giving rise to weak bosons and dark electrons in length scales above $L(167)$ are responsible for multi-cellular structures.

This scenario leaves a lot of questions unanswered. In particular, one should understand in more detail the weak physics at various length scales as well as various exotic nuclear physics defined by dark nucleons and dark variants of nuclei.

6.1.2 Division of the evolution to that of biological body and magnetic body

Electron's Mersenne prime M_{127} is the highest Mersenne prime, which does not correspond to a completely super-astrophysical p-adic length scale. In the case of Gaussian Mersennes $M_{G,k}$ one has besides those defined by k in $\{113, 151, 157, 163, 167, \}$ also the ones defined by k in $\{239, 241, 283, 353, 367, 379, \ 457, 997\}$ [A1]. The appropriately extended model for evolution allows to distinguish between three kinds of values of k_{eff}.

1. The values of k_{eff} for which electron can appear as dark particle and thus satisfying $k_{eff} \leq 205$ (Table 5). These levels would correspond to structures with size below 1.25 m defined roughly by human body size and it is natural to assign the evolution of super-nuclear structures to the levels $167 < k_{eff} \leq 205$.

2. The values of of k_{eff} for which dark gauge bosons are possible in the model. This gives the condition $k_{eff} \leq 235$. These levels correspond to structures in the range 1.25 m-40 km. The identification as parts of the magnetic body can be considered.

3. The values of k_{eff} obtained by adding to the system also the Gaussian Mersenne pair $k \in \{239, 241\}$ allowing also the dark electrons. The lower size scale for these structures is 640 km.

4. The higher levels corresponding to k_{eff} in $\{283, 353, 367, ...\}$. The lower size scale for these structures is 3 AU (AU is the distance from Earth to Sun).

$k_{eff} > 205$ levels would correspond to the emergence of structures having typically size larger than that of the biological body and not directly visible as biological evolution. This evolution could be hidden neuronal evolution meaning the emergence of extremely low Josephson frequencies of the neurons modulating higher frequency patterns and being also responsible for the communication of long term memories.

6.1.3 Biological evolution

In principle the proposed model allowing multisteps between hierarchy levels defined by Mersenne primes and their Gaussian counterparts could explain the size scales of the basic structures below the size scale 1.25 m identified in terms of the $k_{eff} \leq 205$ levels of the hierarchy.

1. The emergence of cells having organelles

The appearance of the structures with $k_{eff} > 167$ (possibly idetifiable as magnetic body parts) should correlate with the emergence of simple eukaryotic cells and organisms, in particular plant cells for which size is larger than 10 μm, which could correspond to $k_{eff} = 171$ for electron and dark variants of weak gauge bosons. $k_{eff} = 177$ is the next dark electron level and corresponds to 80 μm scale. It seems natural to assume that these dark weak bosons do not transform to their $\hbar_0$ counterparts at these space-time sheets.

Cell nucleus would be the brain of the cell, mitochondria would be the energy plant, and centrioles generating microtubules would define the logistic system. Also other organelles such as Golgi apparatus, ribosomes, lysosomes, endoplasmic reticulum, and vacuoles would be present. These organelles would live in symbiosis by topologically condensing to $k_{eff} \geq 171$ magnetic body controlling their collective behavior. Centrosomes associated with animal cells would not be present yet but microtubule organizing centers would already be there.

The recent observations show that centrioles are not always in the characteristic T shaped conformation. Daughter centrioles resulting during the replication of mother centriole use first ours of their lifetime to roam around the cell before becoming mature to replicate. A possible interpretation is that they are also life forms and that magnetic body utilizes daughter centrioles to perform some control functions crucial for the future development of the cell. For instance, centrioles visit the place where axonal growth in neurons starts.

Cytoskeleton would act as a counterpart of a central nervous system besides being responsible for various logistic functions such as transfer of proteins along microtobuli. Centrioles give also rise to basal bodies and corresponding cilia/flagella used by simple cells to move or control movement of air or liquid past them. Centriole pair would be also used by the magnetic body to control cell division.

The logistic functions are the most obvious functions of microtubules. Magnetic body would control cell membrane via signals sent through the cell nucleus and communicated to the cell membrane along microtubuli. Basal bodies below the cell membrane and corresponding cilia/flagella would serve as motor organs making possible cell motion. Tubulin conformations representing bits would allow microtubule surface to represent the instructions of the magnetic body communicated via via cell nucleus to various proteins moving along the microtubular surface so that they could perform their functions.

TGD based view about long memory recall as communication with geometric past allows also the realization of cellular declarative memories in terms of the conformational patterns. Memory recall corresponds to a communication with geometric past using phase conjugate bosons with negative energies reflected back as positive energy bosons and thus representing an "image" of microtubular conformation just like ordinary reflected light represents ordinary physical object. There would be no need for a static memory storage which in TGD framework would mean taking again and again a new copy of the same file.

Receptor proteins would communicate cell level sensory input to the magnetic body via MEs parallel to magnetic flux tubes connecting them to the magnetic body. We ourselves would be in an abstract sense fractally scaled up counterparts of receptor proteins and associated with dark matter iono-lito Josephson junction connecting the parts of magnetosphere below litosphere and above magnetosphere. The communication would be based on Josephson radiation consisting of photons, weak bosons, and gluons defining the counterpart of EEG associated with the level of the dark matter hierarchy in question.

3. The emergence of organs and animals

The emergence of magnetic bodies with k_{eff} in the range $(177, 181, 183, 187, 189, 195, 201, 205)$ allowing both dark electron and weak bosons could accompany the emergence of multicellular animals. Magnetic body at this level could give rise to super-genome making possible genetic coding of organs not yet possessed by plant cells separated by walls from each other. The super

structures formed from centrosomes and corresponding microtubuli make possible complex patterns of motion requiring quantum coherence in the scale of organs as well as memories about them at the level of organs.

4. The emergence of nervous system

k_{eff} in the range $(187, 189, 195, 201, 205)$ allowing dark electrons and weak bosons gives size scales $(.25, .5, 4, 32, 128)$ cm, which could correspond to the scales of basic units of central nervous system. What would be of special interest would be the possibility of charged entanglement based on classical W fields in macroscopic length scales. The emergence of the new level means also the integration of axonal microtobuli to "text lines" at the magnetic flux sheets making possible logistic control at the multineuronal level. The conformational patterns of the microtubular surface would code nerve pulse patterns to bit patterns representing declarative long term memories. An interesting question is whether the reverse coding occurs during memory recall.

6.1.4 The evolution of magnetic body

For mammals with body size below 1.25 m the levels $k_{eff} > 205$ cannot correspond to biological body and the identification in terms of magnetic body is suggestive. The identification of EEG in terms of Josephson frequencies suggests the assignment of EEG with these levels.

1. The emergence of EEG

EEG in the standard sense of the word is possessed only by vertebrates and one should understand why this is the case. The value of Josephson frequency equal to 5 Hz requires only $k_d = 47$ so that something else must be involved. A possible explanation in the framework of the proposed model comes from the following observations.

1. Besides the maximal p-adic scale $k = 205$ for which electron and weak bosons appears as dark variants the model allows also levels at which only gauge bosons appear as dark particles. From Table 9 one finds that levels $k \in \{207, 211, 213, 217, 219, 221, 223, 225, 229, 235\}$ are allowed. Could it be that these levels and possibly some highest levels containing both electrons and gauge bosons as dark particles are a prerequisite for EEG as we define it. Its variants at higher frequency scales would be present also for invertebrates. The lowest Josephson frequency coded by the largest value of $\hbar$ in the cell membrane system determins the Josephson frequency.

2. The membrane potentials -55 mV (criticality against firing) correspond to ionic Josephson energies somewhat above 2 eV energy ((2.20, 2.74, 3.07, 2.31) eV, see **Table 4**). For 2 eV the wavelength 620 nm is near to $L(163) = 640$ nm. Therefore the Josephson energies of ions can correspond to the p-adic length scale $k = 163$ if one assumes that a given p-adic mass scale corresponds to masses half octave above the p-adic mass scale so that the opposite would hold true at space-time level by Uncertainty Principle. Josephson frequencies $f_J \in \{5, 10, 20, 40, 80, 160\}$ Hz correspond to $k_d \in \{47, 46, 45, 44, 43, 42\}$ giving $k_{eff} \in \{210, 209, 208, 207, 206, 205\}$.

   (a) Cerebellar resonance frequency 160 Hz would correspond to $k = 205$ -the highest level for for which model allows dark electrons (also 200 Hz resonance frequency can be understood since several ions are involved and membrane potential can vary).

   (b) The 80 Hz resonance frequency of retina would correspond to $k_{eff} = 206$ -for this level dark electrons would not be present anymore.

   (c) 40 Hz thalamocortical frequency would correspond to $k_{eff} = 207$.

   (d) For EKG frequencies are EEG frequencies below 20 Hz 12.5 and heart beat corresponds to .6-1.2 second cycle (the average.8 s corresponds to $k_{eff} = 212$).

3. Even values of k_{eff} are not predicted by the model based on Mersenne primes allowing only odd values of k_{eff} so that the model does not seem to be the whole truth. The conclusion which however suggests itself strongly is that EEG and its variants identified as something in the range 1-100 Hz, are associated with the levels in at which only dark weak bosons are possible in the proposed model. Note that the size scales involved with EEG would be

k_d	f_1/Hz	f_2/Hz	f_3/Hz
0	707	1000	1412
4	177	250	354
6	89	1250	177
10	22.1	31.3	44.2
12	11.1	15.6	22.1
14	5.5	7.8	11.1
16	2.8	3.9	5.5
18	1.4	2.0	2.8
20	0.7	1.0	1.4
24	0.2	0.2	0.3

Table 4: The Compton frequencies obtained by scaling $2^{k_d/2}$ from the basic triplet $k_{eff} = (239, 240, 241)$. The values of k_d correspond to those predicted by the model based on Mersenne primes.

above the size scale of human body so that we would have some kind of continuation of the biological body to be distinguished from the magnetic body. The time scales assignable to the dark CDs would be huge: for instance, $k = 205$ would correspond to $T = 2^{42} \times .1$s making about 1395 years for electron.

2. Does magnetic body correspond to the space-time sheets carrying dark weak bosons?

The layers of the magnetic body relevant for EEG have have size of order Earth size. Natural time scale for the moment of sensory consciousness is measured as a fraction of second and the basic building blocks of our sensory experience corresponds to a fundamental period of.1 seconds. This scale appears already at $\hbar_0$ level for electron CD. The natural question concerns the relationship of the magnetic body to the $k > 205$ space-time sheets carrying only gauge bosons in the model and having size scale larger than that of biological body. Do they correspond to an extension of biological body or should they be regarded as parts of the magnetic body? The following observations suggest that they could correspond to layers of the magnetic body responsible for the fractal variant of EEG.

1. The primary p-adic time scales (Compton times) $T(239)$ and $T(241)$ correspond to frequencies, which are $2^{\pm 1/2}$ kHz. The geometric average $k = 240$ corresponds to kHz frequency. Is the appearance of kHz scale a mere accident or do the frequencies assignable to the quark CDs correspond to Compton times $\propto \sqrt{2^{k_{eff}/2}}$?

2. One can apply scalings by 2^{k_d} to the triplet $(239, 240, 241)$ to get a triplet $(239 + k_d, 240 + k_d, 241 + k_d)$. The results are summarized in **Table 4**. Clearly the frequencies in question cover also the EEG range. Note that these frequencies scale as $\sqrt{1/r}$ whereas Josephson frequencies scale as $1/r$.

