About Concrete Realization of Remote Metabolism

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Abstract

The idea of "remote metabolism" (or quantum credit card, as I have also called it) emerged more than a decade ago - and zero energy ontology (ZEO) provides the justification for it. The idea is that the system needing energy sends negative energy to a system able to receive the negative energy and make a transition to a lower energy state. This kind of mechanism would be ideal for biology, where rapid reactions to a changing environment are essential for survival. Originally this article was intended to summarize a more detailed model of remote metabolism but the article expanded to a considerably more detailed view about TGD inspired biology than the earlier vision.

It is shown that the basic notions of the theory of Ling about cell metabolism inspired by various anomalies have natural counterparts in TGD based model relying on the notion of magnetic body. Remote metabolism can be considered as a universal metabolic mechanism with magnetic body of ATP, or system containing it, carrying the metabolic energy required by the biological user. In particular, the role of ATP is discussed in Ling's theory and from the point of view of TGD-inspired theory of consciousness.

It is easy to imagine new technologies relying on negative energy signals propagating to the geometric past and ZEO justifies these speculations. Remote

metabolism could make possible a new kind of energy technology. The discoveries of Tesla made more than a century ago plus various free energy anomalies provide excellent material for developing these ideas, and one ends up with a concrete proposal for how dark photons and dark matter could be produced in capacitor-like systems analogous to cell membranes and acting as Josephson junctions and how energy could be extracted from "large" magnetic bodies.

The model identifies Josephson frequency with the subharmonic of the frequency characterizing the periodicity of a periodic voltage perturbation assumed to correspond to cyclotron frequency in biological applications. Together with quantization conditions for charge and effective Planck constant it leads to precise quantitative predictions for capacitor-like systems acting as dark capacitors. Also a relationship between the magnetic field at the magnetic body of the system and the voltage of the capacitor-like Josephson junction emerges.

The predictions allow new quantitative insights about biological evolution as emergence of Josephson junctions realized as capacitor-like systems both at the level of cell, DNA and proteins, and brain. h_{eff} can be related to Josephson frequency and cyclotron frequency and thus to measurable parameters. h_{eff} serves as a kind of intelligence quotient and its maximization requires the maximization of both the voltage and area of the membrane-like capacitor system involved. This is what has happened during evolution. Indeed, the internal cell membranes, cortical layers and DNA double strand in chromosomes are strongly folded, and the value of membrane electric field is roughly twice the value of the electric field for which di-electric breakdown occurs in air. Even 40 Hz thalamocortical resonance frequency can be understood in the framework of the model.

The claimed properties of Tesla's "cold electricity" strongly suggest interpretation in terms of dark matter in TGD sense. This leads to a proposal that a transition to dark phase occurs when the value of voltage equals the rest mass of charged particle involved. This criterion generalizes to the case of cell membrane and relates the values of h_{eff}, p-adic prime p, and threshold potential for various charged particles to each other. The idea that nerve pulse corresponds to the breakdown of super-conductivity as a transition from dark to ordinary phase receives additional support. The resulting picture conforms surprisingly well with the earlier speculations involving dark matter and p-adically scaled variants of weak and color interactions in biologically relevant length scales. An extremely simple mechanism producing ATP involving only the kicking of two protonic Cooper pairs through the cell membrane by Josephson photon as a basic step is proposed. Also the proposal that neutrino Cooper pairs could be highly relevant not only for cognition and but also metabolism finds support.

Contents

1 Introduction

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a system able to receive the negative energy and make a transition to a lower energy state. This kind of mechanism would be ideal for biology, where rapid reactions to a changing environment are essential for survival. Originally this article was intended to summarize a more detailed model of remote metabolism but the article expanded to a considerably more detailed view about TGD inspired biology than the earlier vision.

1.1 Short glossary about the basic concepts of TGD

The model involves several new physics elements. It is good to begin with a little glossary to get a rough view about basic ideas of TGD and TGD inspired biology. The following list explains briefly the notions relevant to the ontology of TGD Universe.

- The notion of ***many-sheeted space-time*** distinguishes between TGD and special and general relativities. In TGD framework space-times are regarded as a 4-D surfaces in certain 8-D space $M^4 \times CP_2$ obtained from empty Minkowski space M^4 by adding four small dimensions. The study of field equations characterizing space-time surfaces as "orbits" of 3-surfaces (3-D generalization of strings) forces the conclusion that the topology of space-time is non-trivial in all length scales. Many-sheeted space-time consists of space-time sheets in various length scales with smaller sheet being glued to the larger ones by wormhole contacts identified as building bricks of elementary particles. The sizes of wormhole contacts vary but are at least about CP_2 size (about 10^4 Planck lengths) and thus extremely small for ordinary elementary particles.

- The notion of many-sheeted space-time forces the replacement of reductionism with ***fractality***. This is the basic motivation for applying TGD in, say, biology. The most radical prediction is the existence of scaled variants of physics of strong and weak interactions in various length scales, and biology is especially interesting in this respect. Fractality reflects itself as various length scale hierarchies.

    1. ***p-Adic physics*** as a physics of cognition and intention and the fusion of p-adic physics with real number based physics are new elements. p-Adic mass calculations lead to the ***p-adic length scale hypothesis*** stating that preferred p-adic length scales correspond to primes p near powers of two: $p \simeq 2^k$, k positive integer. Mersenne primes M_k of form $2^k - 1$, and Gaussian Mersennes $M_{k,G}$ of form $(1+i)^k - 1$ (k some prime in both cases) are especially favored with biologically interesting length scale range [10 nm, 2.5 μm] containing as many as four Gaussian Mersennes, which could be seen as a number theoretic miracle.
    2. ***Dark matter hierarchy*** realized in terms of a hierarchy of values of effective Planck constant as integers using $\hbar$ as a unit. Large value of h_{eff} makes possible macroscopic quantum coherence crucial in living matter. For instance, it allows dark ELF photons with energies above thermal energy ($E = h_{eff} f$).

- ***Topological field quantization***. This distinguishes between TGD and Maxwell's electrodynamics. TGD leads to a geometrization of the notion of classical field.

Both weak, electromagnetic, and gluon fields are known once the space-time surface as a solution of field equations is known. This implies an enormous reduction in the number of degrees of freedom but the many-sheeted space-time brings in additional degrees of freedom allowing to avoid conflicts with known experimental facts about fields.

Topological field quantization means that fields are replaced by quanta of space-time. For instance, constant magnetic field decomposes into space-time surfaces of finite size representing flux tubes or sheets. Field configurations are like Bohr orbits carrying very specific "archetypal" field patterns. Radiation fields corresponds to so called topological light rays or massless extremals (MEs), magnetic fields correspond to magnetic flux quanta (flux tubes and sheets) having as primordial representatives "cosmic strings", electric fields correspond to electric flux quanta (say cell membrane), and elementary particles have so called CP_2 type vacuum extremals as basic building bricks.

- ***Field body*** and ***magnetic body***. These notions follow from topological field quantization. In TGD Universe a physical system has a corresponding field identity - field body or magnetic body - in the sense that a given topological field quantum corresponds to a particular source (or several of them - say in the case of flux tube connecting two systems). In Maxwell's electrodynamics one cannot achieve this kind of identification since the fields created by different sources superpose. Superposition is replaced with a set theoretic union implying that only the *effects* of the fields assignable to different sources on test particle superpose.

  Field body and magnetic body bring in new degrees of freedom highly relevant in TGD inspired quantum biology. Magnetic body has hierarchical onion-like structure reflecting corresponding structure for the system with which it is associated. One can also speak of ***dark magnetic body*** corresponding to the value of effective Planck constant $h_{eff}/h = n$. Dark space-time surface can be regarded as an analog of n-sheeted Riemann surface - an n-furcation of space-time surface occurring because of the extremely non-linear dynamics of Kähler action.

- ***Magnetic body as an intentional agent using biological body as a sensory receptor and motor instrument*** is an attractive identification but one should be cautious. One could argue that magnetic body and biological body together form the natural intentional unit - kind of "super-body" - and that in remote metabolism energy is transferred between biological and magnetic body parts. Note however that personal magnetic body has a hierarchical onion-like layered structure and that several magnetic bodies can use the same biological body making possible remote mental interactions such as hypnosis [L3].

- ***Magnetic flux tubes and sheets*** serve as "body parts" of the magnetic body, and one can speak about magnetic motor actions. Besides concrete motion of flux quanta analogous to ordinary motor activity, basic motor motor actions include the contraction of magnetic flux tubes by a phase transition reducing Planck constant, and the change in thickness of the magnetic flux tube changing the value of magnetic field and thus the cyclotron frequency. Reconnections of the flux tubes allow to magnetic bodies to get in contact and temporal variations of

magnetic fields inducing motor actions of magnetic bodies favor the formation of reconnections. Flux tube connections at molecular level bring a completely new element to biochemistry. Flux tube connection serves as a space-time correlate for attention in TGD inspire theory of consciousness. ATP-ADP process could have interpretation in terms of reconnection.

- ***Cyclotron Bose-Einstein condensates*** of various charged particles can accompany magnetic bodies. Cyclotron energy $E_c = hZeB/m$ is much below thermal energy at physiological temperatures and magnetic fields possible in living matter. In the transition $h \to h_{eff}$ E_c is scaled up by a fractor $h_{eff}/h = n$ and for sufficiently high value of h_{eff} cyclotron energy can be above thermal energy $E = h_{eff}ZeB/m$. The observations of Blackman about quantum like effects of radiation at harmonic of Ca^{++} cyclotron frequency could be used as motivation for introducing the hierarchy of Planck constans. The proposal is that cyclotron Bose-Einstein condensates associated with DNA and cell membrane - perhaps cell membrane proteins - play a key role in biology.

- ***Massless extremals (MEs)/topological light rays*** are extremals of the Kähler action replacing radiation fields in Maxwell's theory. Laser beam serves as a good analogy for ME. MEs are tubular space-time surfaces carrying classical fields propagating with light velocity. Since the waves propagate in single direction only there is no dispersion and MEs make possible precisely targeted communications without loss of information. Linear superposition is possible in the direction of ME. Both electromagnetic, weak, color and gravitational fields are present as induced fields. MEs can carry light-like currents and can be charged: in Maxwell's theory this is not possible. For charged MEs polarization has a longitudinal component. Tesla's scalar waves are obvious analogs for charged MEs. Charged MEs can however serve as correlates also for charged particles like electron.

- ***Josephson junctions*** are junctions between two super-conductors, say, parallel wires or analogs of capacitor plates carrying supra currents. ***Josephson current*** is generated when there is a phase difference $\Delta\Phi(t) = \int ZeV dt/h$ between the two super-conductors involved. Josephson current is of the form $J = J_0 sin(\Delta\Phi(t))$. For constant voltage V the current is oscillating with ***Josephson frequency*** $f_J = ZeV/h$. The frequency for cell membrane is rather high for the ordinary value of Planck constant but $h \to h_{eff}$ scales it down so that even ELF frequencies are possible. The charge carriers of Josephson current are in accelerated motion and expected to radiate. The radiation is quantum process analogous to emission of photon by an atom and occurs with quantized energies coming as harmonics of Josephson energy ZeV having interpretation as electrostatic energy gained by the charge carrier "freely falling" through the junction. Charged particle can jump to the other side of cell membrane by absorbing positive energy Josephson photon or sending negative energy Josephson photon. This would define the basic mechanism of charge transfer for ionic pumps.

  In TGD inspired biology Josephson junctions are associated with electric flux quanta of which cell membrane carrying extremely strong electric field represents the basic example. In low length scale resolution one can regard the entire cell

membrane as a Josephson junction. In improved length scale resolution cell membrane proteins are natural candidates for Josephson junctions and might define quantum counterparts for channels and pumps. The conjecture is that superconductors and Josephson junctions form a length scale hierarchy. The levels of this hierarchy can communicate by exchange of Josephson photons if the values of h_{eff} and Josephson energies were the same for them.

- The recent view about ***negentropic entanglement*** forced by Negentropy Maximization Principle (NMP) [K11] is very simple and leads to a connection between negentropic entanglement, dark matter hierarchy, p-adic physics, and quantum criticality. NMP holds true only in the intersection of realities and p-adicities - that is, applies in the situations in which density matrix for a system and its complement is multiple of identity matrix resulting in general quantum measurement identified as a measurement of the density matrix. Negentropic entanglement is always maximal entanglement so that the density matrix is proportional to unit matrix and corresponds to a value of effective Planck constant equal to the integer $\hbar_{eff} = n\hbar$ telling the number of the entangled states. The p-adic prime assignable to the system corresponds to the largest prime power factor of n. n has interpretation as the number of sheets of multi-sheeted covering defining n-furcation of space-time sheet and the n-furcation is manifestation of quantum criticality implying n-sheeted covering property. Negentropic entanglement is a prerequisite for an experience defining abstraction as a rule having as instances the state pairs appearing in the entangled state. Note that the state pairs are not unique since any unitary transformation acting in the same manner to the two entangled state basis is allowed.

- In ***zero energy ontology*** (ZEO) physical states are pairs of positive and negative energy parts having opposite net quantum numbers and identifiable as counterparts of initial and final states of physical event in ordinary positive energy ontology. Positive and negative energy parts of the zero energy state are at the opposite boundaries of ***causal diamond*** (CD) defined as a double-pyramid-like intersection of future and past directed light-cones of Minkowski space.

  There is a fractal hierarchy of CDs within CDs (and perhaps also overlapping with each other). The sizes of CDs (definable by the temporal distance between its tips) come as integer multiples of CP_2 time T_{CP_2} and the fundamental time scale $T = .1$ s of biology corresponds to $T = nT_{CP_2}$, $n = M_{127} = 2^{127} - 1$. This time scale corresponds to the secondary p-adic time scale assignable to electron and is macroscopic. As a matter of fact, all elementary particles correspond to macroscopic time scales: this predicts a direct connection between elementary particle physics and macroscopic physics.

  In TGD inspired theory of consciousness CD defines what might be called a spot-light of consciousness in the sense that the contents of conscious experiences associated with given CD are about the space-time sheets in the imbedding space region spanned by CD. Physical states are superpositions of pairs of positive and negative energy parts at opposite boundaries of causal diamond (CD) defined as double-pyramid-like intersection of future and past directed light-cones of Minkowski space. The conserved quantum numbers of positive and negative

energy parts are opposite. Zero energy state is actually a superposition of zero energy states associated with CDs of different size scale characterized by integer. Time evolution with respect to subjective time is a sequence of state function reductions at opposite boundaries of CDs involving localization of that boundary and state fiunction reduction at it but necessarily forcing the delocalization of the opposite boundary. During this process CDs in the superposition tend to increase in size, and this gives rise to the experienced flow and arrow of time. The pairs of state reductions at opposite boundaries correspond to sensory percept followed by motor action as reaction at the level of the brain. Phase conjugate laser beam would represent a standard example of negative energy photons.

Negative energy signals would have several functions: realization of intentional action initiating neural activity in geometric past would explain Libet's well-known findings, memory as communication with geometric past with time reflection in time direction defining "seeing" in time direction, and remote metabolism.

1.2 Plan of the article

The model of remote metabolism and the vision behind it is applied to biology. It is shown that the basic notions of the theory of Ling about cell metabolism inspired by various anomalies have natural counterparts in TGD based model relying on the notion of magnetic body. Remote metabolism can be considered as a universal mechanism of metabolism with magnetic body of ATP, or system containing it, carrying the metabolic energy required by the biological user. In particular, the role of ATP is discussed in Ling's theory and from the point of view of TGD-inspired theory of consciousness.

It is easy to imagine new technologies relying on negative energy signals propagating to the geometric past and ZEO justifies these speculations. Remote metabolism could make possible a new kind of energy technology. The discoveries of Tesla made more than a century ago plus various free energy anomalies provide excellent material for developing these ideas, and one ends up with a concrete proposal for how dark photons and dark matter could be produced in capacitor-like systems analogous to cell membranes and acting as Josephson junctions and how energy could be extracted from "large" magnetic bodies.

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roughly twice the value of the electric field for which di-electric breakdown occurs in air. Even 40 Hz thalamocortical resonance frequency can be understood in the framework of the model.

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2 Quantum credit card

The receiving system serving as energy storage would be analogous to a population reversed laser and one can imagine at least two new physics options for the laser like system.

2.1 Two realizations for the "population inverted laser"

The two options could be realized for ordinary matter at biological body and for dark matter at the magnetic body respectively.

1. One possibility is provided by zero point kinetic energy depending on the size scale of the space-time sheets $E \sim \hbar^2\pi^2/2mL^2(k)$, where $L(k)$ is the p-adic length scale given by p-adic length scale hypothesis stating that p-adic primes $p \simeq 2^k$, k integer are favored. m refers to the mass of the particle transferred between space-time sheets as the laser like system is excited or de-excited. I have considered the identification for a hierarchy of metabolic energy quanta in terms of p-adic length scales comings as square roots of powers of two and defining a hierarchy transition energies which are not identifiable as ordinary molecular transition energies [K2]. The ordinary metabolic energy quantum whose nominal value can be taken as .5 eV belongs to this hierarchy and corresponds to proton for atomic p-adic length scale $L(139)$ or to electron Cooper pair with p-adic length scale $L(149)$. From $m_p/2m_e \simeq 2^{10}$ and from the ratio of p-adic mass scales $2^{(149-139)/2} = 2^5$ it follows that zero point kinetic energies are approximately the same. This option makes sense for visible matter and also for dark matter: the zero point kinetic energies are same since $L(k, \hbar_{eff}) = (\hbar_{eff}/\hbar)L(k, \hbar)$ is very natural assumption. $\hbar_{eff} = n\hbar$ is the effective value of Planck constant. This hierarchy most naturally holds true for ordinary matter and I have discussed unidentified spectral lines from outer space as a possible evidence for the existence of this hierarchy.

2. Second option would be natural in dark matter sector for dark matter residing at the magnetic body of a given system serving as the energy storage of the system. The cyclotron Bose-Einstein condensates of bosonic ions or Cooper pairs of fermionic ions would define the analog of population reversed laser. TGD inspired nuclear physics allows also to have bosonic counterparts of fermionic ions behaving chemically in the same manner as their fermionic counterparts [K12]. The excitation energy would be defined by cyclotron energy $E_{=}h_{eff}f_c$, $f_c = qB/4\pi m$: here q and m are the charge and mass of the charged particle in question. If the value of $\hbar_{eff}$ is large enough, cyclotron energies are above thermal energy. For ordinary value of Planck constant they are typically very small.

The realization of quantum credit card for the latter option relies on reconnection of the magnetic flux tubes of the system extracting the energy and those associated with the energy storage. The energy storage could be higher onion-like layer of the personal magnetic body of the system or even some other magnetic body. The reconnection is possible only if the magnetic field strengths of reconnecting flux tubes are identical. Therefore the system needing energy should be able to tune the field strength on the receiving flux tubes by varying their thickness (conservation of magnetic flux guarantees that field strength behaves as inverse of the cross-sectional area of the flux tube). The reconnection gives rise to a formation of a flux tube between two systems and the system needing energy can send negative energy received by the excited cyclotron BE condensate.

This mechanism can also be behind the binding of molecules to corresponding receptors allowing the molecule to recognize the presence of the receptor after which the contraction of the flux tube by a phase transition reducing $\hbar_{eff}$ would bring the molecule to the receptor. Also water memory and homeopathic healing - and also immune system - would rely on the same mechanism. This mechanism appears also in the model of hypnosis as a kind of hijacking of parts of brain of the subject by hypnotist and in the general model of remote mental interactions.

2.2 Support for quantum credit card mechanism

There is some empirical support for the credit card mechanism.

1. Photons of phase conjugate laser light behaves like negative energy photons in the sense that second law holds true in the reversed direction of geometric time which must be distinguished from experienced time.

2. Popp has identified a process equivalent to "sucking of energy" in living matter, interpreting it as an extraction of energy in the form of biophotons [I9]. Extraction mechanism allows interpretation in terms of sending of negative energy photons, which can also be dark. In TGD Universe biophotons would result as dark photons decay in energy conserving manner to ordinary photons [K20]. The decay rate could be very small so that the intensity of dark photons could be quite high.

3. Sleighdogs [I10] can run for several days without eating and no signatures of ordinary metabolism have been found. This phenomenon cannot of course be

specific to sleigh dogs. Remote metabolism could explain the phenomenon as an extraction of metabolic energy from non-standard sources in absence of standard sources - say from the magnetic body associated with the collective formed by the dogs.

4. Yan Xin Qigong practitioners report that in so called Bigu state there is no need to eat solid food at all for days, weeks, months or even years. Western science is beginning to take Bigu state (`http://www.scribd.com/doc/40483378/Bigu-by-R-Roy`) seriously [I1] and the first national conference on Bigu state was held at the Pennsylvania State University in 2000, with presenters such as as Rustum Roy, founding director of Penn State′s Materials Research Laboratory and Hans Peter Duerr, former director of the Max Planck Institute.

One could argue that these individuals live by utilizing dark light as metabolic energy. Does living matter use quantum credit routinely or only in special situations when ATP-ADP mechanism is not available or the neural processing of incoming information leading to the decision about motor action is too slow? Quantum credit card mechanism allows also to initiate the neural activities preceding motor action in the geometric past and Libet's experiments indeed give support for this. Intentional action could be also seen as a top-down process in reverse time direction in which neural activity would be the last step.

One could also raise a more heretical question: could metabolic energy be always received by quantum credit card mechanism? Could the mysterious "high energy phosphate bond" actually reflect the fact that the metabolic energy is extracted from the magnetic body of ATP or some system containing it? Could energy reservoirs be filled by sending dark photon radiation exciting cyclotron states (EEG would be only one example of dark photons)? Or could ATP$\rightarrow$ ADP fill energy reservoirs at magnetic body?

The best manner to test this is by studying cells under metabolic deprivation. Ling [I5] has argued that ionic pumps and channels do not actually exist and the experimental support for this was his experimental finding that cells continue to function under metabolic deprivation. This could be also interpreted as support for the hypothesis that the ionic currents flowing through cell membrane are supra currents so that dissipation is very low and pumping is un-necessary. My own argument [K3] runs as follows:

> "One can also wonder how metabolism is able to provide the needed energy to this continual construction of pumps and channels and also do the pumping. For instance, sodium pump alone is estimated to take 45-50 per cent of the cell's metabolic energy supply. Ling has studied the viability of the notion of the ionic pump experimentally [I5] by exposing cell to a coctail of metabolic poisons and depriving it from oxygen: this should stop the metabolic activities of the cell and also stop the pumping. Rather remarkably, nothing happened to the concentration gradients! Presumably this is also the case for the membrane potential, so that the notion of metabolically driven electrostatic pumps seems to fail. Of course, some metabolism is needed to keep the equilibrium but the mechanism does not seem to be a molecular mechanism and somehow manages to use extremely small amount of metabolic energy."