Also ZEG and WEG would appear but in much shorter scales dictated by k_{eff} and might accompany EEG. Somehow it seems that the effective masslessness of weak bosons below given scale is highly relevant for life. One can of course ask whether some larger Gaussian Mersenne could change the situation. There is a large gap in the distribution of Gaussian Mersennes after $k = 167$ and the next ones correspond to $M_{G,k}$, with k in $(239, 241, 283, 353, 367, 379, 457, 997)$ [A1]. The twin pair $k = (239, 241)$ corresponds to a length scales $(1.6, 3.2) \times 10^2$ km and the minimum value for k_d are (72, 74) ($167 \to (239, 241)$ transition).

3. Long term memory and ultralow Josephson frequencies

What determines the time scale associated with long term memory is a crucial question if one really wants to understand the basic aspects of consciousness.

1. Does the time scale correspond to the size scale of CD assignable to electron scaled by $r = \hbar/\hbar_0$? In this case relatively small values of r would be enough and $r = 2^{47}$ would give

time scale of 10^{13} s for for electron's CD, which is about 3×10^5 years. This does not make sense.

2. Does Josephson frequency define the relevant time scale? In this case the long term memory would require the analog of EEG in the time scale of memory span. $k_{eff} = 205$ would give 6 ms time scale for memory from the assignment of $k_{eff} = 163$ to the Josephson photons at V=-50 mV implying $k_d = 42$. Minute scale would require $k_{eff} = 217$. The highest level $k_{eff} = 235$ allowed by the model involving only Gaussian Mersennes with $k \leq 167$ would correspond to a time scale of 77.67 days (day is 24 hours). For Gaussian Mersennes defined by $k_{eff} = (239, 241)$ the time scales become about (41.4, 82.8) months (3.4 and 6.8 years). These scales should also define important biorhythms. The claimed 7 years rhythm of human life could relate to the latter rhythm: note that the precise value of the period depends on the membrane potential and thus varies. The presence of the scaled up variants of the by $k_d \leq 78$ allows longer time spans of long term memory and the scaling defined by $k_d = 167 - 163 = 4$ scales up the span of long term memories to (54.4, 108.8) years.

4. Cultural evolution

Higher levels in the hierarchy would correspond mostly to the evolution of hyper-genome coding for culture and social structures. Introns are good candidate for the nucleotides involved. The development of speech faculty is certainly a necessary prerequisite for this breakthrough. Already EEG seems to correspond to dark layers of biological body larger than biological body so that one can cask whether the weak bosons and dark electrons in the length scales $k = 239, 241, 283, 353, 367, ...$ could be relevant for the collective aspect of consciousness and cultural evolution. Maybe the size scales $(175, 330)$ km and their scaled up variants by $k_d \leq 78$ might have something to do with the spatial scale of some typical social structure (not city: the area of New York is only 790 km^2).

6.2 Some TGD Inspired New Ideas About Biochemistry

TGD provides several new physics concepts whose role in biochemistry is now relatively well understood thanks to the insights provided by the construction of the model of pre-biotic evolution [**?**]. Hence there are hopes of understanding the basic principles of cellular control at macromolecular level, and to apply these principles to understand what happens during nerve pulse in the interior of neuron. It is not possible to overestimate the importance of the fact that p-adic length scale hypothesis makes the model quantitative and reduces the number of alternatives dramatically.

6.2.1 Increments of zero point kinetic energies as universal metabolic currencies

The protons and also various other ions and possibly even electrons liberate their zero point kinetic energy while dropping to larger space-time sheets. This process and its reversal define metabolism as a universal process present already during the pre-biotic evolution rather than as an outcome of a long molecular evolution [**?**]. ATP-ADP transformation, polymerization by dehydration, and its reversal are key examples of the many-sheeted dynamics involving the dropping of protons from $k = 137$ space-time sheet liberating about.4-.5 eV of zero point kinetic energy and the reversal of this process. In TGD framework metabolism generalizes to a fractal metabolism involving a large number of metabolic currencies.

Negative energy MEs make possible remote metabolism realizing what might called quantum credit card. This makes energetic economy extremely flexible. F-actin polymerization [J12] is an interesting application of this notion.

1. Each G-actin unit of F-actin is stabilized by Ca^{+2} ion and contains one ATP molecule. The polymerization of G-actin molecule is accompanied by an ATP-ADP transformation involving the dropping of a proton to a larger space-time sheet.

2. The fact that F-actin polymerization does not require energy [J12] suggests that the zero point kinetic energy liberated in this manner is used to kick one proton to an atomic space-time sheet in G-actin molecule needed in dehydration inducing the polymerization.

3. This is achieved if the G-actin molecule emits a $.4-.5$ eV negative energy photon inducing the hopping of proton to an atomic space-time sheet associated with G-actin. The negative energy photon is received by the ATP molecule and induces the dropping of proton from atomic space-time sheet associated with the ATP molecule. This energetic seesaw could be controlled by a precisely targeted intentional action of the G-actin molecule by the generation of p-adic ME transformed then to negative energy ME. The seesaw mechanism can be generalized to a mechanism controlling the occurrence of sol-gel transitions.

A natural guess is that the emergence of larger space-time sheet with sizes characterized by p-adic length scales is a correlate for the evolution of more refined control and information processing structures utilizing smaller energy currencies. The situation is essentially quantal: the longer the length scale, the smaller the quantum of the metabolic energy. Micro-tubuli and other intracellular organelles represent excellent candidates for this kind of higher level metabolism refining the standard metabolism based on.4-.5 eV energy currency.

Since negative energy MEs with energies above thermal energy scale cannot induce transitions to lower energy states, a good guess is that negative energy MEs corresponding to metabolic currencies above the thermal energy $T_{room} \sim .03$ eV can be utilized for entanglement purposes. This is only a rough rule of thumb since the energy spectrum of systems at a given space-time sheet is expected to have an energy gap. Therefore negative energy MEs, even those below the ELF frequency range, are expected to be important.

Allowing n-ary p-adic length scales, this would mean in the case of hydrogen atom the upper upper bound $L(3,47)\backslash = "L(141) = 2L(139)$ for the p-adic length scales in the hierarchy of water clusters. For electron the upper bound is cell membrane thickness $L(151) \simeq 10$ nm, which corresponds to the effective axonal electronic super-conductivity with the metabolic currency $.025 - .03$ eV. Interestingly, the water at room temperature contains flickering structures of size of order 20-30 nm with lifetime of order.1 ns [D6]. MEs at energy $\simeq .03$ eV could stabilize these structures by kicking the dropped Cooper pairs back to k=151 space-time sheets. One can also ask whether micro-wave MEs at GHz frequency, perhaps generated in the rotational transitions of water molecules, modulate the generation of .03 eV MEs and are thus responsible for the flickering.

6.2.2 Liquid crystal phase of water as a stabilizer of biopolymers

The second key element is the understanding of the role of the liquid [F1] [D1] water in the stabilization of various bio-polymers. The reason is that the water molecules making possible depolymerization by hydration (also other means, say by the addition of heavy water or the increase of salt concentration, of reducing water activity have a stabilizing effect) are frozen to the liquid crystal. Thus the control at the level of bio-polymers could reduce to the control of whether cellular water is in sol or gel phase and to the understanding of what sol-gel difference means in the many-sheeted space-time.

Local gel-sol transitions could also provide a fundamental mechanism of cellular locomotion applied by, say, amoebae. Quite generally, various conformational changes needed in the cellular control are made possible by a local melting of the gel to sol followed by the conformational change in turn followed by a local sol-gel transition stabilizing the resulting conformation. The technological counterpart of this process is welding. The ME-controlled local melting and solidification of metals might in future technology make possible machines changing their structure routinely.

Local sol-gel transitions could also make possible the control of the conformations of the tubulin dimers expected to be sensitive to the di-electric constant of the water between the alpha and beta tubulin. This would mean that sol-gel phase transition and its reversal could define the bit of the declarative long term memory. Em MEs inducing gel-sol phase transition could provide a precisely targeted control of this kind. This would mean that coherent BE condensed photons associated with MEs could induce the sol-gel phase transition.

6.2.3 What distinguishes between sol and gel phases?

Sol-gel transition is crucial for the polymerization of actin molecules and micro-tubuli, and this dynamics probably involves something more refined than the molecular $k = 137$ metabolism. The dropping of protons/hydrogen atoms or of protonic Cooper pairs from $k = 139$ space-time sheet to larger space-time sheets is thus a unique candidate for what is involved with sol-gel transition.

The liberated zero point kinetic energy would be.1 eV for the dropping of proton or hydrogen atom (if.4 eV is the fundamental metabolic quantum whose value varies roughly in the range.4-.5 eV). For protonic Cooper pairs the energy would be.05 eV. According to the findings of Albrecht-Buehler [I12], the response of cells to IR radiation at.1 eV photon energy is maximal.

The presence of protonic Bose-Einstein condensate at $k = 139$ space-time sheet might thus distinguish between the liquid-crystalline gel phase from sol phase. The particles of this effectively 2-dimensional liquid would be loosely bound tubular structures having a radius of about $L(139)$ and the BE condensate of the dropped proton would bind the water molecules to form this structure. Ordinary water would result when protons at $k = 139$ space-time sheet drop to larger space-time sheets. $k = 139$ space-time sheets would be also associated with small sized water clusters.

This phase could be interpreted in terms of the partially dark water whose existence is suggested by the empirical finding that the chemical formula of water seems to be $H_{1.5}O$ in atto-second scale in the sense that neutron diffraction and electron scattering see only 1.5 protons per oxygen molecule [D8, D7, D9, D4]. As proposed in [K15], every fourth proton would be in dark phase, the lowest dark matter phase and protons would form string like structure which could be regarded as scaled up nuclei consisting of protons (also ordinary nuclei correspond to nuclear strings in TGD framework and exotic $k = 127$ quarks play a key role in the model [K35]).

Attosecond suggests itself as the scale for the average time T_d spent by proton in dark phase in this case. In ordered water the lifetime of this phase might be considerably longer. If a dark variant of $k = 139$ space-time sheet is in question, T_d is scaled up by $r = \hbar/\hbar_0$. Zero point kinetic energy and the energy of photons would remain invariant, which makes possible quantum coherent control in multi-neuron length scale.

6.2.4 IR radiation as a stabilizer of gel phase?

The model for the effective electronic super-conductivity generalizes to the case protonic Cooper pairs and ionic Bose Einstein condensates, and allows to develop a more precise picture. At the room temperature the thermal photons have energy lower than the zero point kinetic energy .1 eV so that the BE condensate can be maintained only by feeding IR photons kicking the hydrogen atoms back to $k = 139$ space-time sheet with a high enough rate. Therefore the stabilization of the gel phase requires an expenditure of metabolic energy. The simplest view is that in the ground state the entire interior of the cell is in gel phase so that the cell interior would have tonus analogous to muscular tonus.

By stopping the feed of the energy by IR photons to a particular region of cell, gel-sol transition with its various outcomes would occur spontaneously. A faster and energetically more economic manner to achieve the same outcome is to generate negative energy IR photons which induce the dropping of the hydrogen atoms from $k = 139$ space-time sheets. This mechanism also guarantees the stability of polymers by making hydration impossible. A more clumsy manner to guarantee this is to feed protons back to $k = 137$ space-time sheet where they induce dehydration: this process would probably cost much more energy.

Note that the gel-sol transition of the peripheral cytoskeleton assumed to occur during nerve pulse would rely on different different mechanism. Ca^{+2} ions act as cross links between actin molecules and the lengthening of the cytoskeleton-membrane flux tubes in $\hbar$ increasing phase transition makes possible the flow of dark monovalent ions from cell exterior to peripheral cytoskeleton and induces gel-sol phase transition. This phase transition is initiated with the voltage over membrane is reduced to very small value inducing quantum criticality. The proposal is that dark ionic currents from microtubules to axonal membrane induces this reduction.