My proposal has been that pumps and channels can be there, but are needed basically for the purpose of taking samples about the state of the cellular environment. This view was inspired by the vision that cell membranes serve as sensors communicating information about the cellular environment to the magnetic body. Metabolic energy is however needed for other purposes and one might argue that the finding of Ling supports the view that a cell in this kind of situation uses quantum credit card to extract energy from some magnetic body.

3 Comparison of Ling's vision of the cell to TGD view

Gilbert Ling (`http://gilbertling.org`) has proposed a theory of cell and living systems which challenges some basic assumptions of standard cell biology [I8, I5, I6, I7, I2, I3, I4]. This theory has several points of contact with the TGD view about living matter and it is interesting to compare the two approaches.

3.1 Ling's basic ideas and concepts

Ling challenges the notions of ionic pumps and channels, the notion of high energy phosphate bond, and the prevailing view about the role of ATP as energy currency. Ling also questions the views about the role of water and lipid layers of cell membrane in biology. Reading Ling's article about mitochondria [I4] revealed to me how little is known about living matter and how primitive the theories really are. It is difficult to avoid the feeling that the biochemical approach is a heroic attempt to understand living matter without appropriate concepts and ideas and therefore doomed to lead to a vicious cycle of ad hoc hypotheses.

Ling's finding [I6] that a cell can survive for days under conditions of metabolic starvation is his basic argument in favor of the proposal that ionic pumps do not actually exist and that the transfer of various ions and molecules through cell membrane relies on different mechanisms.

Ling's theory [I5] is summarized in the article "Main principles of Lings physical theory of the living cell" (`http://vladimirmatveev.ru/mainprinciples.html`) by Vladimir Matveev [I8]. Ling introduces several new notions.

1. ***The notions of resting state and activated state***.

   Biological basic structures in various scales appear in two states: resting state and activated state. These states are characterized by the associations between molecular pairs (to be described below). In the resting state most proteins are folded being covered with ordered water giving rise to several layers at the surface of the folded protein. Some protein however remain unfolded. In active state this layer melts and the protein's charged active sites become active and associations form between them and various ions or other active sites. Some proteins are unfolded also in the resting state. According to Ling ATP, water, and potassium ions (K^+) are adsorbed on the active sites of the unfolded proteins in resting state. In the activation ATP molecules are split and they give up phosphate ions to other molecules.

2. ***Association between two molecules - call them A and B for definiteness***.

   Association of B with A means that B tends to be adsorbed by A. Ling's argument [I5] goes as follows. Consider molecules A and B with opposite charges and assume that A is fixed in space (A could be protein and B ion). The fixing of the position reduces the kinetic energy and therefore reduces the total energy of the pair since Coulomb interaction energy is negative. Therefore the association of the molecules is energetically favored. An example of an associated pair would be protein and ion attaching to a charged active site of the protein, which is either anionic or cationic (negatively or positively charged). In this case one can indeed assume that the position of the protein is fixed.

3. ***Selective adsorption of B by A.***

   Adsorption probability described quantitatively in terms of affinity of A with respect to B - is enhanced by the presence of association so that one can speak of selective adsorption. Affinity of A with respect to B is defined as the energy liberated as B is attached to A. Electron affinity (`http://en.wikipedia.org/wiki/Electron_affinity`) of atom is an especially important affinity. In Ling's theory affinities of various biomolecules or their functional groups with respect to water molecules, Na^+ and K^+ ions, and other functional groups appear as parameters. In particular, the affinities of C=O and N-H groups of the peptide bonds of proteins with respect to water molecules and other such groups are important. Also the affinities of COOH groups of the amino-acid residues containing two COOH groups with respect to Na^+ and K^+ ions are important.

   Affinities characterize the state of the molecule: in particular, they are different for the resting state and activated state. For instance, unfolded proteins are highly affine with respect to K^+ in the resting state and with respect to Na^+ in the activated state. The phase transition changing the affinities accompanies the generation of action potential. The challenge is to understand why the affinities with respect to two ions with same charge and naively with same chemical properties are not essentially same. In principle, the definition of affinity as energy liberated in adsorption can explain this in terms of details of molecular chemistry since the geometry of the molecules matters besides charge distribution. The exponential dependence of Boltzmann factors appearing in equilibrium distributions could explain strong dependence of affinity on molecule.

   The physical nature of selective adsorption - that is affinity - is assumed to depend on electron density in the functional group considered. Low electron density characterizes the resting state and high electron density the activated state. The main regulator of the electron density is ATP, which has electron acceptor properties (Ca^{++}, signal factors, hormones, and chemical modifications of proteins serve as regulators) In the resting state ATP adsorbed to the protein site displaces electron density to the adsorption site and when ATP is split, the electron density is transferred to the activated state. This displaced electron density is analogous to "high energy phosphate bond".

4. ***Adsorption of water***.

In Ling's theory the role of water [I2] differs from than in standard theory. The polypeptide backbone of any completely unfolded protein has a geometrically regular order of positive (N-H) and negative (C=O) charges of the dipoles. This geometry is complementary to the space between water molecules surrounding the protein. This complementary makes possible multilayer adsorption of water on the protein surface. Large fraction of the cellular water is transformed to an ordered water. The outcome are stronger dipole-dipole interactions (hydrogen bonds are the major contributors). As a consequence, the water layers become a poor solvent as compared to bulk water and solutes are displaced from the volume of the adsorbed water. Ordered water acts like an ice layer serving as a barrier against diffusion of large solute molecules. The ordered water at cell surface is assumed to explain cell's selective permeability.

As the cell is activated, the "ice layer" melts and diffusion into cell becomes possible and is not prevented by lipid layers. Also the selectivity of each functional group of polypeptide changes: instead of a high affinity with respect to water molecules one has a high affinity with respect to the functional groups of the back-bone. This gives rise to secondary structures of protein (such as alpha-helix).

5. ***Induction process changing in a phase transition-like manner the associations between molecule pairs***.

   Activation process is a thermodynamical phase transition. Ling uses as an analog system magnet, a roughly linearly ordered sequence of magnetizable nails, and iron powder. When the magnet is brought to the system, the first nail is magnetized and magnetizes the second nail, which in turn magnetized the third,... The nails also attract that iron powder. The outcome is the organization of the system to a linear structure minimizing free energy. Skeptics can of course argue that this is just a metaphor involving in essential manner non-locality brought in by the presence of the long range magnetic field. Chemistry is however local and it is difficult to see how the non-locality could creep in without introducing some explicit realization for it. The problem is actually much more general: how it is possible that biomolecules manage to find their associates in the dense molecular crowd: how molecule A recognizes the presence of molecule B and how A and B then go to find each other to react chemically.

3.2 The fundamentals of Ling's vision from TGD view point

It came as a surprise that Ling's basic notions have rather direct TGD counterparts in terms of magnetic flux tubes and their dynamics based on reconnection and phase transitions changing the value of $\hbar_{eff}$ inducing the change of flux tube length.

3.2.1 The new view about metabolism

More than 15 years ago I used [K2] Ling's finding [I6] related to the ability of the cell to survive under metabolic deprivation as an argument to support the hypothesis that ionic currents are supra currents running with low dissipation; in addition direct measurements support the quantal character of these currents identified as Josephson

currents - in particular the fact that they do not depend on the properties of the membrane in question. Ling does not assume channels and pumps [I3], although in TGD framework they could be present. My cautious proposal has been that they exist for the purpose of taking samples about the molecular environment generating chemical sensory data communicated to the appropriate appropriate part of the magnetic body. In any case, metabolic energy is needed for may other purposes - in particular, in the transition to activated state, and one could argue that Ling's experiments indicate the existence of an un-identified energy source used when ordinary metabolic energy is not available.

The recent view about TGD suggests that magnetic bodies serve as metabolic energy reservoirs analogous to population inverted lasers defined by excited cyclotron BE condensates of electron and proton Cooper pairs and of various ions. Electronic Cooper pairs are preferred because of their small mass. Quantum credit card mechanism would allow the extraction of energy from the BE condensates by sending negative energy dark photon signals leading to de-excitation of the BE condensates. In this framework the questionable notion of high energy phosphate bond could be replaced with the storage of energy of this kind associated with ATP or with a system containing ATP. The loading of metabolic batteries could take place by sending positive energy dark photons to excite the BE condensates in question and solar radiation could do this as it generates ATP from ADP by adding single phosphate ion. In cell respiration dark photons at the magnetic body of molecules providing the energy would do the same thing using essentially the same mechanism involving electrons and transfer of three protons per ATP through mitochondrial cell membrane.

3.2.2 TGD counterparts for the basic notions of Ling

Ling's vision is very attractive - at least from a TGD point view. One can however wonder whether it can be realized in the framework of standard chemistry. Can the proposed mechanism of association really lead to the selective adsorption? In particular, it is not clear how a given active site of protein can select between ions of same charge? The basic concepts of Ling find natural TGD counterparts and TGD allows one to overcome the restrictions posed by sticking to the framework of standard chemistry.

1. In TGD framework the notion of association would reduce to that of flux tube or a flux tube pair connecting a pair of molecules or molecule (say active site of protein) and ion. Flux tube pair is favored since it allows to interpret reconnection process as touching of closed flux loops associated with A and B so that flux tube pair connecting A and B is generated.

   This view fits also nicely with one of the variants of the model of DNA as topological quantum computer [K6]. For the variant in question the two flux tubes would carry electrons at their ends and the spin states of the two electrons would give rise to 4 states in 1-1 correspondence with DNA nucleotides so that one would obtain a realization of DNA code in terms of flux tube pairs.

   Flux tube connections allow without further assumptions an additional selectivity in the sense that they can can exist between protein active site and on a particular ion only. As such Ling's proposal cannot distinguish between ions of same

charge. TGD allows flux tube connections also between various biomolecules and even between larger structures so that the notion of association is not restricted to protein-ion pairs or pairs of active sites. These connections are absolutely essential for the understanding of DNA transcription, translation and various bio-catalytic processes.

2. Adsorption process would mean a reduction of the length of the flux tube by a phase transition induced by the reduction of the value of $\hbar_{eff}$ so that molecules would get near to each other and chemical reaction would become possible.

   It is intuitively clear that the length of the magnetic flux tube increases by $\hbar_{eff}/\hbar = n$ in the phase transition $\hbar \to \hbar_{eff}$, or more generally by $\hbar_{eff,2}/\hbar_{eff,1}$ in the phase transition $\hbar_{eff,1} \to \hbar_{eff,2}$. Consider a momentum eigenstate $exp(ipz/\hbar_{eff,1})$ with wave vector $k_1 = p/\hbar_{eff,1}$ defined at a straight flux tube satisfying periodic boundary conditions and therefore satisfying $k = m2\pi/L$, L the length of the flux tube. Suppose that momentum p is conserved in the phase transition. This means that wave vector k is transformed from $k_1 = p/\hbar_{eff,1}$ to $k_2 = p/\hbar_{eff,2}$. To preserve the periodic boundary conditions the length of the flux tube must be scaled by $\hbar_{eff,2}/\hbar_{eff,1}$.

3. Induction process would mean a phase transition inducing reconnection process changing the flux tube connections between molecule pairs. This process would be a quantum phase transition. Whether two molecule can associate depends on the values of the local magnetic fields associated with the reconnecting flux tubes. If the values of both the magnetic field and flux tube thickness are same for the two tubes, association is possible. The value of the flux tube thickness allows to discriminate between different ions of same charge. Flux tube thicknesses characterize also the state of the system (resting state and various activated states). It is also possible that the protein can vary the thickness of the flux tube and therefore reconnect with different molecules. The change of flux tube thickness would take place in the quantum phase transition changing the connectedness structure of the net formed by molecules. The phase transition can be seen as a motor action of the magnetic body. Magnetic body "wakes up" in the activation process.

   Concrete examples about a process in which flux tube connectivities change in a phase transition-like manner would be melting of the "ice layer" around a folded protein bringing the proteins into "open air". The shortened flux tubes connecting the active sites of the peptide backbone and di-carboxylic amino-acid residues to water molecules would expand in $\hbar_{eff}$-increasing phase transition and de-reconnect. Water would transform to ordinary water. The resulting closed flux tubes accompanying amino-acids can reconnect with similar loops associated with other active sites of peptide and various secondary structures (such as α-helix) of the protein can form. I have discussed TGD inspired models of protein folding in [K1] in a rather light-hearted manner - mainly as an exercise in order to get familiarity with the notion of magnetic flux tube - and it would be interesting to reconsider the situation by characterizing the active sites by values of magnetic field/cyclotron frequency.

4. Why should the $\hbar_{eff}$ increasing phase transition accompanying the activation process require energy? The following argument suggests an explanation.

   (a) As explained, the length of the flux tube is proportional to $\hbar_{eff}$ and therefore changes. What happens to the thickness of the flux tube? The simplest assumption is that magnetic field strength is preserved so that cyclotron energy scales like $\hbar_{eff}$ if the sheet containing single high frequency boson is transformed to an n-sheeted state with one low frequency boson at each sheet. This brings to mind Bose-Einstein condensate and one can ask whether the formation of BE condensates of genuine bosons could have a microscopic space-time description as n-furcations.

   If bosons are Cooper pairs of fermions one encounters a problem with fermion number conservation in positive energy ontology. In ZEO one can in principle avoid this problem but one can argue that the change of fermion number in quantum jump for the positive energy part of the state is too radical an option. One possibility is allowance of fractional fermion number for a given sheet so that one can say that Cooper pair is delocalized between the sheets. One could also start from many-fermion state so that in the final state one would have one Cooper pair per sheet of the n-sheeted covering. For very large values of n this option is highly questionable.

   (b) The conservation of magnetic flux poses an additional constraint. If the number of sheets becomes n-fold and the total flux is conserved, the flux of single sheet must be a fraction $1/n$ the original total flux. Therefore the transition producing n-sheeted covering of flux tube scales down its cross sectional area roughly by a factor $1/n$.

   (c) A further condition comes from the quantization of magnetic flux telling that the net flux is integer multiple of $m_i\hbar_{effi,i}$ in the initial state ($i = 1$) and final state ($i = 2$). Conservation of the magnetic flux gives $m_1n_1 = m_2n_2 = m$ so that integer m giving the flux in units of $\hbar$ must be divisible both by n_1 and n_2. Therefore the phase transition can occur only when the magnetic flux using $\hbar$ as unit is larger than 1 and the allowed values of n_i are factors of m. For large values of integer n_2 this means that the thickness of the magnetic flux in the initial state must be macroscopic.

   (d) What happens to the magnetic energy of the flux tube? By considering a constant magnetic field one easily finds that flux conservation and invariance of B together with longitudinal scaling imply that the energy is scaled by integer $n = \hbar_{eff,2}/\hbar_{eff,1}$. Therefore part of the metabolic energy would be needed to make the flux tubes longer and thus to gain quantum coherence in a longer scale.

   One could say that the pumping of the metabolic energy is needed to preserve macroscopic quantum coherence. An attractive idea is that the energy is extracted from some magnetic body by sending negative energy dark photons. The contraction of flux tubes would occur spontaneously and liberate magnetic energy and reduce the value of $\hbar_{eff}$. It is natural to interpret this process as dissipation and loss of potentially conscious information.

5. Also the notions of resting state and activated state of biological structure (cell, protein, etc) have natural counterparts in TGD framework, together with the vision about the role of ordered water in biology. I have used the metaphor "cellular winter" for the resting state and "cellular summer" for the activated state induced by the feed of energy to the system so that it begins to self-organize. The TGD inspired model for ordered water (`http://tgdtheory.com/public_html/articles/activatedwater.pdf`) [L1] [K7] relies on topological quantization of the magnetic field giving rise to flux sheets giving rise to layered structure and there is also a connection with the notion of pairs of dark DNA identified as sequences of dark protons at opposite sides of the layer realizing genetic code [K12, K7].

It seems that the basic notions of Ling's theory - in particular the notion of association, which in my view remains questionable in the framework of standard chemistry - find natural counterparts in TGD framework. The view about cell membrane as Josephson junction leads to a new view about nerve pulse with Josephson currents of Cooper pairs of electrons and fermionic ions and of bosonic ions serving in the key role.

The ground state of the axon would correspond to a propagating soliton sequence mathematically analogous to that appearing in the sequence of mathematical pendulums. Nerve pulse would correspond to a propagating perturbation analogous to that obtained by kicking one pendulum to rotate in opposite direction. The detailed modeling of ionic currents is a fascinating challenge, and the view about the pairing of molecules and ions by flux tubes could provide a much more detailed and maybe realistic view about what really happens at cell membrane. It would also allow us to answer the question of whether pumps and channels are needed or whether they could be replaced with the TGD variants of the notions introduced by Ling.

Clearly, the basic question is whether standard biochemistry based on locality assumption is enough to describe living matter or whether the non-local quantum physics involving dark matter at magnetic flux tubes and transforming living matter from a soup of free ions and molecules to a dynamical Indra's net formed by biomolecules and flux tubes connecting them is needed.

3.2.3 Ling's view about ionic pumps and channels as compared to TGD views

Ling has empirical evidence that the prevailing ionic pump paradigm is wrong. The basic assumption of the prevailing theory is that both water molecules and various ions inside cell are free. This determines the kinetic equations used in the modeling of ion concentrations in chemi-osmotic theory [I4]. Ling assumes that in the resting state the important ions are adsorbed to proteins and that the activation of the cell changes the situation.

Besides adsorption also the notions of association and induction are needed in the formulation. Ling also emphasizes the role of the cellular water [I2]. Cellular water is not ordinary water but ordered water forming multilayered coverings of biomolecules in the resting state of the cell. This covering prevents various chemical activities of the molecules below the "ice layer". Only when the ordered water around proteins and other molecules melts, they become active and can participate biochemical reactions via

their active anionic or cationic sites to which ions or other biomolecules attach. In this framework the notions of ionic pump and channel must be given up or reformulated.

This picture is consistent with that provided by TGD. Instead of treating cell interior as a soup of free molecules one must treat the system as a kind of dynamical Indra's web in which flux tube connections are changing all the time. If ions are part of this web, one cannot apply ionic pump theory unless one can neglect the constraints caused by the presence of flux tubes.

The most important implication is that the web dictates to a high degree what biochemical reactions can occur and also takes care that the reactants are brought together when needed by reducing the value of Planck constant for appropriate flux tubes of the web. This transition also induces phase transitions changing the volume of a given region of cell. Sol-gel phase transition is basic example in this respect. It would seem that the best manner to describe the transfer of various molecules and ions through the cell membrane in TGD framework is as motor activities of the magnetic body of the cell quantum mechanically rather than biochemistry trying to reduce everything to single particle level and to thermodynamics.

The fact is however that channel and pump proteins exist and must have some function. The minimal function would be taking of samples from the chemical environment. Also in the generation of nerve pulses various voltage-gated ion channels play a key role. As will be found, the construction of a simple model for these channels demonstrates that quantal versions of channels and pumps emerge rather naturally in TGD framework: as a matter of fact, channel and pump proteins realize dark Josephson junctions! In particular, dissipation for ionic pumps is minimized since the transfer of ion through the cell membrane is a purely quantal process involving absorption/emission of Josephson photon with large value of h_{eff}. The unexpectedly low dissipation indeed served as a partial motivation of Ling in his approach.

3.3 The role of ATP according to Ling and in TGD framework

The notion of high energy phosphate bond and the real role of ATP in biology has been one of the long standing problems of TGD inspired biology. What is certainly clear is that ATP/ADP in which phosphate ion is transferred to the acceptor molecule is a fundamental process. Often this process is interpreted in terms of the transfer of metabolic energy and the view is that "high energy phosphate bond" carries the energy.

TGD inspired theory of consciousness however suggests a deeper meaning for ATP/ADP process.

1. Negentropic entanglement serves in TGD Universe as a correlate for a conscious experience of understanding: negentropic entanglement would be transferred in the process. The negentropic entanglement need not as such correspond to conscious experience but its presence makes possible conscious experience. Negentropically entangled systems would define what I have called "Akashic records", whose reading by interaction free quantum measurement (and idealized notion) would give rise to conscious experiences. "Akashic records" would be repre-

sentations defining the reflective level of consciousness giving rise to memories, predictions, sensory and cognitive representations,etc [K21].

2. My own view have been that ATP either carries and provides, generates, or induces a transfer of negentropic entanglement. I have considered all these options. The key observation is that negentropic entanglement is not a single particle property but characterizes the relationship between two particles. If ATP gives P to a particle B one would expect that B is one of the negentropically entangled particles in the final state. The other particle - call it A - must be negentropically entangled with P.

3. The recent view about negentropic entanglement forced by Negentropy Maximization Principle [K11] is very simple and leads to a connection with dark matter hierarchy, p-adic physics, and quantum criticality [K11] [L2]. The negentropic entanglement which can result in quantum measurement is always maximal entanglement so that density matrix is proportional to unit matrix and correspond to a value of effective Planck constant equal to the integer $\hbar_{eff} = n\hbar$ telling the number of the entangled states. Negentropic entanglement is a prerequisite for an experience defining abstraction about the rule having as instances the state pairs appearing in the entangled state. Note that the state pairs are not unique since any unitary transformation acting in the same manner to the two entangled state basis is allowed.

4. In the recent case this would mean that P and A at the ends of the exchanged flux tube $A - - - P$ must have negentropic entanglement characterized by integer n and that the flux tube $A - - - P$ associated with ADP in the initial state is associated with molecule B in the final state. The transfer of negentropic entanglement is indeed in question. The exchange of the flux tube $A - - - P$ can take place using reconnection process as the basic process.

5. Negentropic entanglement is conjectured to have as a correlate the braiding of the flux tubes connecting the entangled systems. Does this conjecture survive in the recent case? The flux tubes connect two partonic 2-surfaces at the boundary of causal diamond (CD). The space-time correlate for $\hbar_{eff} = n\hbar$ is the analog of n-sheeted Riemann surface. At the partonic 2-surfaces the sheets co-incide. Is it possible for the 3-D projections of the n sheets of single flux tube to become braided (linked and knotted)?

   If closed flux loops associated with A and B reconnect to form a *pair of* flux tubes connecting them (as suggested above) one has two alternative reconnections and one of them is uniquely selected by the conservation of flux. The first has minimal braiding and second one does not. Therefore two-tube connections do not guarantee that negentropic entanglement always corresponds to non-trivial braiding.

   The following argument assigns the braiding to *single* flux tube.

   (a) TGD also predicts another kind of braiding assignable to the ends of string world sheets at which the solutions of the modified Dirac equation are localized by the conditions that electric charge as spin-like quantum number

is well defined for them (eigenstate property). The string ends at the 3-D light-like orbit of the partonic 2-surface define a braid and the other ends of strings at other partonic 2-surfaces get braided during time evolution so that space-like braidings are generated.