One can of course ask whether the mere influx of monovalent ions is enough to induce the gel-sol phase transition in the required millisecond time scale. The reduction of cell potential to about.05 V, quite near to the value inducing action potential, implies that the photons of Josephson radiation have energy.05 eV. At this energy a resonant absorption of phase conjugate IR photons by the peripheral cytoskeleton inducing in turn the dropping protons to larger space-time sheet could induce the gel-sol transition.

6.2.5 Cell membrane Josephson junction as a generator IR coherent light

What is then the mechanism generating IR MEs acting as space-time correlates for coherent IR photons? The crucial observation is that the Josephson energy $E_J = ZeV$ for $Z = 2$ for cell membrane Josephson junction is.1 eV at threshold $V = 50$ mV for nerve pulse generation. The value of the metabolic energy quantum varies in certain range and the value .13 eV for the resting potential 65 mV would correspond to.052 eV metabolic quantum. Hence Josephson radiation could take care of kicking protons back to $k = 139$ space-time sheet thus stabilizing gel phase above the threshold for nerve pulse generation. The IR photons generated by Josephson current tend to propagate parallel to the axon and axon could act as a waveguide. When nerve pulse is generated at axonal hillock the frequencies of Josephson radiation are reduced below the threshold allowing stability of gel phase in region near axonal hillock and gel-sol transition should occur.

During nerve pulse the Josephson frequency varies in a wide range and has also negative values during the period when membrane voltage is positive (below 35 meV). A possible interpretation is that a phase conjugate IR radiation with energies $|E| < .07$ eV is generated. These photons could draw protons to large space-time sheet but with kinetic energy $E_0 - E$ rather than at rest.

The scaled up variants of IR photons at higher levels of dark matter hierarchy de-cohering into ordinary IR photons could make possible coherent quantum control in length scales given by $\lambda^n \times \lambda_{IR}$. For instance, EEG photons with frequency of about 5 Hz would correspond to the large $\hbar$ variants of IR photons with the same energy.

6.2.6 What happens in gel-sol phase transition?

The minimal model for the gel-sol transition could be following. When the membrane potential falls below the threshold value, Josephson radiation does not take anymore care of the stability of gel phase in the zone in the radiation zone directed parallel to the axon and gel-sol phase transition is generated in cellular water. The gel-sol transition occurs also at the level of micro-tubules and de-stabilizes them unless they take care of themselves by generating negative energy IR radiation received by cellular water. This might quite well occur.

6.2.7 How Ca^{+2} ions are involved with gel-sol phase transition?

Besides IR MEs also Ca^{+2} ions are involved with the gel-sol transition and if these ions act as cross links between proteins in gel, their role can be understood. Ca^{+2} waves are indeed known to be a fundamental cellular control mechanism. Ca^{+2} ions are known to induce a de-polymerization of micro-tubules even in micro-molar concentrations whereas Mg^{+2} ions having much smaller ionic radius are known to favor the polymerization of the actin molecules [J12]. Ca^{+2} ions which are more abundant in the cell exterior have a large ionic radius of order .099 nm whereas Mg^{+2} ions, which are abundant in the cell interior, have much smaller ionic radius. This supports the view that these ions have dual roles in cellular control.

As positive ions both Ca^{+2} and Mg^{+2} ions tend to increase the probability of the dropping of protons from the atomic $k = 139$ space-time sheets by repelling the protons from $k = 139$ space-time sheets to larger space-time sheets. This could mean gel-sol phase transition and the transformation of ordered water to ordinary water and the increase in the rate of de-polymerization by hydration. On the other hand, both Ca^{+2} and Mg^{+2} tend to bind with themselves water molecules which lowers de-polymerization rate. For Mg^{+2} with a small ionic radius the latter tendency wins: one can also say that Mg^{+2} is too small to act as a seed for de-polymerization.

Bose-Einstein condensates of bosonic ions are key element of the proposed quantum control mechanism involving charge entanglement induced by W MEs connecting magnetic body and cell interior or exterior. The question is whether de-polymerization involves the charge entanglement of Ca^{+2} and Mg^{+2} ions. One could argue whether the low amount of Ca^{+2} (Mg^{+2}) in cell interior (exterior) actually means that most of Ca^{+2} (Mg^{+2}) ions are in dark phase in cell interior (exterior). If so then at least sol-gel phase transition would be initiated by Josephson radiation and only at the later stages as Ca^{+2} rush into neuronal interior Ca^{+2} take the lead.

6.3 Nerve Pulses And Microtubules

As an application of above general view one can consider a model for what might happen during the nerve pulse inside axon and neuronal soma (this time interval can be as long as.5 seconds). The known pieces of information [J12] indeed fit nicely with the above general principles and one ends up with the following scenario. Note again that this scenario has not been updated to correspond to the most recent view about nerve pulse.

6.3.1 Propagating sol-gel transitions as representations of declarative memories

The propagation of nerve pulse along axon means a propagation of gel-sol-gel phase transition along microtubule. Declarative long term memories could correspond to the temporal sequences of nerve pulses represented as propagating gel-sol-gel phase transitions. The representation of memories would be rather rough as compared to the capacity of microtubular conformations to represent bits: for a conduction velocity $v = 10$ m/s and duration of pulse about 1 ms single pulse would correspond to an axonal length of 10^{-5} meters meaning that 10^3 conformational bits would lumped to single bit

6.3.2 What happens inside neuron soma as nerve pulse is generated?

Consider first what could happen inside neuronal soma as nerve pulse is generated.

1. The positive energy Josephson radiation at IR frequency generated by cell membrane Josephson junction ceases temporarily and induces gel-sol transition in cellular water. Ca^{+2} ions flowing into the neuronal interior favor further the de-polymerization of actin molecules. The micro-tubules of cytoskeleton receive the stabilizing IR radiation still from parts of neuronal membrane other than the throat of axon. They can also take care of themselves by sending phase conjugate IR radiation received by cellular ordered water.

2. The hydration of actin molecules in the vicinity of axonal hillock means that the activity of the water is reduced inside cell and water molecules from the cell exterior rush to the cell interior. The resulting swelling of the cell tears the positively charged ends of the micro-tubuli from the cell membrane. The micro-tubuli are now free to change their conformations and the micro-tubuli associated with different cells can arrange themselves in parallel configurations temporarily. Therefore they could act as quantum antennas generating coherent IR light needed to re-establish the gel phase very effectively: in an ideal case the power radiated is proportional to N^2, N the number of synchronously firing neurons. Also the return of membrane potential to the resting value brings back the IR radiation stabilizing the gel phase.

3. Gel phase is re-generated. Actin molecules re-polymerize and micro-tubuli stick again to the cell membrane. Synaptic contacts and the distribution of the ionic channels in neuronal membrane are re-structured in the process and this means that learning occurs in the sense that cell begins to respond slightly differently to neuronal inputs. This does not correspond to conscious long term memories, which are represented as temporal conformational patterns of tubulin dimers. These memories are in the geometric past, and can change, and are re-experienced by sharing of mental images or communicating the memories classically as field patterns associated with MEs using memetic code.

4. Tubulin dimers are electrets and can be regarded as miniature capacitor plates containing 18 Ca^{+2} ions at the other plate and 18 electrons at the other plate [J12, J17]. The average increments of WCW zero modes in the quantum jump sequence giving rise to the change of the conformation defines a two-valued geometric quale characterizing single bit of the long term memory. In [K26] a micro-tubular spatial cognitive code based on 13×13 bits is discussed. Temporal pattern extends this code to $13 \times 13 \times 126$ bit code.

6.3.3 Could micro-tubule-axon system perform topological quantum computation?

The proposed picture is consistent with the model of DNA as a topological quantum computer [K1] and with the idea that also micro-tubules could be involved with TQC. The model of DNA as TQC

in its basic form assumes that DNA is connected to the nuclear membrane and cell membranes associated with the cell body by magnetic flux tubes such that each nucleotide is connected to single lipid. Tqc programs are coded to the temporal braiding patterns of lipids. This requires that lipid layer is liquid crystal and thus below the critical temperature. The flux tube connecting DNA to inner lipid layer and that beginning from outer lipid layer can form single flux tube or be split. If they form single flux tube braiding and TQC are not possible. During TQC the braid strands going through cell membrane are split and the dance of lipids induced by water flow defining time like braiding (hydrophilic lipid ends are anchored to the cellular water) induces braiding of the magnetic flux tubes which write the TQC program to memory. Furthermore, the lifetimes of flux tubes in the connected state must be short enough to prevent the generation of a nerve pulse. This is the case if the temperature is sufficiently below the critical temperature. The ionic supra currents are identifiable as the observed quantal non-dissipative currents flowing through the cell membrane when TQC is not on.

Centrioles have their own genetic code realized in terms of RNA and they play key role during gene replication when DNA is out of the game. This encourages to think that micro-tubules make possible an independent TQC like process. The question is how micro-tubule-axon system could perform TQC assuming that the recent picture about DNA as TQC [K1] is roughly correct. The assumptions of the model relevant for the recent situation are following.

1. Flux tubes consists of pieces between standard plugs represented by hydrogen bond acceptors ($O=$, aromatic rings, ...). For instance, XYP molecules, $X = A, T, C, G$, $Y = M, D, T$ would represent standard plugs and that the transformation $XTP \to XDP + P_i$ represents the splitting of the flux tube and thus of braid strand. The XMPs associated with DNA would represent the ends of the braid strands. The formation of hydrogen bond between water molecule and $O=$ associated with phosphates at the hydrophilic ends of phospholipids would initiate TQC [K1].

2. In the model for protein folding [K2] free amino-acid corresponds to a codon XYZ in the sense of wobble base pairing meaning that the third nucleotide corresponds to a quantum superposition of colors of nucleotides coding for the same amino-acid. Hydrogen bonds correspond flux tubes also and hydrogen bonds between $N-H$ and $O=$ groups in alpha helices and beta sheets mean a shortcut making it impossible to continue the flux tube from $O=$ further. Only the continuation of the flux tube through non-hydrogen bonded $O=$ acting as a plug is possible. $Y = Z$ rule holds true for the $O = -N - H$ hydrogen bonds and defines folding code. Inside proteins amino-acids correspond to code YZ part of the codon XYZ and inside alpha helices and beta sheets the flux tubes from DNA would end to amino-acids and for them one could have only braiding between DNA and tubulins. Only in the case of non-hydrogen bonded amino-acids the flux tube connection from DNA could continue to the lipid layer and only in this case one could have the generalization of DNA TQC with flux tubes connecting DNA via tubulins to the axonal lipid layer.

Taking this picture as a starting point one can consider several options. For two first options tubulins are basic units. For the third one DNA nucleotides and amino-acids would have this role.

Option I: Tubulins could be connected to the lipid layer of the axonal membrane by flux tubes and the melting of the axonal membrane would induce braiding during the propagation of nerve pulse. α tubulins are accompanied by stable GTPs analogous to single DNA nucleotide so that α tubulin could takes the role of DNA nucleotide with braid strands to lipids having only single color. Compared to DNA TQC this computation would represent much rougher resolution. β tubulins are accompanied by unstable GTPs able to suffer a hydrolysis to GDP. Also this process would correspond to the splitting of flux tube but the connection to TQC remains unclear. One can imagine one/two connected flux tubes to lipid layer represents bit.

Option II: For some years ago I considered the possibility of a gel-sol-gel phase transition proceeding along the surface surface of the micro-tubuli, accompanying nerve pulse, perhaps inducing nerve pulse, and coding for long term sensory memories in terms of 13 13-bit sequences defined by the tubulin helices with bit represented as a conformation of micro-tubule. This hypothesis might be easily shown to be wrong on basis of the available experimental facts already now. Suppose however that this phase transition happens and that the braid strands do not continue from the

micro-tubular surface to the cell nucleus. In this case the braiding could be induced by a gel-sol-gel transition accompanying and perhaps generating the nerve pulse at the micro-tubular level and inducing the disassembly of the microtubule to tubulins followed by re-assembly inducing the braiding. Also this braiding would contribute to TQC like process or at least to a memory storage by braiding and options I and II would provide the complete story.

Option III: What about the variant of DNA-membrane TQC for axons? In the model of DNA as TQC these flux tubes continue back to the nucleus or another nucleus: the flux tubes must be split at cell membrane during TQC and this splitting induces the required isolation from the external world during TQC. During nerve pulse the situation would be different and the flow of lipids in liquid phase could induce DNA-lipid layer braiding: the isolation could however fail now. Tqc would explain why the axon melts during nerve pulse.

There are objections against this option.

1. By previous argument only Y-codons of DNA and only non-hydrogen bonded O =s of amino-acids would contribute to the braid strands. This does not look nice.

2. The idea about magnetic flux tubes emanating from DNA and flowing along micro-tubules interiors and radiating to the axonal membrane looks also ugly: in any case, this would not affect TQC and nerve pulse could be seen as a direct gene expression not conforming with the idea that microtubules define an independent computational system.

3. One can wonder why also the magnetic flux tubes from DNA could not end to the space-time sheet of the cell exterior if they do so in the case of axon. The justification for "No" (besides isolation) could be that also cell soma would possess standing soliton sequence like waves and standing nerve pulses in this kind of situation.

The following considerations do not depend on the option used.

1. What comes first in mind is that the braiding codes memories, with memories understood in TGD sense using the notion of 4-D brain: that is in terms of communications between brain geometrically now and brain in the geometric past. In standard neuroscience framework braiding of course cannot code for memories since it changes continually. Nerve pulse sequences would code for long term sensory memories in a time scale longer than millisecond and micro-tubular phase transition could have a fine structure coding for sensory data in time scales shorter than nerve pulse duration. The fact is that we are able to distinguish from each other stimuli whose temporal distance is much shorter than millisecond and this kind of coding could make this possible. Also the direct communication of the auditory (sensory) input using photons propagating along MEs parallel to axon could also explain this.

2. In the model of DNA as TQC nucleotides A, T, C, G are coded into a 4-color of braid strand represented in terms of quarks u, d and their antiquarks. An analogous coding need not be present also now: rather, all braid strands could have same color represented by G of GTP. Tubulins could be seen as higher level modules consisting of order hundred 500 amino-acids. This corresponds to a DNA strand with length of about.5 μm corresponding to the p-adic length scale $L(163)$ which is one of the four magic p-adic length scales ($k = 151, 157, 163, 167$) which correspond to Gaussian Mersennes. This higher level language character of micro-tubular TQC programs would conform with the fact that only eukaryotes possess them.

3. Cellular cytoskeleton consists of micro-tubules. Could micro-tubular TQC -in either of the proposed forms- take place also at the cell soma level? Could DNA-nuclear membrane system define the primordial TQC and micro-tubular cytoskeleton-cell membrane system a higher level TQC that emerged together with the advent of the multicellulars? Is only the latter TQC performed at the multicellular level? The notions of super- and hypergenome encourage to think that both TQCs are performed in all length scales. One can imagine that ordinary cell membrane decomposes into regions above and below the critical point (the value of the critical temperature can be controlled. Those below it would be connected to DNA by flux tube bundles flowing inside the micro-tubular cylinders. Micro-tubular surfaces would in turn be connected to the regions above the critical point. One should also understand the role of $M_{13} = 2^{13} - 1$ 12-bit higher level "genetic code" assignable naturally to micro-tubules.

For instance, could the bit of this code tell whether the module defined by the tubulin dimer strand bundle participates TQC or not?

6.4 Magnetic Bodies, MEs And Microtubules

It would seem that magnetic bodies are the intentional agents and the most natural assumption is that micro-tubuli are used by the magnetic body of cell for logistic purposes as well as to represent memories. First p-adic MEs representing the intention to suck energy and momentum from a particular part of the gel phase and transformed then to negative energy IR MEs by p-adic-to-real transition. Negative energy IR MEs would also serve as space-time correlates for the bound state quantum entanglement responsible for the generation of a multi-neuron macroscopic and -temporal quantum state.

Phase conjugate laser beams are the most plausible standard physics analogs for negative energy MEs and the coherent photons generated and Bose-Einstein condensates of photons contained by them. Since the energy.1 eV is above the range of the thermal energies, one can argue that negative energy photons can be absorbed only resonantly and thus very selectively. This view is supported by the demonstration of Feinberg showing that it is possible to see through chicken using phase conjugate laser beam [D2].

Still an open question is whether laser beams actually correspond to dark photons having thus large value of $\hbar$ and scaled up wavelength. Scaled up wave lengths for.1 eV IR photons would be very natural concerning the control in length scales longer than that of single neuron and synchronous neuronal firing might involve the de-coherence of these dark photons to ordinary IR photons.

6.4.1 Could memes express themselves in terms of modulated IR radiation?

In TGD framework cell nucleus is the brain of the cell and acts as the fundamental controller of the cellular dynamics. Genetic expression is the slow part of this dynamics analogous to a rebuilding of the computer hardware. Software corresponds to memes, sequences of memetic codons realized as sequences of 21 DNA triplets in the intronic part of the DNA. Memetic codons would be the language with which the cellular programs are written. Super-genes or at least hyper-genes would naturally correspond to the sequences of memetic codons.

Memes could express themselves as temporal patterns of IR radiation amplified by micro-tubuli of length ~ 12.4 micrometers. Of course, in accordance with the fractality, also wavelengths corresponding to other metabolic currencies are probably realized. Single memetic codon carries 126 bits and single bit has a duration of about 1/1026 s, the basic time scale of the neuronal dynamics. Both the frequency for the occurrence of sol gel transition and the duration of memetic codon in turn corresponds to 10 Hz frequency in alpha band, which suggests that $k_d = 46$ hierarchy level of dark matter hierarchy is involved with the periodically occurring sol-gel phase transition. The general framework would suggest that this phase transition occurs with this frequency only in vertebrate neurons.

These patterns of IR radiation at $\sim .1$ eV energy induce temporal sequences of sol-gel transitions representing memes physically. The beauty of MEs is that as topological field quanta of radiation they allow a precisely targeted local control not possible in Maxwellian electrodynamics. In particular, temporal sequences of micro-tubulin conformations could represent long term declarative memories expressed in a universal language using memetic codons as basic units.

6.4.2 Seesaw mechanism as a general manner to generate long term memories?

Micro-tubuli can act as quantum antennae producing IR photons by the dropping of proton Cooper pairs and amplified resonantly, when the micro-tubule has a length of about 12.4 micrometers. The absorption of these photons would in turn re-establish the gel phase in receiving system. This energetic gel-sol seesaw would be obviously ideal for the minimization of the dissipative losses.

The seesaw mechanism for the cellular control by micro-tubuli means that sol-gel transition in tubulin induces a gel-sol transition in the controlled part of the cell. Thus it would automatically construct micro-tubular declarative long term memory representation as a record about sol-gel

transition history in various parts of the cell or cell substructure coded by the positions of tubulin dimers at the tubulin cylinder.

These dynamical maps about the active structures in the cell interior would be analogous to neuronal maps in cortex. If cell nucleus is the fundamental controller, also chromosomes might be seen as structures analogous to brain hemispheres forming dynamical sensory and motor maps about the interior of the cell. The static conformations would not represent memory bit. Rather, the changes of the conformations would represent the bit in accordance with the view that moments of consciousness correspond to quantum jumps between histories, and that the sequence of quantum jumps effectively integrates to a single quantum jump during macro-temporal quantum coherence.

7 Are lithium, phosphate, and Posner molecule fundamental for quantum biology?

I encountered a very interesting Facebook link (see `http://tinyurl.com/zyy3b4l`) to the work of Mathew Fisher [J33] (see `http://tinyurl.com/hd3t6sr`) related to quantum biology, in particular to the possible role of Posner molecules. Posner molecules (see `http://tinyurl.com/ya2vura9`) are not some bio-chemical rarity. Betts and Posner, while examining the x-ray crystal structure of the bone mineral hydroxyapatite $Ca_{10}(PO_4)_6$ (see `http://tinyurl.com/y7quv997`), found that within each unit cell there were two calcium-phosphate clusters with atomic constituents $Ca_9(PO_4)^6$.

I attach below the abstract of the first article [J33] of Fisher.

> *The possibility that quantum processing with nuclear spins might be operative in the brain is proposed and then explored. Phosphorus is identified as the unique biological element with a nuclear spin that can serve as a qubit for such putative quantum processing - a neural qubit - while the phosphate ion is the only possible qubit-transporter. We identify the* ■*, $Ca_9(PO_4)^6$, as the unique molecule that can protect the neural qubits on very long times and thereby serve as a (working) quantum-memory.*
>
> *A central requirement for quantum-processing is quantum entanglement. It is argued that the enzyme catalyzed chemical reaction which breaks a pyrophosphate ion into two phosphate ions can quantum entangle pairs of qubits. Posner molecules, formed by binding such phosphate pairs with extracellular calcium ions, will inherit the nuclear spin entanglement. A mechanism for transporting Posner molecules into presynaptic neurons during a* ■ *exocytosis, which releases neurotransmitters into the synaptic cleft, is proposed. Quantum measurements can occur when a pair of Posner molecules chemically bind and subsequently melt, releasing a shower of intra-cellular calcium ions that can trigger further neurotransmitter release and enhance the probability of post-synaptic neuron firing. Multiple entangled Posner molecules, triggering non-local quantum correlations of neuron firing rates, would provide the key mechanism for neural quantum processing. Implications, both in vitro and in vivo, are briefly mentioned.*

The model of Fisher [J33] (see `http://tinyurl.com/hd3t6sr`) for how phosphate ion and calcium phosphate known as Posner molecule could play a central role quantum neural processing is described. Fisher assumes that the nuclear spin $S = 1/2$ of phosphate ions could make possible long range correlations and allow long decoherence lifetimes in these degrees of freedom. Fisher emphasizes also the possible role of Lithium in quantum biochemistry.

About two years after writing the first version of this article, I learned about a second article about Posner molecules by Fisher, Swift and Van de Walle [J37] (see `http://tinyurl.com/ycyu5bj9`) describing a detailed study of Posner molecules. The abstract of the article gives idea about what is done.

> *We investigate* ■*, calcium phosphate clusters with chemical formula $Ca_9(PO_4)^6$. Originally identified in hydroxyapatite, Posner molecules have also been observed as free-floating molecules in vitro. The formation and aggregation of Posner molecules have important implications for bone growth, and may also play a role in other biological processes such as the modulation of calcium and phosphate ion concentrations within the*

mitochondrial matrix. In this work, we use a first-principles computational methodology to study the structure of Posner molecules, their vibrational spectra, their interactions with other cations, and the process of pairwise bonding. Additionally, we show that the Posner molecule provides an ideal environment for the six constituent ^{31}P nuclear spins to obtain very long spin coherence times. In vitro, the spins could provide a platform for liquid-state nuclear magnetic resonance quantum computation. In vivo, the spins may have medical imaging applications. The spins have also been suggested as ■ in a proposed mechanism for quantum processing in the brain.

I also learned about the finding of M.Y. Simmons *et al* [D5] (see `http://tinyurl.com/ydx6v7xa`) about electronic qubits realized with phosphorus atoms serving as donors. This inspires the question whether also electronic qubits might be realized by using the valence electrons of P.