(b) The strings seems to be in a natural 1-1 correspondence with magnetic flux tubes defining their cores. If this is the case the braiding for strings corresponds to the braiding for flux tubes idealized with infinitely thing strings. For $\hbar_{eff} = n\hbar$ one should have a light-like braiding of the ends of strings assignable to different sheets of the n-fold covering at the orbit of partonic 2-surface and this braiding would induce the space-like braiding.

It must be admitted that the connection between braiding and negentropic entanglement remains an attractive conjecture at this moment.

What does the transfer of negentropic entanglement mean metabolically?

1. As already noticed, Ling does not believe that energy is transferred in this process and "high energy phosphate bond" is certainly a questionable notion. I tend to believe that also energy is transferred as well but the open question is where it comes from. One can argue that the energy is needed to overcome the potential wall separating the states distinguished by different braidings.

   Remarks:

   (a) Four-dimensional spin glass property of TGD Universe gives rise to a fractal energy landscape and different valleys could be characterized by different braiding structures and phase transitions changing these structures would lead from a valley to another one.

   (b) Spin glass property means breaking of ergodicity. In a phase transition from resting state to activated state a large number of these transitions would occur and ATP $\rightarrow$ ADP transferring the entanglement would also involve the extracting of energy from some magnetic body to overcome the potential wall.

2. There is a large number of candidates for the carrier of the energy and Ling's findings about metabolic deprivation suggest that several magnetic bodies can in principle provide the metabolic energy. The energy could be assigned to a population inverted cyclotron BE condensate at the magnetic body of P, ATP, the flux tube AP, or a larger system containing ATP.

   Ling introduces permanently unfolded proteins as a special system and the magnetic body of single unfolded protein or even the system defined by them could be the carrier of the cyclotron BE condensate. One could imagine that under normal circumstances the magnetic body assignable to ATP or a system containing it provides the metabolic energy but under metabolic deprivation (as cells in Ling's experiment [I6]) the metabolic energy could be extracted from some other magnetic body. One can compare ATPs with jam jars in the refrigerator: when the jam jar becomes empty, the jam jars in the cellar can come to the rescue. This would require the generation of magnetic flux tube contact to the bigger

energy storage using reconnection mechanism and tuning of flux tube strength and would require some time.

3. I have proposed that in photosynthesis solar photons excite the cyclotron BE condensate of electron Cooper pairs at the magnetic flux tubes of some system. This conforms with the idea that magnetic bodies serve as energy supplies and that the motion of the system defined by magnetic body and biological body is basically transformation of cyclotron energy to kinetic energy, chemical energy, heat and other forms of energy needed by the visible part of the organism. TGD assigns to electron with standard value of Planck constant a causal diamond (CD) with a size, which corresponds to 10 Hz frequency defining a fundamental biorhythm. This would conform with the fundamental role of electrons in metabolic energy storage. There are of course many details to be filled in but this picture looks to me very attractive.

3.4 Ling's theory from the perspective of TGD inspired theory of consciousness

Ling formulates his theory using ***only the notions of biochemistry and thermodynamics***. This means taking a risk since it is not at all obvious that these notions are enough for understanding life. My personal conviction is that one cannot really understand life without a theory of consciousness. Ling ends up with the notions natural in TGD inspired theory of consciousness but a proper justification of these notions remains lacking because it is simply impossible in the conceptual framework used. Basic problem is of course the non-locality of association process having no description in standard biochemistry.

One can indeed interpret the ATP/ADP process also from the point of view of TGD inspired theory of consciousness from ***purely quantal perspective***, and I have already discussed the interpretation of the process as a ***transfer of negentropic entanglement.***

1. Flux tubes serve as correlates for attention and ATP serves as re-orientation of the attention by inducing reconnection process. In the transition $A--C\&B---D \rightarrow A---D\&B---C$ by reconnections the attention of A is directed from B to C and attention of B from D to A.

   Note: Is direct attention really asymmetric with respect to A and B? Could attention be symmetric at the fundamental level? Is the "directed" only due to the fact that A is responsible for the variation of flux tube thickness in order to get in tune. The belief that I am aware of the presence of some system but not vice versa might indeed be an illusion: the other system could also be aware about my presence, even in the case that I regard it as "inanimate". It might be however possible to tell which of the two systems performs magnetic motor action generating flux tube connection (by tuning the field value so that reconnection takes place). This argument applies even to the ordinary sensory perception. The conservation of the signed magnetic flux assigns an arrow to the flux tube and gives precise selection rules: the magnitudes of the fluxes are same

for reconnected flux tubes of and also signs so that only one reconnection instead of two is possible.

2. Ling's model assigning different roles to permanently unfolded proteins and folded proteins in resting state has a nice interpretation in TGD context. ATPs are attached to the permanently folded proteins in the resting state. The unfolded protein A would be connected to the phosphate P of ATP by flux tube, and one could say that protein A directs its attention to ATP. The permanently folded proteins would be like guards of a bastion in a permanent wake-up state. In resting state the folded proteins would "sleep" .

3. As the system is activated, the flux tube connection A—PB is generated and one can say that A directs its attention to B, which could be ion, other protein, or some invader molecule. If A has the role of guard, one can expect that A can control the thickness of the flux tubes of its magnetic body and in this manner tune to detect the presence of other molecules. Therefore the system of unfolded proteins could define the part of cell which is in permanent wake-up state and monitors the state of the cell. Activation would wake up and unfold the folded proteins and the cell would be in a kind of alarm state as long as external perturbation lasts.

4 Capacitor-like Josephson junctions as systems with large $\hbar_{eff}/h$?

Both Tesla coil and magnifying transmitter can be regarded as a pair of systems in which primary drives secondary system with resonant frequency so that energy is transferred to the secondary. Primary has air gap which acts as a switch. Above a critical voltage about 10 V in the air gap a di-electric breakdown occurs and current runs through the gap. What is remarkable is that the duration of the breakdown period is few milliseconds: this is the time scale for the nerve pulse and suggests an analogy with cell membrane which is also a system with ultrahigh voltage between the plates of a capacitor-like system defined by the two lipid layers of the cell membrane. Also the secondary coil, which can be regarded as a plate of capacitor with Earth defining the second plate, develops local di-electric breakdowns seen as "mini lightnings". The analogy with cell membrane suggests that also these breakdowns are mathematically analogous to the generation of nerve pulse. The glossary of the introduction explains the basic notions related to Josephson junctions.

4.1 Cell membrane as Josephson junction

I have developed a model for cell membrane as Josephson junction leading also to a model of nerve pulse, and there is interesting to see whether the findings of Tesla could be understood in terms of this model.

1. Cell membrane is assumed to be a Josephson junction in which a Josephson current

$$J = J_0 sin(\frac{Ze\int V(t)dt}{h_{eff}}) \tag{4.1}$$

is running. For a constant resting potential $V(t) = V_{rest}$ one obtains

$$J = J_0 sin(\omega t) \ , \ \omega = 2\pi f_J \ . \tag{4.2}$$

a current oscillating with the Josephson frequency

$$f_J = \frac{ZeV_{rest}}{h_{eff}} \ . \tag{4.3}$$

Z is the charge of the super-conducting charge carriers. Electronic Cooper pairs with $Z = 2$ are certainly involved and very probably also bosonic ions and Cooper pairs of fermionic ions. The Josephson currents run along super-conducting space-time sheets. $V(t)$ varies rather slowly. Josephson current generates dark Josephson photons with frequencies coming as multiples of f_J having interpretation in terms of EEG and its generalizations [K4].

The dominating contribution to the membrane voltage is constant resting potential. Besides this there is varying part reflecting various activities near cell membrane and the idea is that dark Josephson photons emitted by Josephson current communicate sensory information about these activities to the magnetic body.

2. Without further assumptions one cannot predict the value of $h_{eff} = nh$. One can however end up with a prediction for h_{eff} by considering a more general situation in which the voltage containing time dependent part - briefly "AC part".

   (a) Suppose that this contribution is periodic with a period characterized by AC frequency f_{AC}. This does not mean that the AC part is of simple sinusoidal form but only that $V(t)$ is a superposition of harmonics of some fundamental frequency f_{AC} containing also a constant part defining the resting potential. The alternating part of voltage is expected to relate closely to cyclotron contribution to the membrane voltage so that cyclotron frequency f_c of electron, proton or some ion defines a good candidate for f_{AC} which would depend on cell. Neglecting nuclear binding energies the cyclotron frequencies of ions in given magnetic field are subharmonics of proton's cyclotron frequency.

   (b) The natural assumption is that in dynamical equilibrium the periodicity of Josephson current is that of the alternating current. This gives as the first guess the condition

$$f_J = f_{AC} \tag{4.4}$$

One can also consider also sub-harmonics:

$$f_J = \frac{f_{AC}}{l} \ , \ l = 1, 2... \tag{4.5}$$

so that Josephson radiation would be seen as master and cyclotron radiation as slave. This condition fixes the value of h_{eff}:

$$\frac{h_{eff}}{h} = l \times \frac{ZeV_{rest}}{hf_{AC}} = n = 1, 2, ... \ , \ l = 1, 2, .. \ . \tag{4.6}$$

From this formula one can readily calculate the value of h_{eff} assignable to say EEG frequencies and integer valuedness of h_{eff}/h fixes the spectrum of EEG frequencies and implies that this spectrum can be regarded as union of sub-harmonics of maximum frequencies f_{max} such that each sub-harmonic corresponds to its own value of h_{eff}. The cyclotron frequencies of various ions in given magnetic field correspond in first approximation to various values of n in above equation and by small tuning of the magnetic field strength associated with flux tubes carrying particular kind of ions the same formula applies to all ions.

(c) For $f_{AC} = f_J$ option the value of h_{eff} would be completely fixed by the periodic perturbation and the system produces dark photons with harmonics of Josephson frequency. For more general option $\hbar_{eff}$ is divisible by integer l which would naturally relate to p-adicity with p-adic prime appearing as a factor of l. The results is rather powerful and gives the long sought for quantitative grasp about the hierarchy of effective Planck constants.

3. The integer quantization of h_{eff}/h implies that the resting potential of the cell membrane obeys integer quantization for given value of l and that the changes of the membrane potential correspond to quantized change of the charge of the effective capacitor from $Q = CV$. The resting potential of the cell membrane is indeed known to be quantized. The unit for the resting potential is known as miniature end plate potential (`http://en.wikipedia.org/wiki/Miniature_end-plate_potential#Miniature_End_Plate_Potential`) of order $\Delta V = .5$ mV to be compared with the resting potential of order 60 mV. This would give $\Delta h_{eff}/h_{eff} \sim 1/100 = \Delta n/n$ if neither l nor f_{AC} changes. The changes of h_{eff} would be of order one per cent.

   I have made a conjecture that the phase transitions changing h_{eff} are such that $h_{eff}/h = n$ is replaced with its factor. In this case the change of h_{eff} is large and cannot apply in the case considered. h_{eff}/h can be kept however constant if the change $l_i \to l_f$ compensates the change of V_{rest} so that one would have

$$\Delta \frac{V_{rest}}{V_{rest}} = \frac{l_i}{l_f} - 1 \simeq -\frac{\Delta l}{l} \ .$$

   l is however expected to be rather small integer on basis of the model of EEG so that Δl need not compensate small changes of V_{rest}. h_{eff}/h remains also

invariant if V_{rest} and magnetic field defining cyclotron frequency can scale in the same manner. This follows from the basic conditions automatically. If neither l or B is changed then a phase transition satisfying $\Delta n/n < 1$ must occur and proceed via a transition to an intermediate state with $h_{eff} = h$ - that is ordinary matter.