About two years after writing the first version of this article I ended up with a model of valence bond [L17] (see `http://tinyurl.com/ycg94xpl`) assuming that the electrons at valence bonds can have non-standard value of Planck constant $h_{eff} = n \times h$ (the hierarchy of Planck constants characterizing dark matter as phases of ordinary matter comes as a basic prediction of adelic TGD [L21, L22]). The starting point of the model was the surprisingly weak variation of the bond energy along the rows of the periodic table.

The model provides a vision about the role of valence bonds in biology and provides a precise identification for the notion of metabolic energy. The binding energies of bonds decrease with the value of $h_{eff}/h = n$ increasing along the rows of the periodic table, and the reduction of the binding energy can be identified as potential metabolic energy liberated in catabolism. The bonds involving atoms towards the right end of the rows of the periodic table have highest metabolic energies, and are indeed the bonds appearing in nutrient molecules. Phosphate ion has especially high bond energy so that Posner molecules could be also ideal for storing metabolic energy.

In the sequel I will consider the proposal of Fisher from TGD view point. I will describe first the Lithium mystery, which served as a motivation of Fisher and also TGD view about the role of Lithium. I also present TGD view about the situation suggesting that Posner molecule might indeed have a deep role but perhaps also in different sense to that in Posner's proposal. ELF radiation at frequencies equal to multiples of 15 Hz cyclotron frequency for Calcium ion in endogenous magnetic field $B_{end} = .2$ Gauss was found by Blackman and others to have effects on vertebrate brain. Furthermore, the cyclotron frequency of phosphate ion in endogenous magnetic field B_{end} corresponds to the 10 Hz alpha resonance frequency defining a fundamental biorhythm. This suggests that Ca ions and phosphate ions might form two separate cyclotron Bose-Einstein condensates at different magnetic flux tubes so that cyclotron energies. I will also represent a brief comment about the realization of electronic qubits with P atom serving as a donor.

7.1 Lithium mystery

The starting point of Fisher was a very interesting finding challenging the hypothesis about life as mere bio-chemistry. Already in 1986, scientists at Cornell University examined the effects of the two isotopes of Lithium on the behavior of rats. Pregnant rats were separated into three groups. One group was given Li^7, one group was given the isotope Li^6, and the third served as the control group. Once the pups were born, the mother rats that received Li^6 showed much stronger maternal behaviors, such as grooming, nursing and nest-building, than the rats in either the Li^7 or control groups.

Li^6 therefore as has a positive effect on maternal behaviour unlike Li^7. The chemistry is exactly the same. According to the popular article, Fisher believes that the higher nuclear spin of Li^6 could give it special role.: in the article he talks about nuclear spin $J = 1/2$ which cannot be true since the spin must be even. As a matter fact, according to my Nuclear Physics by Howard Li^7 has nuclear spin of $J = 3/2$ units whereas Li^6 has nuclear spin $J = 1$ so that neither of the above claims is correct. Could the bosonic character of Li^6 nucleus provide an alternative explanation? In any case, the finding strongly suggests that magnetic fields are involved.

Lithium - presumably Li^6 - has also other positive effects. If the positive effects are indeed due to Li^6 isotope, the dose of Lithium could be reduced by using only Li^6 isotope. I attach here the

abstract of the article that I wrote as a reaction to discussions with my friend Samppa who told about Lithium [L13] (see `http://tinyurl.com/j44epwp`).

> Lithium has been used for more than 50 years as a mood stabilizer in manic depression. During last years Lithium has been studied intensively and found that it can be used also in treatment of schizophrenia and many other brain disorders. The effectiveness of Lithium is however difficult to understand in the standard framework of biology. In TGD framework organism-environment pair of standard biology is replaced with the triplet magnetic body - organism -environment. Magnetic body uses biological body as sensory receptor and motor instrument. This suggests that the re-establishment of communications of brain with some level of the magnetic body is how lithium causes its positive effects. Magnetic body does not receive information about brain and cannot control it since dark Lithium ions and correspond- ing cyclotron radiation are not present. The disorders caused by the lack Lithium and other biologically important ions would therefore be something totally new from the perspective of standard neuroscience.

TGD explanation for the effects of Lithium relies on the notions of magnetic body and dark large $h_{eff} = n \times h$ photons, electrons, and ions and relies on cyclotron frequencies as frequencies assignable to the dark photons responsible for the communications between magnetic body and biological body. In this picture the charge of the ion and its total magnetic moment would be relevant rather than only nuclear magnetic moment characterizing also neutral atoms (which could also contribute to the magnetic moment of ion). Cyclotron frequencies would replace Larmor frequencies.

1. For Li^6 the cyclotron frequency is about 50.0 Hz in the endogenous magnetic field $B_{end} = .2$ Gauss explaining the quantal effects of em fields at ELF frequencies on vertebrate brain reported by the pioneers of bio-electromagnetism such as Blackman [J16] to occur at multiples of cyclotron frequency in this magnetic field for Calcium ion and also for other biologically important ions. For Ca^{+2} ion the cyclotron frequency is 15 Hz. Thanks to the large value of $h_{eff} = n \times h$ dark photons would have energies above thermal threshold. An attractive hypothesis is that the energies are in the range of bio-photon energies (visible and UV).

2. In the case of Li^6 the dark photons would make possible communication to and control by the magnetic body relevant for maternal behaviors. Magnetic fields oscillating at 50 Hz frequency are known to have biological effects [K30]. The size of the corresponding magnetic body part would be obtained from the wavelength $\lambda = 2\pi R$ (R denotes the radius of Earth) of the lowest Schumann frequency 7.8 Hz as $L = (7.8/50) \times R = .98 \times R$. This suggests that dark magnetic flux tubes assignable with Earth are involved: not however that the field strength is $2B_E/5$.

3. For Li^7 the dark photons would have cyclotron frequency about 42.9 Hz, which brings in mind the thalamocortical resonance with frequency around 40 Hz assigned to consciousness at the time when the use of the word "consciousness" ceased to be pseudo-science. The more abundant Li^7 (92.5 per cent) should be also important but could be associated with other kinds of biological functions.

7.2 Phosphate, Posner molecule, and cognition

Fisher as also other quantum biologists tries to understand quantum biology as an improvement of biochemistry. One assumes that standard quantum theory brings in small effects allowing to optimize biological functions. In the case of the avian navigation and also in many other situations the problem is that Earth's magnetic field is only 2 per cent of the minimum magnetic field at which the proposed radical-pair mechanism is found to work [L11] (see `http://tinyurl.com/jnxvdmf`). To my opinion much more radical approach challenging the basics of quantum theory itself is necessary.

Fisher wants to identify the quantum mechanism behind neural activity assumed to rely on nuclear spins. This is quite a demanding challenge. One should understand long coherence time for nuclear spins representing the qubits, discover a mechanism transporting the qubit through

the brain to neurons, identify a molecular scale quantum mechanism entangling qubits, identify a chemical reaction inducing quantum measurement of the qubits dictating the subsequent neuron firing, and understand what happens in nerve pulse transmission from pre- to post-synaptic neuron at quantum level.

1. Fisher assigns fundamental qubit and the ability to develop lon lasting quantum entanglement with phosphate ion (see `http://tinyurl.com/zgbgtwy`). Phosphate ion would be qubit transporter. The transfer of phosphate ion from APT to a molecule is fundamental part of metabolism and the TGD proposal is that a transfer of negentropic entanglement (NE) (purely TGD based notion involving p-adic physics as correlate for cognition) is in question.

2. Enzyme catalyzed qubit entanglement would emerge in the reaction ATP→ AMP+PPi. PPi is diphosphate ion with entangled phosptate and the reaction PPi→ Pi+Pi would create two entanglement phosphates. The reaction rate is proposed to depend on whether the 2Pi state is spin single or spin triplet.

3. Quantum memory is assigned with so called Posner molecule $[(PO_4)^{-3})]_6Ca_9^{+2}$ made of 6 phosphate ions and 9 calcium ions would be the key player. Posner molecule belongs to a family of calcium phosphates having as building bricks PO_4^{-3} and Ca^{+2} ions (see `http://tinyurl.com/jftjmro`). Calcium phosphate is the principal form of calcium found in bovine milk and blood. 70 percent of bone consists of hydroxyapatite, a calcium phosphate mineral known as bone mineral. Tooth enamel is composed of almost ninety percent hydroxyapatite.

   Posner molecule is neutral since the charges of 9 Ca ions and 6 phosphate ions cancel each other: $9 \times 2 - 6 \times 3 = 0$. Geometrically Posner molecule can be described as a cube with Calcium ions at corners and center and phosphate ions at the centers of faces. The nuclear spin of the Posner molecule assignable to phosphates is 0, 1, 2, or 3. Posner molecule has also reduced rotational degrees of freedom characterized by group Z_3 giving rise to pseudospin. Posner molecule would be a carrier of phosphate qubits giving rise to (working) quantum-memory realized in terms of entangled Posner molecules.

4. Fisher proposes the notion of quantum entangled chemical reactions. This notion does not make sense if one identifies chemical reactions as processes involving state function reduction as assumed in chemical kinetics. The notion could make sense if chemical reactions are identified as unitary time evolutions for entangled systems such as Posner molecules. In TGD framework the notion of entangled time evolutions could make sense in zero energy ontology (ZEO).

5. Nerve pulse tranmission from pre- to postsynaptic membrane would entangle neurons by entangling Posner molecules. Biochemistry is complex but to my opinion the proposed model is too complex to be feasible. My view is that the enormous complexity of the description based on biochemical reaction pathways reflects the failure to realize the presence of control level - magnetic body. Situation would be like trying to understand the functioning of computer program regarding it as mere physical phenomenon without any idea about its purpose.

7.3 TGD view

In TGD framework both nuclear spins and angular moment of dark nuclei in the magnetic fields assignable to dark magnetic flux tubes would be important: Larmor frequencies would be replaced with the sums of Larmor - and cyclotron frequencies assignable to (usually) charged particles. It is interesting to look whether the cyclotron frequencies of phosphate and Posner molecule could teach something about their possible role.

1. Phosphate PO_4^{-3} with mass number $31 + 4 \times 16 = 95$ has cyclotron frequency 9.5 Hz in the endogenous magnetic field $B_{end} = .2$ Gauss assumed in TGD model and therefore in alpha band. For smaller charges -2 and -1 one has frequencies 6.26 Hz and 3.13 Hz. In TGD framework the transfer of phosphate from ATP to the acceptor bio-molecule could be at the fundamental level transfer of NE from metabolites [K21, K22]. This could reduce to the transfer the ends of the associated flux tubes between the molecules.

2. Posner molecule is neutral since the charges of 9 Ca ions and 6 phosphate ions cancel each other: $9 \times 2 - 6 \times 3 = 0$. Being neutral Posner molecule as a whole does not couple to the magnetic field except through its total magnetic moment. TGD proposal that ions form Bose-Einstein condensates encourages however to consider the possibility that the building bricks of Posner molecule form separate Bose-Einstein condensates. One can ask whether this is possible also more complex calcium phosphates: could bones be much more than just passive building bricks?

   The simplest possibility is that 3 Cooper pairs of fermionic PO_4^{-3} molecules (as is easy to check by noticing that phosphorus and oxygen atoms are bosons and there are surplus 3 electrons: note that phosphorus nucleus is fermion and oxygen nucleus a boson) form a Bose-Einstein condensate a their own circular portion of flux tube. 9 bosonic Ca^{+2} ions would form similar Bose Einstein condensate at their own flux tube portion.

3. The value of h_{eff} proportional to the mass of the ion if $h_{eff} = h_{gr}$ hypothesis is accepted. The formation of Cooper pairs of phosphate ions would conform with the conjecture of Fisher that two phosphate ions can entangle.