4.2 Quantization of the DC voltage of capacitor from the quantization of charge

For a given value of $f_{AC} = lf_J$ the formula for h_{eff}/h implies quantization of the capacitor voltage. The quantization of the voltage of a capacitor follows also from the quantization of charge implying $\Delta Q_{min} = e$ as the minimal change of charge. This gives a condition on the AC frequency f_{AC}:

$$\Delta(\frac{h_{eff}}{h}) = l\frac{Ze\Delta V_{min}}{hf_{AC}} = lr\frac{Ze^2}{Chf_{AC}} = k \ . \tag{4.7}$$

Here r is the number of elementary charges in the pulse changing the voltage. If this condition is assumed to hold true for all values of l and r, one can conclude that

$$\frac{Ze^2}{Chf_{AC}} = s = 1, 2, ... \ . \tag{4.8}$$

and that s divides k. This is true for any k for $s = 1$. This would give a quantization condition for $\lambda_{AC} = c/f_{AC}$:

$$\begin{aligned} \lambda_{AC} = \lambda_{min} = \frac{\hat{C}}{2Z\alpha} \ , \quad \alpha = \frac{e^2}{4\pi\hbar\epsilon_0 c} \simeq 1/137 \ . \\ \hat{C} = \frac{C}{\epsilon_0} \ , \qquad \epsilon_0 = 8.854 \times 10^{-12} F/m \end{aligned} \tag{4.9}$$

Equivalently, one would have

$$f_{AC} = f_{max} = \frac{c}{\lambda_{min}} = \frac{2Z\alpha c}{\hat{C}} \ . \tag{4.10}$$

λ_{AC} as the minimum wave-length is therefore dictated by capacitance. In biological applications $f_c = f_{max}$ follows.

Before discussing concrete examples note that C is expressed using Farad as unit: micro-, nano-, and picofarad are more natural units. $\hat{C}$ having dimension of length makes manifest the geometric meaning of C. The allowed values of f_{AC} must come as sub-harmonics of the maximum frequency determined completely by the capacitance.

1. For a plane capacitor one has

$$\hat{C} = \frac{\epsilon_r A}{d} \ . \tag{4.11}$$

Here $\epsilon_r = \epsilon/\epsilon_0$ is the relative permeability, and A and d are the area of the plate and d the distance between them. For $\hat{C} = 1$ m one has

$$\lambda_{min} \simeq \frac{\hat{C}}{m} \times 67.5 \ , \quad f_{max} \simeq \frac{1}{\hat{C}/m} \times 4.4 \times 10^6 Hz \ . \tag{4.12}$$

2. This gives strong bound on the capacitance. For instance, in the experiments of Tesla f_{AC} is in the range $20 - 100$ kHz. For $f_{AC} = f_{max}$ the corresponding range for $\hat{C}$ is 1.15 mm-0.23 mm. For $f_{AC} = f_{max} = 10$ kHz one would have $\hat{C}/m \simeq 2.30$ mm.

3. Kennelly-Heaviside layer has thickness $d = 90 - -150$ km and be approximated as a spherical capacitor with

$$\hat{C} = \epsilon_r \times \frac{4\pi R^2}{R - \frac{R^2}{R+d}} \simeq \frac{4\pi R^2}{d} = \frac{A}{d} \ . \tag{4.13}$$

In this case one has $f_{max} \simeq 19$ minutes.

4.3 Constraint on cyclotron frequency

The TGD inspired model of EEG [K4] suggests that f_J assignable to the neuronal membrane is around 5 Hz. This would suggest that it is second sub-harmonic of an ionic cyclotron frequency around 10 Hz (say that of Mg^{++}) or the third sub-harmonic of cyclotron frequency of Ca^{++} equal to 15 Hz. This would support the formulas

$$f_J = \frac{f_c}{l} \ , \quad f_c = f_{max} = \frac{2Z\alpha c}{\hat{C}} \ . \tag{4.14}$$

Through these equations the field values at magnetic flux tubes, cell membrane potential, and the shape and size of cell membrane would be in tune. This constraint relates cyclotron frequency and therefore the value of the magnetic field at given flux tube to the capacitance. In terms of the magnetic length $L_B = \sqrt{h/eB}$ this gives rise to the following equivalent correspondences

$$\begin{aligned} L_B &= \sqrt{\frac{r_C \hat{C}}{\alpha}} l \ , \\ \hat{C} &= \frac{\alpha}{l} \frac{L_B^2}{r_C} \ . \end{aligned} \tag{4.15}$$

Some numerical correspondences are helpful in quantitative estimates. $B = 1$ Tesla corresponds to magnetic length $L_B \simeq 64.3$ nm, and capacitance of 1 Farad to the "capacitance length" $\hat{C} = 1.1 \times 10^{11}$ m. Compton length for electron is $r_C \simeq 2.43 \times 10^{-12}$ m.

Some comments from the point of view of the model of cell membrane as super conductor are in order.

1. The effects of ELF radiation on vertebrate brain suggest the presence of endogenous magnetic field with field strength $B \simeq 2B_E/5$, where $B_E = .5 \times 10^{-4}$ T is the nominal value of the Earth's magnetic field with magnetic length $L_B = 14.4$ μm. For electron the corresponding value of $\hat{C}$ would be $\hat{C} = .62$ m for $l = 1$. For large neurons with radius of order 10^{-4} m one has $\hat{C} \simeq 12.6$ m^2 for $l = 1$. For $l > 1$ the proportionality $\hat{C} \propto 1/l$ however allows smaller cell sizes.

2. For proton and ions $\hat{C}$ would be obtained by scaling down the electronic $\hat{C}$ by the mass ratio $m_E/Am_p \sim 2^{-11}/A$, A the mass number of nucleus. For proton one would have $\hat{C} = 3.3 \times 10^{-4}$ m and for Ca^{++} ion with mass number $A = 40$ one would have $\hat{C} \simeq 1.3$ μm, which corresponds to the length scale of cell nucleus and could characterize nuclear membrane as capacitor.

3. Somewhat unexpectedly, ions would correspond to a capacitor assignable to nuclear membrane whereas electron would correspond to size scale of large neuron. Alternatively large value of l could allow smaller cell sizes. Electron could also correspond to a multicellular system behaving effectively as a single capacitor by quantum coherence. DNA double strand and its subsystems might also correspond to the capacitor-like systems involved with both electrons, protons, and ions.

4.4 What about more general capacitor-like systems?

There is a temptation to assume that the situation for the air gap of Tesla coil and for the capacitor formed by the secondary and Earth is same as for the cell membrane except that the DC voltage is replaced with AC voltage. The generalization might apply quite generally to any capacitor-like system.

1. Now electronic and possibly also protonic Cooper pairs with large $\hbar_{eff}$ would be the current carriers. Josephson currents would be present all the time. Dielectric breakdown would be analogous to nerve pulse. The analog of the membrane potential would be defined by the voltage associated the Earth's electric field $E_E \simeq 100$ V/m unless DC voltage is present. Note that the orientation of the capacitor with respect to the Earth's electric field matters. This would define Josephson frequency in absence of other currents and one would have Josephson current even for an ordinary capacitor with frequency $f_J = ZeV/h_{eff}$. Same conditions would apply to f_J and f_{AC} as for cell membrane system. Only V_{rest} would be replaced with V_E so that one would have

$$\frac{h_{eff}}{h} = \frac{ZeV_E}{hf_{AC}l} = n \ , \ \ l = 1, 2.2, ... \ , \ \ n = 1, 2, ... \ . \tag{4.16}$$

for the space-time sheet along which the Josephson current runs. The value of effective Planck constant is therefore completely fixed! Rather remarkably, the proposed amplitude modulation mechanism predicts exactly the same value $\frac{h_{eff}}{h}$ as ratio of Josephson frequency for ordinary Planck constant and of AC frequency and it might be possible to regard the two mechanisms as equivalent.

2. If *all* capacitor-like systems carry a small oscillatory Josephson current satisfying $f_J = f_{AC}$ ($l = 1$ in more general formula) in presence of AC current, one could assign to a capacitor a unique value of h_{eff} depending on it orientation with respect to Earth's electric field. This would predict production of dark photons with the AC frequency and its harmonics. Also a capacitor added to DC circuit would carry a small dark Josephson current but now one cannot predict the value of h_{eff} as found in the beginning. This indeterminacy would conform nicely with the quantum criticality of TGD Universe: a small periodic perturbation would fix the value of h_{eff}. The new physics might be present in ordinary AC circuits and might relate to the poorly understood $1/f$ noise in electric circuits. Dark Josephson currents and probably also supra currents would be present in ordinary circuits and one might imagine building a technology based on this new form of high T_c superconductivity.

3. By introducing to the Josephson potential constant part artificially, one can increase the value of h_{eff}/h and cell membranes have indeed done just so.

4.5 What $f_J = f_{AC}/l$ condition implies for Earth's electric field?

As argued, if the situation is analogous to asymptotic self-organization pattern, the Josephson current must be periodic having the same periodicity as the external AC voltage. This is guaranteed if $V_J(t)$ is a superposition of Fourier components coming in multiples of f_{max}.

1. If this condition is satisfied and if the voltage $V(t$ contains a DC part - containing at least the contribution V_E associated with the Earth's electric field - to the Josephson voltage, then the condition $f_J = f_{AC}$ reads as

$$f_J = \frac{ZeV_E}{h_{eff}} = \frac{f_{AC}}{l} = \frac{f_{max}}{l} \quad , \quad f_{max} = \frac{2Z\alpha}{\hat{C}} \quad . \tag{4.17}$$

   The value of h_{eff}/h for $f_{AC} = f_{max}$ would be given by

$$\frac{h_{eff}}{h} = \times \frac{eV_E}{hc}\frac{\hat{C}}{2\alpha l} = n \quad . \tag{4.18}$$

2. This in turn poses a condition to $\hat{C}$. For a plane capacitor one has $\hat{C} = \epsilon_r A/d$. This formula applies in good approximation also to spherical capacitor. For a more general capacitor-like system - defined by say folded cell membrane or the neuronal membrane containing also axon and dendites - the capacitance can be parametrized as $\hat{C} = yA/d$.

   For $E_E = x\times 100V/m$ one $eV_E/hc = d\times x\times 10^2 eV/hc\times m^{-1} = d\times 1.24\times 10^8 x\times m^{-2}$ and one obtains

$$\frac{h_{eff}}{h} = 1.24 \times 10^8 \epsilon_r xy \times \frac{A}{m^2}\frac{1}{2\alpha l} = n \ . \tag{4.19}$$

This translates to a quantization condition for the area of the plane capacitor:

$$A = nl \times A_{min} \ , \ A_{min} \simeq \frac{118}{\epsilon_r xy} \ (\mu m)^2 \ . \tag{4.20}$$

The size scale of the minimal capacitor is that of cell: in cell scale nk is small integer and therefore also n is near unity. That condition correctly relates the size scale of the cell to the magnitude of the electric field of Earth strongly suggests that both E_E and B_E have been key players in the evolution of life and also supports the vision about Kennelly-Heaviside layer as the analog of cell membrane.

3. As discussed, also Kennelly-Heaviside layer with thickness $d \sim 100$ km can can be approximated as a spherical capacitor with $\hat{C} \simeq xA/d$. One obtains expression for nl from the expression of A as a multiple of A_{min} as

$$nl \ = \ \epsilon_r xy \times 4.56 \times 10^{24} \ . \tag{4.21}$$

The allowed values of n and l are huge. In the case of cell membrane the values of l would be however rather small. For the value of n corresponding ot $n \sim l$ one has $n \leq 2 \times 10^{12}$. The frequency of dark variants of visible photons with energy 2 eV would correspond to dark photon with frequency around 150 Hz, which is somewhat above EEG range.