   These observations put the bells ringing - with a frequencies of 10 Hz and 15 Hz, one might say. Unfortunately this frequency is not directly audible, so that I cannot hope that colleagues would hear the ringing! There are however some hopes: also 10 Hz and 15 Hz can be made audible as difference of frequencies fed to right and left ear! Maybe some experimentalist could get interested!

4. A further intriguing observation is that the Larmor frequency of P for B_{end} is 10.96 Hz. This is marginally in alpha band. This suggests that also Larmor frequency of P is indeed important in bio-control by magnetic body.

5. An alternative and more realistic sounding hypothesis is $h_{eff} = h_{em}$. $h_{eff} = h_{em}$ would hold true when em interaction becomes non-perturbative. In this case NE would be short ranged and associated with atomic/molecular systems. At this moment one cannot exclude the possibility that only short range NE is involved with living matter.

   Short ranged NE could be associated with dark atoms for which the scale of binding energy behaves like $1/h_{eff}^2$ and is thus reduced for dark atoms [**?**]. The creation of dark atoms would require metabolic energy. This metabolic energy could also be liberated as dark atoms transforms to ordinary atom. Metabolic electrons could be associated with dark atoms and also the dark atoms in nutrients could provide metabolic energy driving protons through the mitochondrial membrane against potential gradient and transforming ADP to ATP contains high energy phosphate bond, which would actually correspond to the presence of dark (say hydrogen -) atom. Phosphate containing the dark atom would carry the NE or be accompanied by dark magnetic flux tube.

   The simplest view about photosynthesis would be that the absorption of solar photons excites some atoms to dark states and that nutrients contain these dark atoms as stable enough entities. The contamination of nutrients could mean the decay of these dark atoms to the normal states.

6. The cyclotron frequencies of these Bose-Einstein condensates would be 9.5 Hz *resp.* 15 Hz in $B_{end} = .2$ Gauss. This model could allow to improve the understanding about why the radiation at harmonics of 15 Hz has effects on vertebrate brain and also about the realization of alpha rhythm as a control signal from magnetic body. Fisher proposes that in nerve pulse transition two Posner molecules fuse temporarily and produce a spray of Ca^{+2} ions. This could make sense also in TGD framework.

7.4 A new step of progress after two years

Roughly two years after writing the first version of this article I ended up with a model of valence bond [L17] (see `http://tinyurl.com/ycg94xpl`) assuming that the electrons at valence bonds can have non-standard value of Planck constant $h_{eff} = n \times h$ (the hierarchy of Planck constants characterizing dark matter as phases of ordinary matter comes as a basic prediction of adelic

TGD [L21, L22]). The starting point of the model was the surprisingly weak variation of the bond energy along the rows of the periodic table and the observation that the heating of Ruthenium leads to a mysterious disappearance of valence electrons known for decades: the interpretation would be that they are transformed to dark electrons [L20].

The model provides a vision about the role of valence bonds in biology and provides a precise identification for the notion of metabolic energy. The binding energies of bonds decrease with the value of $h_{eff}/h = n$ increasing along the rows of the periodic table, and the reduction of the binding energy can be identified as potential metabolic energy liberated in catabolism. The bonds involving atoms towards the right end of the rows of the periodic table have highest metabolic energies, and are indeed the bonds appearing in nutrient molecules. Phosphate ion has especially high bond energy so that Posner molecules could be also ideal for storing metabolic energy.

Posner molecule would be ideal for both control purposes and for metabolism.

1. There are 9 Ca^{2+} ions and 6 PO_4^{3-} ions with cyclotron frequencies of 15 Hz and 9.5 Hz respectively in the endogenous magnetic field $B_{end} = .2$ Gauss explaining the observations of Blackman [J16] about the quantal effects of ELF em fields on vertebrate brain: thus these molecules are ideal for control by and communication to magnetic body.

   Also the fact that the Larmor frequency of P is 10.96 Hz and marginally in alpha band, suggests that MB uses spin flips for control purposes. MB could control and coordinate all phosphate containing biomolecules usign this Larmor transition of P. This includes ATP, DNA, RNA, the tubulins of microtubules containing GTP and all biomolecules to which phosphate is attached. This would conform with the frequencies in alpha band as a universal biorhythm used by magnetic body to keep metabolism in synchrony in body scale.

   P nuclei serve as qubits and 6 qubits in Posner atom could realize genetic code with 64 code words. Could our bone marrow be performing massive quantum information processing?!

2. The 6 phosphates with high energy phosphate bonds are in turn ideal for metabolism: P and O related valence bonds indeed have nearly maximal metabolic energy content in the proposed model of valence bonds based on $h_{eff}/h = n$ hierarchy [L17] (see `http://tinyurl.com/ycg94xpl`).

   Remark: Totally unrelated association: the magic number 6 appears also in the structure of cortex: could the six layers represent qubits and realize genetic code?

   This suggests that bones might also serve as energy storages and - of course - as nutrients. Interestingly, in the evolution of humans the discovery of stones as tools to break down bones of prey animals to get bone marrow has been seen as a critical step leading to the growth of cortex requiring a lot of metabolic energy (to generate large n valence bonds providing ability to generate negentropy).

What is interesting that ATP molecule - the basic metabolic currency - has triphosphate with total charge -4 as a building brick. Triphosphate is characterized by cyclotron frequency 4.8 Hz which is one half of the alpha band frequency. The diphosphate in ADP has cyclotron frequency 5.2 Hz. Note that the cyclotron frequency of Fe^{2+} ion central in oxygen based metabolism is 10.7 Hz and in alpha band as also the Larmor frequency of P.

Note that in DNA the singly charged phosphates in XMPs, X = A, T, C, G, have cyclotron frequency, which is one third of this, that is 3.1 Hz. This frequency appears in EEG as a kind of resonance frequency during deep sleep. DNA nucleotides as whole have cyclotron frequencies around 1 Hz. In microtubules the phosphate of GTP can have three different charge states allowing frequencies 3.1,6.2 and 9.4 Hz. I have proposed that these charge states together with two different tubulin conformations give rise to a realization of the genetic code.

The proton cyclotron frequency 300 Hz has been already earlier assigned with ATP and the models for the lifelike properties of a system consisting of plastic balls involved cyclotron frequency of Ar^+ ion which is same as that of Ca^{2+} ion and cyclotron frequency 300 Hz of proton [L19] (see `http://tinyurl.com/yassnhzb`). Also the two important frequencies associated with honeybee dance [L25]correspond to the cyclotron frequencies of Ca^{2+} and proton (see `http://tinyurl.com/ycnst4z5`).

7.5 Phosphorus electrons as qubits

M.Y. Simmons *et al* [D5] (see `http://tinyurl.com/ydx6v7xa`) have found that P atoms can serve as donors of electrons giving rise to very long-lived qubits (see `http://tinyurl.com/y88d7vhf`). I attach the abstract of the article here.

Substitutional donor atoms in silicon are promising qubits for quantum computation with extremely long relaxation and dephasing times demonstrated. One of the critical challenges of scaling these systems is determining inter-donor distances to achieve controllable wavefunction overlap while at the same time performing high fidelity spin readout on each qubit. Here we achieve such a device by means of scanning tunnelling microscopy lithography. We measure anti-correlated spin states between two donor-based spin qubits in silicon separated by 16±1nm. By utilising an asymmetric system with two phosphorus donors at one qubit site and one on the other (2P1P), we demonstrate that the exchange interaction can be turned on and off via electrical control of two in-plane phosphorus doped detuning gates. We determine the tunnel coupling between the 2P1P system to be 200MHz and provide a roadmap for the observation of two-electron coherent exchange oscillations.

A controllable exchange interaction between electron spins is needed for the realization of 2-qubit quantum gate. The valence electron of P atom rather than P nucleus serves as a qubit. The qubits have unexpectedly long relaxation times (measured in seconds) and dephasing times. $2P$ (2 P atoms) and $1P$ serve as electron donors. The distance of 2P and 1P is rather long - 16 ± 1 nm - 1.6 times the p-adic length scale $L(151)$ (p is Gaussian prime $M_{G,151} = (1+i)^{151} - 1$ assignable to neuronal membrane. Exchange interaction occurs if there is an overlap between electron wave functions.

In TGD framework the electrons donated by phosphorus atoms and forming the qubits could be actually dark electrons with $h_{eff}/h = n$ larger than for atoms or normal valence bonds. This would scale up the domain of electron wave functions by n^2 and make possible the overlap. This also increases relaxation and dephasing times.

Remark: In living matter negatively charged phosphate ions for which P atoms have received electrons (negative oxidation number) are important. In the experiment discussed P atom loses electron and becomes a positive ion.

8 DMT, pineal gland, and the new view about sensory perception

The recent discussions with artist Sini Kunnas [L14] about perception as creation of an artwork inspired additional insights about how sensory perception, imagination as almost sensory perception, dreams and hallucinations as virtual percepts, and their motor analogs relate to each other.

What distinguishes TGD from neuroscience is that sensory receptors are assumed to serve as carriers of sensory percepts. Zero energy ontology (ZEO) providing new view about time and memory allows to solve the basic objections related to phantom limb phenomenon: pain in phantom limb would be sensory memory.

The assumption that sensory percepts are artworks rather than passive records of sensory input requires virtual sensory input from brain to sensory organs and build-up of the final percept by pattern recognition - an iterative procedure involving very many forth-and back signals. Nerve pulse transmission is quite too slow process to allow this and signals propagating with maximal signal velocity are suggestive.

Nerve pulses and neurotransmitters would not represent real communication but give rise to temporary intra-brain communication lines along which communications as dark photon signals would take place with maximal signal velocity using dark photons (characterized by $h_{eff}/h = n$) transforming to biophotons in an energy conserving manner [K10, K5]. Neurotransmitters and also other information molecules (hormones, messengers) attached to receptors would serve as bridges fusing permanent but disjoint communication lines along axons to a connected temporary communication line for dark photons to propagate. Nerve pulses would also generate generalized Josephson radiation allowing communications between biological body (BB) and magnetic body (MB) using EEG. Meridian system would be permanently connected system of communication lines.

This picture leads to a concrete proposal about the roles of DMT and pineal gland concerning imagination and dreams and hallucinations.

8.1 Zero energy ontology (ZEO)

Zero energy ontology distinguishes TGD from standard model, and this distinction plays a key role in TGD based view about consciousness and sensory perception.

1. In ZEO quantum states are pairs of positive and negative energy states. Positive energy states are analogous to the usual quantum states assignable to time=constant section of space-time. Time=constant section is replaced with a pair of 3-surfaces located at the opposite boundaries of causal diamond (CD) defined as the intersection of future and past directed light-cones of M^4 with each point replaced with CP_2. CDs form a hierarchy with CDs within CDs. In consciousness theory CD is identifed as the perceptive field of self and sub-CDs correspond to subselves defining mental images of self.

   Space-time surfaces are preferred extremals of certain action serving as analogs to Bohr orbits having 3-surfaces at the opposite boundaries of CD as their "ends". Quantum states are quantum superpositions of preferred extremals. Holography is realized in the sense that 3-D data (3-surfaces) at the boundaries of CD fixes the space-time surface. In fact, preferred extremal property implies what I call strong form of holography (SH): 2-D data at string world sheets and partonic 2-surfaces is enough to fix the preferred extremals.

2. ZEO forces a modification of the standard quantum measurement theory. One must allow moduli space for CDs corresponding to a varying temporal distance between the tips of CDs. Lorentz transformations leaving the second tip of CD invariant generate new CDs. Besides this the position of the tip of CD can vary: one has full Poincare group transforming CDs to each other.

   During unitary time evolution the passive boundary of CD and members of state pairs at it are unaffected: they represent prepared state. The sequence of unitary time evolutions of this kind gives rise to a generalization of Zeno effect or what is called weak measurement.