4.6 Cell membrane, DNA double strand, and cortical layers as capacitor-like Josephson junctions

Earth's electric field E_E would not allow large h_{eff} Josephson photons generated by capacitor-like Josephson junctions with much larger size than that of cell. By previous arguments neurons can emit large $\hbar$ Josephson photons and the high value of the resting potential saves the situation: large h_{eff}/h as a prerequisite of intelligent life provides the answer to the question why strong voltages are needed in biology. The resting potential $V_{rest} = .06$ V is by a factor $x = V_{rest}/E_E d \simeq 6 \times 10^4$, $d = 10^{-8}$, stronger than that corresponding to E_E.

4.6.1 Cell membrane as capacitor

Using spherical capacitor as a model for the cell membrane as starting point in the parametrization of capacitances as $\hat{C} = yA/d$, the quantization condition deriving from quantization of elementary charges reads as

$$\begin{aligned} \frac{h_{eff}}{h} &= 7.44 \times 10^{14}\epsilon_r y \times \frac{A}{m^2} \times \frac{1}{2\alpha l} = n \ , \\ A &= nl \times A_{min} \ , \ A_{min} \simeq \frac{20}{\epsilon_r y} \times (nm)^2 \ . \end{aligned} \tag{4.22}$$

A scale of about 5 nm defines the size scale of the minimal capacitor. $n \sim 2^{16}$ is possible even for the size scale of cell nucleus.

For a large neuron with size scale of 10^{-4}m one obtains $h_{eff}/h \sim 10^{10}$. The area of cell membrane can be increased by folding and cell interior is indeed filled with a folded membrane. This allows even larger value of h_{eff}/h at neuronal level. Therefore one can understand the required large values of h_{eff}/h and a direct correlation between the evolutionary level measured by h_{eff}/h and cell size scale and total membrane area is predicted.

4.6.2 DNA double strand as capacitor?

Each DNA nucleotide carries two units of negative charge. Could one somehow assign a pair of cylindrical surfaces with the highly coiled DNA double strand and describe it as a cylindrical capacitor? Where are the positive charges? Are positive charges associated with Earth identified as a cylindrical surface around DNA with radius of order $L(151) = 10$ nm defining the radius of the chromosome? And is the idealization as a perfect conductor meaning constant charge distribution at the coiled inner cylindrical surface and outer chromosome surface really justified?

In any case, the capacitance of co-axial cable is given by

$$\hat{C} = \frac{2\pi\epsilon_r \times L}{log(R_2/R_1)} \tag{4.23}$$

is good approximation for the capacitance of the system if it behaves as a conductor. $\hat{C}$depends linearly on length L. Similar formula is expected to apply in the first approximation also to the coiled DNA strand defining chromosome. The value of h_{eff}/h would increase as the total length of DNA strand increases during evolution: for human DNA the length is about $L \sim 1$ m. The linear charge density per unit length is for double strand $4e$ per nucleotide pair and makes $6e/nm$ so that the total charge is $6eL/nm$ and about 6×10^9 for human DNA. $R_1 = 1$nm and $R_2 = 10$ nm are reasonable first estimates.

The expressions for various parameters are

$$\begin{aligned} \hat{C} &= \frac{2\pi\epsilon_r \times L}{log(R_2/R_1)} \simeq 14.5\epsilon_r L \ , \\ f_{max} &= 2Z\alpha \times log(\frac{R_2}{R_1}) \times \frac{c}{2\pi\epsilon_r \times L} \simeq 3.2 \ MHz \ , \\ \frac{h_{eff}}{h} &= n = \frac{24\pi}{l} \times (L/nm) \simeq \frac{1}{l} \times 75.4 \times (L/nm) \ , \\ L &= nlL_{min} \ , \ L_{min} = \frac{1}{24\pi} \ nm \simeq .13 \ Angstrom \ . \end{aligned} \tag{4.24}$$

For $L = 1$ m (of the order of the total length of human DNA) one obtains $h_{eff}/h \simeq .75 \times 10^{11}/l$. Cyril Smith [J3] claims that for water memory frequency ratio $f_h/f_l = 2 \times 10^{11}$ is special: this ratio corresponds in TGD framework to h_{eff}/h [K7]. $L_{min} \simeq .1$ Angstrom means that non-standard values of Planck constant can be important already for the shortest possible DNA strands. f_{max} is of order MHz and for largest possible values of l ($n = 1$) $f_J = f_{max}/l$ is or order 10^{-5} Hz: $n = l$ gives $f_{max} \simeq 10$ Hz which is perhaps not an accident.

Also proteins are charged (the sign and magnitude of the charge depends on pH of the environment) and this suggests that also they define capacitor type Josephson junctions.

4.6.3 Cortical layers as Josephson capacitors

TGD Universe is fractal and therefore a highly attractive idea is that also the highly folded layers of various brain areas correspond to capacitor-like systems acting as Josephson junctions. Also the six cortical layers- decomposing to cortical columns of radial size scale of order mm would correspond to Josephson junctions but in smaller length scale. The hierarchy of Planck constants would thus make itself directly visible in the structure of brain.

The total area of cerebral cortex (`http://www.wikilectures.eu/index.php/Function_of_Cerebral_Cortex`) is about .25 m^2. For $A = .25$ m^2 - possibly making sense for the highly neural circuits associated with the highly folded membrane-like structure defined by cortical layers - one would have $nl = 1.25 \times 10^{14} \times (\epsilon_r/1.18)$ so that $h_{eff}/h = n \leq 1.5 \times 10^{14}\epsilon_r$ holds true. The frequency of a dark variant of 2 eV visible photon would be about 40 Hz for $\epsilon_r = 1$. This happens to be the celebrated thalamo-cortical resonance frequency (`http://en.wikipedia.org/wiki/Recurrent_thalamo-cortical_resonance` suggested to be an important correlate for consciousness.

voltage is taken to be the resting potential. 10-20 mV is the typical value of the oscillating EEG potential (`http://en.wikipedia.org/wiki/EEG`) when measured from subdural electrodes and one expects that the constant part has magnitude which is larger: in the case of cell membrane by a factor of order 100. If the ratio is same in the scale of cortex, one would have "resting potential" of order 1.2-2-4 V which is by a factor 50-100 higher than resting potential. The average thickness of human cortex is 2.8 mm - largest for mammals but for mouse (2.2 mm) larger than for macaque (1.7). In the Earth's electric field $E = 100$ V/m the maximum voltage difference over is 0.28 V of this distance which would be roughly twice the nominal value .06 V of the resting potential. Interestingly, the thickness of cortex is known to be thicker for meditators (`http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1361002/`) [J2]: in principle this means larger value of h_{eff}. One can wonder what happens when the local section of (folded) cortical layer is not orthogonal to the Earth's electric field. If cortical layer behaves as an ideal conductor, the surface charges should arrange the situation in such a manner that the voltage is same along cortical layers and that the orientation of head does not matter.

The quantization of capacitance basically due the quantization of elementary charges and $f_J = f_{AC}/l$ condition is rather strong. Cell membrane is however able to change its shape and could find a shape in which the condition is satisfied.

4.6.4 Artificial life?

The above considerations inspire the question about a recipe for building primitive life forms. Both magnetic and electric fields are needed. Concerning the electric part of the system the following recipe comes in mind.

1. Take a capacitor-like system with as large area as possible and feed in electric field as sum of as strong as possible DC part and AC part. From charge quantization the frequency characterizing the periodicity of AC part must be subharmonic of a fundamental frequency expressible in terms of the capacitance. Capacitance itself and thus the area of capacitor is quantized too. In living matter the quantization rules require a flexible geometry . This might explain why living matter is "soft". Cell membranes can indeed vary their capacitance by deforming their shape. The frequency f_{max} identified as cyclotron frequency f_c in turn can be varied by varying the flux tube thickness. Maybe this kind of softness is required for artificial cells too. The resulting system is critical in the sense that it satisfies very strong quantisation conditions but state function for density matrix makes the system critical and thus gives excellent hopes for "self-organized quantum criticality".

2. The inclusion of magnetic fields is certainly an essential element. In the case of cell membrane and DNA one assumes that flux sheets traverse through DNA double strand and cell membrane and also flux tubes connecting DNA and lipids are assumed. How couls the magnetic body be realized artificially? In Tesla coil secondary serves both as inductance and capacitor so that also magnetic body is present and is able to perform "motor actions" essential for generating reconnections. Here the identification $f_J = f_{AC}/l = f_{max}/l = f_c/l$ would give an additional constraint: $f_c = f_{max}$.

4.6.5 Remote metabolism and the question about simplest possible metabolic pathway

Remote metabolism suggests an extremely simple manner to produce ATP without the need for metabolic machinery and allowing to avoid production of free radicals causing molecular damage. This mechanism could explain the reported ability to survive without nutrition described in the introduction [I10, I1].

1. Drop out all initial steps of the oxidative phosphorylation appearing in both photosynthesis and cell respiration (`http://en.wikipedia.org/wiki/Oxidative_phosphorylation`), and replace the last step involving formation of ATP using ATP synthase (pumping protons against membrane resting potential) with much simpler process.

2. The final step in oxidative phosphorylation involves dropping of 4 protons through the cell membrane. The liberated electrostatic energy goes to ATP as it is formed. The electrostatic energy ZeV_{rest}, $E = eV_{rest} \simeq .06$ eV depends on the charge Z of the charged particle only. One can therefore imagine several basic units: two Cooper pairs of protons, two Cooper pairs of fermionic ions or two doubly

charged ions such as Ca^{++}, and electron Cooper pairs moving in opposite direction through the membrane could liberate same energy to be used to build ATP. One could even say that resting potential defines fundamental metabolic energy quantum.

3. The loading of metabolic batteries could take place by remote metabolism in very simple manner: charged particles with charge $\pm 2e$ send negative energy Josephson photon energy $E = -2eV_{rest}$ to some magnetic body and in this manner gain opposite energy as a recoil energy and is pumped to the other side of the membrane.

4. Note that the fundamental energy quantum would be about .06 eV. Metabolic energy quantum has nominal value of .5 eV. This process would not therefore use dark variants of visible photons (decaying to biophotons) but dark variants of infrared photons decay to IR counterparts of biophotons. A killer test for the proposal could be a check whether IR analogs of bio-photons with these energies exist.

Absorption of photons at Josephson frequency is obviously a very primitive manner to receive metabolic energy. What about photosynthesis? Could it rely on the absorption of visible photons at Josephson frequency kicking ions to the other side of the photo-receptor membrane, dropping back spontaneously and transferring their electrostatic energy to the electrons in the electron transport chain? This would eventually lead to the kicking of four protons (or two proton Cooper pairs) through the membrane and generation of ATP? Photosynthesis would transform solar photons as natural metabolic energy quanta assignable with near vacuum extremals to the IR metabolic energy quanta. In [K19] and accompanying JNL article it is demonstrated that this kind of scenario can be considered.

1. TGD suggests two possible states for cell membrane corresponding to far from vacuum extremals and near to vacuum extremals for Kähler action [K3]. For the latter one the Z^0 contribution to membrane potential would dominate and the energies of charged particles defined by membrane voltage are proportional to $Q_Z g_Z V_Z$. Basically due to the large isospin of nuclei the scaling of Josephson energies is large but the energies remain below visible range. If Weinberg angle is reduced from $p = sin^2(\theta_W) = .02397$ to $p = .0295$, the electrostatic energy differences over membrane for ions are scaled up to energies of visible photons for $V = .055$ eV [K3].