   Active boundary becomes delocalized in moduli space of CDs with fixed passive boundary and also the states at it are affected in given unitary evolution. "Small" state function reduction localizes the active boundary in the moduli space. The distance between the tips of CD increases during sequence of "small" reductions.

   The observables measured in "small" state function reduction must commute with the observables, whose eigenstates the states at the passive boundary are. It sooner or later happens that all possible observables are measured and "big" reduction occurs and changes the roles of the boundaries of CD.

3. From the point of view of consciousness theory "big" reduction means death of the self assignable to a given choice of passive boundary and re-incarnation of self with opposite arrow of geometric time: active and passive boundaries of CD change their roles.

   The state function reduction sequence defining experienced time is mapped to a clock time defined by the increasing temporal distance between the tips of CD maps defined by sequences of unitary evolutions followed by "small" reductions. Only correlation would be in question. The identification of these times would lead to the well-known problems both in the philosophy of free will and in quantum measurement theory.

4. Since zero energy states are 4-D in well-defined sense, one can say that also the geometric past changes in state function reductions - this gives a connection with Libet's findings about active aspects of consciousness [J13]. Signals can propagate in both time directions, which allows to fuse sensory percepts and memories to single 4-D perception: CD and sub-CDs represent the 4-D perceptive field.

   Sensory input would be localized in good approximation near the active boundary of CD whereas the other aspects of 4-D percept would be interpreted as memories - mental images (subselves) located in geometric past. Symbolic representation of memories (only cognitive

mental images) would allow to distinguish sensory "Now" from past. Sensory memories are in principle possible and can be indeed induced by electric stimulation of temporal lobes. Some people with cognitive defects might be more or less permanently in a state of consciousness in which sensory input is 4-D (memory feats of autists). Memories could be also seen as communications with geometric past inside CD. Motor actions could be seen as sensory perceptions in non-standard direction of time.

8.2 A new view about the role of nerve pulses in sensory perception

Sensory perception would in TGD generate sensory mental images at sensory organs: this would solve a basic problem of neuroscience due to the similarity of neural tissue in various sensory areas. The new view about time and memory implied by ZEO solves the problem cause by the phantom limb. The pain in phantom limb is sensory memory of pain. The stimulation of temporal lobes indeed generates sensory memories, and people with cognitive inpairment are known for memory feats such as being able to draw some building seen in past with every detail or to learn music pieces with single listening. These feats can be understood if memories correspond to "seeing" in time direction with beam of dark photons travelling to past reflected back. ZEO allows this.

Also Libet's findings about active aspects of consciousness [J13] involving subject person deciding to raise his index finger and reporting it to experimetner can be understood in ZEO without giving up the notion of free will. In the quantum jump also the geometric past would be affected and this would explain why neural activity begins fraction of second before the conscious decision the subject person decides to raise his index finger.

Since perception involves a lot of processing this would require forth-and back signaling between brain and sensory organs. There would be virtual sensory input from brain or via brain. Sensory percept would be an artwork, standardized mental image, resulting as pattern recognition assigning to sensory input standardized mental image nearest to the input.

1. Nerve pulses would not mediate information inside brain. They would only build short connections between existing flux tube connections parallel to axons. Same happens in old fashioned telephone network by relays: it would be energy consuming to keep the connections on all the time.

   The velocity of nerve pulse conduction is quite too slow to realize the iteration leading to a standardized sensory mental image. If the signal velocity is light velocity, duration of order 1 ms for nervepulse also for 10 cm neural pathway about 10^6 forth and back travels between sensory cortex and retina.

   Communications would occur by dark photons signals with $h_{eff}/h = n$ and with maximal signal velocity allowing for an iteration leading to standardized percepts as near as possible to the sensory input and representing only the essential features. Dark photons could transform in energy conserving manner to biophotons with energies in visible and UV range (at least) and thus above thermal energy and therefore having effects not masked by thermal radiation. Brain is known to emit biophotons and they are also associated with axons [K10, K5].

2. All information molecules (neural transmitters, hormones, messengers) would be connection builders so that the view of neuroscience would be badly wrong here. I have discussed this idea earlier but in slightly different form: the proposal was that information molecules are attached to the end of a flux tube getting longer as the molecule travels to its target. This is possible but un-necessary since it is enough to build just the bridge between existing connections.

   Remark: The view of neuroscience might be very different if information technologies would have been known century ago. Same applies to homeopathy and water memory [K19], which still remains curse words in mainstream science, although a lot about the mechanisms involved is known.

   The standard view about learning as strengthening of synaptic connections would translate to a gradual build-up of permanent flux tube connections so that communications with dark photon signals would be possible all the time. This would lead to fusion of sender and receiver to single quantum entangled system.

If the meridians of acupuncture network correspond to this kind of permanent network, they would not require nerve pulses, transmitters, nor information molecules.

3. Nerve pulse patterns would however generate Josephson radiation at EEG frequencies propagating from brain to its MB from axonal membranes serving as Josephson junctions. EEG would code the nerve pulse patterns as frequency modulated Josephson radiation [K14].

This picture leads also to a more precise vision about how anesthetes act on human brain. The popular article "Scientists Just Changed Our Understanding of How Anaesthesia Messes With The Brain" (see `http://tinyurl.com/y8vxuorf`) tells about the [J19] finding that anesthetes weaken the communications between neurons (see `http://tinyurl.com/y976p94b`). It is found that an anesthete known as propofol restrics the movement of protein syntaxin 1a appearing as neurotransmitter at synapses and neurons.

The TGD inspired explanation for the loss of consciousness would be following. Nerve pulse activity is needed to generate neurotransmitters attaching to the receptors of post-synaptic neuron and in this manner forming connections between pre- and post-synaptic neurons giving rise to networks of active neurons. The transmitter would be like a relay in old-fashioned telephone network. Propofol would prevent the formation of the bridges and therefore of the networks of active neurons serving as correlates for mental images. No mental images, no higher level consciousness. At deeper level flux tube networks would accompany the networks of active neurons as already explained.

The earlier TGD inspired proposal was that anesthetes induce a hyperpolarization reducing the nerve pulse activity. How anesthetes could induce hyperpolarization [L9] (see `http://tinyurl.com/yatfreqe`): the model involves microtubules in an essential manner. Hyperpolarization would have same effect as the restriction of the movement of syntaxin 1a. This mechanism might be at work during sleep and also some anesthetes (but not propofol) could use it.

8.3 The role of DMT and pineal gland

Concerning sensory perception, dreams, hallucinations (psychedelic experiences), and imagination the roles of DMT and pineal gland are extremely interesting and suggests a unified view about these aspects of consciousness.

1. Pineal gland is third eye in quite concrete sense for some amphibians and reptiles. This suggest that it still has some function: biology does not invest metabolic energy without return. Could pineal gland serve as the eye of imagination?

   Dark photons would arrive from brain or via brain to pineal gland and give rise to imagined sensory experiences (almost seeing, almost hearing, ... thoughts as internal speech, etc...). All these signals would be realized in terms of dark photons in different wave length ranges for various sensory qualia and the entire energy range of biophotons could be involved: visible light involves one octave in good approximation. At this level perception would be basically "seeing".

2. DMT (N-N dimethyltryptamine, see `http://tinyurl.com/osfg9r3`) is the only psychedelic manufactured by brain itself: in pineal gland (see `http://tinyurl.com/86joshm`) in the case of rodents and therefore also in the case of higher mammals.

   Remark: In "DMT" "N-N" refers to two nitrogen atoms; "Dimethyl" refers to two CH_3 groups replacing H; ttryptamine is the only amino-acid having two aromatic rings.

   Endogenous DMT could have same role as psychedelics and could induce dreams. The state between wake-up and sleep is somewhat analogous to REM sleep and characterized by hallucination like sensory percepts. This cold be due to DMT. During wake-up state dreams would be intefere with genuine sensory percepts and would be replaced by imaginations. It would seem that the virtual sensory percepts associated with the build-up of sensory percept and via pineal gland must be independent.

3. The binding of DMT to receptors in pineal gland would give rise to small bridges connecting disjoint dark photon carrying flux tubes to connected flux tubes going down to sensory organs,

where the dark photon signals would give rise to dreams and hallucinations. What would be needed is that dark photons induce sensory stimulus at sensory organ.

Remark: Interestingly, the inverted structure of the lense in eye is optimal for receiving virtual visual input.

4. Also motor actions would be prepared by iterative process analogous to the build-up of sensory percept but in reverse direction of time as Libet's findings [J13] about active aspects of consciousness (volition) suggest. Motor action would be sensory perception in opposite direction of time: this makes sense in ZEO one makes distinction between experienced and geometric time. Imagined motor actions would be mediated by similar mechanism involving DMT and pineal gland.

A further fascinating possibility is that the flux tube connections extend even to outer space, to the brains of members of advanced civilization in distant galaxies. Could the experiences about encounters with ETs or god-like creatures reported by the uses of psychdeles could be real?

1. This is in principle possible since in TGD Maxwellian fields are topologically quantized. Magnetic field decomposes into flux tubes represented as flux sheets in many-sheeted space-time. One can say that any system has field identity, field body.

2. Dark photons can travel along the flux tubes of MB to arbitrary distances without weakening of the signal as in Maxwellian world.

3. ZEO allows also signals in non-standard time direction so that it is possible to send signal which is time-reflected back as signal in opposite time direction: this can happen almost instantaneusly so that finite light-velocity ceases to be a restriction to communications.

8.4 Your eyes are the mirrors of my soul!

A fascinating finding again (see `http://tinyurl.com/yabyjbp6`): neuroscientist Giovanni Caputo reports that staring into someone's eyes for 10 minutes induces an altered state of consciousness.

This findings seems to provide direct support for one of the most radical predictions of TGD based quantum view about brain (see `http://tinyurl.com/yczv2o5b`). Neuroscientists assume that nerve pulse pattern generate in brain sensory mental images, in particular visual mental images. In TGD framework brain would build cognitive representations and decompose perceptive field into standard objects in this manner but would not produce sensory qualia. The sensory mental images would be realized at the level of sensory organs. This would involve repeated feedback by using virtual sensory input from brain (or even magnetic body of brain) to build standardized sensory mental images giving rise to pattern cognition. During REM sleep the virtual sensory input would form the entire sensory input. Nerve pulses are quite two slow to achieve this and they would only generate sensory patways, kind of wave guides, along which dark photons with non-standard value $h_{eff} = n \times h_0$ of Planck constant would propagate forth and back.

This view allows to avoid the problem due to the fact that neuronal networks in various sensory areas look very much the same so that it is difficult to understand why they give rise to so different sensory qualia. The obvious objection is phantom limb phenomenon, which could be however understood is the pain in phantom limb is sensory memory of pain. It is indeed possible to produce sensory memories by an electrical stimulation of brain. In TGD the perceptive field would be 4-D and only sensory percepts would be localized to approximate time=constant snapshot having actually a finite duration of about .1 seconds. Memories (as distinguished from learned skills and conditionings) would correspond to contributions to memories from the geometric past.

Staring into eyes experience provides an opportunity to test the idea about virtual sensory input. A fusion of two conscious entities, call them A and B, at some level of self hierarchy might occur. This would involve entanglement, which in TGD framework would accompany the generation of magnetic flux tubes or actually flux tube pairs (by reconnection of flux loops) connecting the eyes of the experiencers and the propagation of the dark photons along flux tubes between the brains of A and B so that visual consciousness would be shared. For instance, A could see the virtual sensory input representing her own face at the face of B. This indeed happened! Volunteers had

also out of body experiences (OBEs), had hallucinations of monsters, and saw besides themselves their relatives.

One particular fascinating question is what seeing one's own relatives could mean. The answer depends on whether the subject persons knew each other or not. If not, then the information about relatives of say A would have been transferred from A to B and then returned as virtual sensory input via eyes of B to eyes of A. This is of course possible also when the persons know each other. A would be looking into consciousness mirror defined by B! This experiment would be the first direct realization of fusion of two selves by quantum entanglement. The revolution in neuroscience is now in full swing!

9 How did language emerge?

I encountered in FB a link to an article titled "*Unique mix of brain chemicals separates humans from other primates*" (see `http://tinyurl.com/y7vrjflv`). The article inspired the following comments as a reaction, which are not so much about the chemistry but about what to my view goes outside chemistry.

Cultural evolution is what distinguishes us so sharply from our cousins. The evolution of social structures made possible by the emergence of language is certainly crucial for it. To me it is far from obvious whether this can be explained in terms of chemistry alone. My views are based on TGD inspired theory of consciousness and quantum biology and involve notions like magnetic body and hierarchy of Planck constants.

In the sequel I will consider a scenario in which language as internal speech preceded ordinary spoken language. At gene level this language was based on the expression of DNA as "m"usic of light with codons represented as allowed 3-chords in given harmony [L6]. It would have later found neural expression and via a mechanism analogous to a generation of sensory hallucinations led first to genuine hearing of internal voices. The mimicry of these internal voices would have served as the evolutionary pressure leading to the evolution of speech and speech organs.

9.1 The notion of magnetic body and the emergence of language and cultural evolution

1. The notion of magnetic body (MB) as intentional agent using biological body as motor instrument and sensory receptor is central in TGD based view about biology and neuroscience. Flux tubes serving as correlates of attention and making possible quantum entanglement and communications by dark photons give quite concretely rise to bonds between systems in various scales. In TGD Universe the notion of magnetic body in crucial for understanding life in general. The emergence of collective levels of consciousness involving large scale MBs would make possible cultural evolution and allow to understand the dramatic difference between humans and other animals.

2. The hierarchy of Planck constants $h_{eff}/h = n$ would be crucial. The larger the value of n, the larger the scale of quantum coherence. Cultural evolution would involve increase of n leading to a formation of large MBs characterizing collective levels of consciousness. The MBs of DNAs consisting of flux sheets going through DNA would combine to bigger structures assignable to organs, organisms, and even populations. This could make possible cultural evolution as emergence of higher level conscious entities with collective genome and collective gene expression.

3. There might be also other deep differences at DNA level not visible at the level of chemistry. The braiding of magnetic flux tubes emanating from the intronic part of DNA could make possible topological quantum computations and a new kind of memory and this might led to the quantum leap to real cultural evolution: the portion of introns is largest for humans.

9.2 What internal speech could be?

The emergence of language and speech organs is certainly a revolutionary step in evolution. What language is at quantum level? What thoughts as internal speech are at deeper level.

1. My own proposal is that internal speech has as neuronal correlates linear structures of activated neurons giving names for things and having linear flux tube sequences and corresponding quantum states as correlates at the level of MB. This does not however tell what internal speech is at deeper quantum level.

2. Did thinking as internal speech precede ordinary speech or vice versa? If internal speech came first, one avoids the problem of understanding why only certain sounds have meaning as words. Assume that this is the case.

3. Genes are fundamental in biology. Did internal speech evolve as one particular form of gene expression? TGD inspired model for music harmony based on 12-note scale realize as Hamilton's cycle at icosahedron [L6] (see `http://tinyurl.com/yad4tqwl`) leads to a model of genetic code predicting correctly the numbers of codons coding for given amino-acid and to the proposal that genes express themselves are controlled by signals consisting of sequences of 3-chords allowed by a particular bio-harmony with 64 3-chords (256 of bio-harmonies) [L26] (see `http://tinyurl.com/ydhxen4g`). Given harmony would define an emotional state, mood.

   Gene would be represented as a sequence of 3-chords - accompaniment for a song, melody. Melody would be a sequence of single notes of 12-note scale consistent with the bio-harmony. The sequence of 3-chords allowed by the harmony would define the emotional character of the "music piece". Harmony would be something which chemistry cannot explain.

4. How the accompaniment and song were represented at gene level? The most natural guess is that both the notes of 3-chords of the harmony defining the mood and the melody were represented as dark light. This would be music of light consisting of dark photons rather than phonons: notes would have been analogs of laser beams along flux tubes characterized by frequency and duration.

   How singing was represented at neuronal level? My proposal is that it was represented as 2-D structure of activated neurons having connected magnetic flux tube network as correlate and representing the mental image. Perhaps the pitch and duration of the note served as 2 discrete coordinates in neuronal lattice [L16] (see `http://tinyurl.com/yczv2o5b`).

5. It is said that right brain sings and left brain talks. These two modes of expression relate like function and its Fourier transform. Did (internal) singing precede (internal) speech? At neuronal level this is suggested by the fact that Alzheimer patient who has lost understanding of language and ability to talk can still understand singing and also sing. Indeed, 1-D linear flux tube structures representing thoughts splits as amylose splits the neuronal connection so that speech is not possible. 2-D structures survive even if some connections are split [L18] (see `http://tinyurl.com/ybq6r3xu`). Note that these two modes relate to cognition and emotion. Emotion came first as indeed evolution of nervous system demonstrates.

9.3 How did spoken language emerge?

How do the words of spoken language transform to internal speech and vice versa? What distinguishes words from ordinary sounds?

1. The piezoelectric property of bio-matter makes possible the transformation of light to sound: now light would consist of dark photons with energies $E = h_{eff}f$ in bio-photon range (visible and UV) and frequencies f in the range of audible sound frequencies. Did this transformation somehow give rise to genuine auditory experience of internal song/speech? Did internal singing/speech transform to heard singing/speech by virtual sensory input from brain to ears?

   In TGD based model for sensory perception, hallucinations/psychedelic experiences, and imagination [L16] (see `http://tinyurl.com/yczv2o5b`) this kind of virtual sensory input is essential since sensory qualia are at the level sensory organs and the objects of perceptive field are standardized mental images, kind of artwork requiring resulting from pattern recognition involving a lot of forth-and-back signalling between brain and sensory organs by dark photons).

We would experience mere virtual sensory input in dreams (REM), hearing voices from head, etc... Pineal gland ("third eye") receiving dark photons signals would receive internal speech and in presence of DMT would channel it to ears producing heard internal song/speech. Jaynes argues that what he calls bicameral consciousness preceded modern consciousness and was like that of schizophrenic and people heard their thoughts as voices in head and interpreted these voices as voices of Gods.

2. Did speech and speech organs evolve from the attempts to mimic this genuinely heard internal singing/speech. This would answer the question why only certain kind of sounds have meaning as words. Did this attempt provide evolutionary pressure leading to the emergence of genes coding for speech organs and speech as a motor activity?

   Remark: An amusing analogy pops in mind: internal speech viz. internal song is like rap viz. ordinary singing dropping out much of the emotional content.

   This cannot be the whole story. Language learning is a social phenomenon involving mimicry. Modern human cannot learn to speak by listening only voices in his head! One can however ask whether languages have some universal pattern. For instance, could very primitive languages depend only on species? What is the role of the collective consciousness: does it talk in the same manner to individuals of the group who then mimic this talk. Was the God of the bicamerals the collective consciousness of the group?

10 Revolution in neuroscience: Hebb's rules updated?

A group of scientist, led by Prof. Ido Kanter, of the Department of Physics and the Gonda (Goldschmied) Multidisciplinary Brain Research Center at Bar-Ilan University [J10] (see `http://tinyurl.com/ydb2awmt`), has published an article Scientific Reports, which could have revolutionary implications for neuroscience.

Kanter *et al* claim that the old Hebb that learning takes place in synapses, is mistaken. Instead, the learning would take place in dendrites and much nearer to the neuron and only few parameters would determine the outcome unlikes in Hebbian approach in which thousands of parameters - synaptic strengths determine the outcome. Furthermore, weak synaptic connections - most of synaptic connections are weak - would be more significant as believed.

What the new view about learning could mean from the viewpoint of quantum brain paradigm according to TGD? In this vision magnetic tube pairs having define connections of a dynamical network having neurons at nodes. The connectivity/topology of this network is changing all the time. At deeper level supra currents and dark photons would be responsible for signalling and the function of nerve pulses would not be communication but to change the topology of the network via the activation of synaptic contacts. Neurotransmitters would be like relays in old fashioned telephone network.

If Kanter *et al* is right, dendrites would learn instead of synapses. Should one talk about dendritic strengths instead of synaptic strengths? Also weak synapses - most synapses are weak - would be important. What happens to "neurons that fire together wire together" paradigm?

Consider first as background TGD vision about neuroscience. The following article summarize the recent developments [L15, L16, L18, L26] (see `http://tinyurl.com/y75246rk`, `http://tinyurl.com/yczv2o5b`,`http://tinyurl.com/ybq6r3xu`, and `http://tinyurl.com/ydhxen4g`).

1. In TGD picture axons and dendrites would be accompanied by pairs of flux tubes carrying opposite magnetic fluxes. This is required by their super-conductivity based on spin zero Cooper pairs - this is quite general model of high Tc superconductivity in which the flux tube pairs are made possible by anti-ferromagnetism.

2. Reconnection of flux tubes is the basic topological mechanism changing the topology of the network. It corresponds in string theory the basic vertex for closed strings.

What does this give?

1. One can represent axon and dendrite by two parallel lines with opposite directions representing flux tubes with opposite fluxes.

2. Consider first axon and dendrite (or axons and axon, or dendrite and dendrite, etc...). What synaptic connection could mean in this picture? I wis I could draw. One has a pair of lines A_+A_-. One has B_+B_- has U-shape. B_+ simply turns back as B_-.

   Then reconnection takes place. Nothing happens for A_+. A_- splits to two piece $A_-(1)$ $A_-(2)$ and the end cap of B_+B_- U-shape is cut off.

   B_- reconnects with $A_-(2)$ and B_+ reconnects with $A_-(1)$. One obtains V shaped structure with edges of V represented by pairs of lines with opposite directions: nowhere opposite arrows meeting each other. Synaptic strength tells the probablity for the formation of this structure, which represent change in the topology of the network.

   The reconnection for flux tube pairs makes the earlier topological picture more complex. The communication channels defined by flux tube pairs can branch or fuse so that the network structure is much richer. Supra-currents or dark photon signals from two sources can superpose. Also more complex entanglement patterns become possible.

3. What about the new notion of dendritic strength? It should tell the probability that there indeed exists a flux tube pair connection between neuron and the rest of the network. This connection can be however split by reconnection. Parallel lines with opposite fluxes pinch together and transform to two U-shaped structures: two U:s face-to-face.

   Dendrite strengths tells how stable the parallel flux tube pair is against this reconnection. In TGD model of superconductivity it tells how stable supracurrent "wire" is and transition from small scale super-conductivity to genuine super-conductivity occurs when long flux tube pairs become stable.

What can one conclude?

1. The claimed findings would say that the dendritic connections are most important for learning and certainly they are so: without dendritic connection at flux tube level, no signals enters neuron. Neuron becomes a hermit isolated from the rest of the brain.

   But also synaptic strengths are important although not important from the point of view of single neuron but from the point of view of the topology of the entire network: the qualitative features of this topology distinguish between spatial thinking involving 2- or even 3-D networks and verbal cognition involving linear networks: this explains why right brain signs and left brain talks. Dendritic strength as a measure for the stability of the connection of neuron to the network and synaptic strength for the ability to change topology of the network temporarily.

2. Hebb's statement could be rephrased as follows. Distribution of synaptic strengths would determine which neurons can wire together and dendritic strength would determine the probability with which neuron can fire together with others.

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