2. The following argument demonstrates that the questionable assumption about Weinberg angle for near to vacuum extremals is actually un-necessary.

3. From Table 1 below one indeed learns that for $p = .0295$ and $eV_{rest} = .055$ eV the Josephson energies for Na^+, Cl^-, K^+ and Ca^{++} for near to vacuum extremal using eV as a unit are 2.2, 2.74, 3.07 and 2.31. The peak energies for red, green, blue and white light are 2.19, 2.32, 3.06, and 2.49 eV respectively. For ordinary value of Weinberg angle given by $p = sin^2(\theta_W) = .23$, the energies are below visible energies, and this motivated the hypothesis that Weinberg angle is different for near to vacuum extremals. This hypothesis can be criticized.

4. In the earlier version of the model I however failed to notice that it is Cooper pairs of fermionic ions rather than ions that must be the charge carriers. For Cooper pairs of Na^+, Cl^-, and K^+, $p = .23$ and $E_J = .04$ eV assignable to visual receptors the Josephson energies are doubled being $2.02, 2.80, 3.02$ eV and these energies could correspond to peak energies for visible photons. Therefore there is no need to make the questionable assumption $p = .02397$ nor to assume that instead of fermionic ions one has their exotic bosonic counterparts allowed by the nuclear string model [K12]. For electron the Josephson energy would be scaled by a factor $-1 + 1/2p$ to $E(e) = 1.0859 \times eV_{rest}$ for $p = .2397$. For neutrino the energy would be given by $E_(\nu) = -0.0859 \times V_{rest}$: for $p = 1/4$ it would vanish by the vanishing of vectorial part of Z^0 charge. For proton the energy would be $E(p) = (3 - 1/2p)V_{rest} = .914 \times V_{rest}$ and for neutron $E(n) = V_{rest}/2p = 2.086 \times V_{rest}$.

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

Table 1. The table gives the prediction of the model of photoreceptor for the Josephson energies for typical values of the membrane potential. For comparison purposes the energies E_{max} corresponding to peak sensitivities of rods and cones, and absorption ranges for rods are also given. R,G,B,W refers to red, green, blue, white. The values of Weinberg angle parameter $p = sin^2(\theta_W)$ are assumed to be .23 and .0295. The latter value is forced by the fit of Josephson energies to the known peak energies.

Could photo-reception (`http://en.wikipedia.org/wiki/Photoreceptor_cell`) in rods and cones and photosynthesis be initiated by the same first step - a resonant absorption of visible photon by a ionic Cooper pair at its Josephson frequency and kicking it through photosystem II (`http://en.wikipedia.org/wiki/Photosystem_II`) part of thylakoid membrane, which would therefore be near-to-vacuum extremal? If thylakoid membranes are near to vacuum extremals, the Josephson energy of proton Cooper pairs would : $E_J = 2eV_{eff}$, $eV_{eff} = (3 - x) \times eV_{thr}$, $x = 1/2p$. For $eV_{thr} = .044$ eV favored by the considerations of [K19] this would give $eV_{eff} = .040$ eV. This happens to be just the nominal threshold potential for sensory receptors. After the absorption

the energy of photon would be transferred to electron transfer chain in far from vacuum extremal region of the thylakoid membrane.

Remote metabolism for visible photons would mean the transfer of ion through thylakoid membrane inside photosystem II induced by sending of negative energy photon. One can wonder whether plants could make photosynthesis more effective by by emitting long wave length dark photons received by a source of visible light. Similar mechanism would make possible active vision.

4.7 Further comments

The model deserves some further comments.

1. It should be made clear that the basic assumption $f_J = f_{AC}/l = f_c/l$ is perhaps un-necessarily strong. The idea that Josephson voltages and "alternating voltages" assignable to cyclotron BE-condensates are in resonant interaction requires only $f_J = (k/l)f_c$, where k/l is small rational. It is however easy to generalize the above estimate by replacing l with k/l.

2. The above arguments lead to a possibly new mechanism producing dark photons and allowing a control of the value of $\hbar_{eff}/\hbar$ in terms of periodic perturbation of DC voltage. Also very tight conditions on system parameters, such as for allowed values of f_{AC} follow and the charge of the charge pulse follow. I have proposed also amplitude modulation as a mechanism of production of dark photons. In this case one modulates high frequency (f_h) em field with low frequency (f_l) em field and the value of h_{eff}/h is simply the ratio of frequencies: $h_{eff}/h = f_h/f_l$. The mechanism requires that the frequency ratio is integers. The two mechanisms make the same prediction but it is not clear whether one should regard them as equivalent.

3. Especially fascinating is the consistency of the resulting picture with the vision about cell membrane and even larger structures of brain as plane capacitor -like Josephson junctions maximizing their area to maximize the values of h_{eff}/h. This would give direct quantitative grasp to evolution as increase of h_{eff}/h.

4. The model provides a quantitative formulation of an old vision. Already more than fifteen years ago I talked about a fractal hierarchy of super-conductors and Josephson junctions [K14] of which the cell membrane is only one representative. I proposed that even the region between ionosphere and Earth's surface could be analogous to cell membrane and that lightnings are analogous to nerve pulses. It was however not possible to concretize the idea at that time. Now the situation has changed.

   Kennelly-Heaviside layer of thickness about 150 km could have interpretation as the analog of cell membrane. The analogy with cell membrane as Josephson junction goes actually further. Kennelly-Heaviside layer decomposes to two layers with thickness of order 80 km: the lower one corresponds to atmosphere. 172 km corresponds to the thickness assignable to the p-adic length scale L(239), which corresponds to the next Gaussian Mersenne prime after L(167)= 2.5 μm defining the size scale of cell nucleus. Therefore L(237) = 86 km would correspond to the

thickness L(149) of lipid layer and 176 km to the thickness L(151) of the lipid layer associated also with Gaussian Mersenne. Kennelly-Heaviside layer would be the analog of cell membrane and Earth interior the analog of the cell interior in accordance with early speculations [K9, K8].

The first guess for the Josephson frequency would be as Schumann frequency $f_S \simeq 8$ Hz or at least a frequency which is of the same order of magnitude. From the knowledge of the magnitude of the electric field of Earth and from the value of Schumann frequency one can deduce the value of $\hbar_{eff}/\hbar$ associated with this system. The radial electric field of Earth is not constant and goes to practically zero within few kilometers. At the surface of the Earth it is about $E = 100$ V/m so that for 10 km height one has $eV_E < 1$ MeV to be compared with the membrane potential $eV_{rest} \simeq .06$ eV. The value of $\hbar_{eff}/\hbar = ZeV_E/f_S$ would be rather large of order $\hbar_{eff}/\hbar \sim 10^{19} \sim 2^{63}$.

5. Tesla argued that the magnifying transmitter generated telluric currents, which could propagate in the scale of Earth. The skin depth for Earth estimated from the resistance which is $10^{10} - 10^{12}$ times that of copper is in the range 4-40 km and from $j = \sigma E$ it is clear that also telluric currents decay exponentially with distance travelled so that Tesla's claim cannot hold true in Maxwell's electrodynamics.

   One can however ask whether the currents could propagate as dark currents along magnetic flux tubes. In this case the damping would be very small and one can imagine current circuits in the scale of entire Earth. Also Schumann resonances at dark flux tubes would have very high Q-value as opposed to ordinary Schumann resonances whose Q-value (`http://www-personal.umich.edu/~pran/jackson/P506/hw02a.pdf`) is estimated to be about 4 so that one fourth of the energy of the mode is lost during one cycle of duration 1/7.8 seconds.

5 Tesla's work, biology, and TGD

If TGD world view is correct, remote metabolism could also have technological implications. Three different applications mimicking biology come in mind. The communication with geometric past by sending negative energy photons and receiving positive energy photons - as memory recall and remote sensing; the initiation of motor actions by sending negative energy signal to geometric past; and remote metabolism. Zero energy ontology justifies these ideas.

Energy is the bottleneck of recent day technology. Nuclear energy has well-known problems. Also the use of, say, oil as a fuel produces environmental problems and for long travels - in particular space travel - the needed amount of fuel poses an insurmountable problem. The storage of energy as electric energy has also its difficulties due to the fact that the lifetimes of accumulators are very limited.

Tesla had surprisingly far reaching vision about the means of generating and transferring energy in the future society. Tesla speculated about an analogy with biology: in future technology the energy user would extract energy from environment and do this only when it needs the energy. Tesla also believed that there exist unidentified energy sources. This does not imply their identification with zero point energy (ZPE) as often

erratically claimed - ZPE emerged as an outcome of quantum field about which Tesla knew nothing. Tesla also speculated on a connection to biology.

To me the most amazing and perhaps most important finding reported by Tesla is what he called "cold electricity" and as a child of his time interpreted it as an evidence for aether particles and scalar photons. What is amazing is that in TGD framework the reported properties of cold electricity and aether particles suggest an interpretation as Cooper pairs of dark electrons and dark photons (recall that we *know* that dark matter is there!). If this is really the correct interpretation, dark matter would have been discovered more than century ago!

In the sequel I will discuss a simple formula expressing the conditions for the transition to a phase that Tesla called "cold electricity", identified in TGD framework in terms of dark matter - and study its generalization to the case of cell membrane allowing to deduce formulas relating cell membrane critical potential and p-adic length scale assigned to given dark particle. These formulas are of course only guesses based on general principles and on available numbers. If the proposed general principles are not correct, one can forget the formulas!

5.1 Tesla's work

In this section Tesla's work about energy transmission and cold electricity are briefly discussed. After that TGD inspired interpretation of the findings is discussed.

5.1.1 Tesla's vision about energy transmission

Probably already Tesla (`http://en.wikipedia.org/wiki/Tesla`) realized the deep problems related to energy and Tesla's technology based on alternative currents initiated by the discovery of AC magnetic motor became the basis of the modern society and the transfer of information by radio waves the standard.

Tesla's vision was that not only information but also energy could be transmitted as radiation and this served as his motivation in transmitter experiments. The idea (`http://www.teslatech.info/ttmagazine/v1n4/valone.htm`) [H1] was that the energy beam sent to what is now known as Kennelly-Heaviside layer is echoed back and received by the user. The objection against the transfer of energy by radiation is obvious. In Maxwellian world the radiation from energy source propagates to all directions and the power density decreases as $1/r^2$ with distance. Only a small fraction of radiative energy can be used.

One can of course consider a situation in which geometric optics applies reasonably well: this requires however that the wavelength used is small as compared to the size of the antenna. For 200 kHz corresponding to the highest frequency used by Tesla the wavelength is about 1.5 km. For smaller wavelengths one cannot anymore assume that the radiation is reflected from the upper boundary of Kennelly-Heaviside layer.

To develop this vision Tesla studied so called Tesla transmitters (`http://en.wikipedia.org/wiki/Tesla_transmitter`) and magnifying transmitters (`http://en.wikipedia.org/wiki/Magnifying_transmitter`) [H1], which instead of serving as voltage transformers acted as amplifiers: the primary circuit acted as a resonant driving force so that an energy transfer to the secondary was achieved. These circuits act as both receivers and antennas. The circuits applied dynamic switches based on the

di-electric breakdown of the surrounding air and generated in the secondary di-electric breakdowns through surrounding air to surprisingly long distances. Rather interestingly, the duration of resonant period after di-electric breakdown putting the switch on was few milliseconds which is the time scale associated with nerve pulse. I do not know whether anyone has really explained this co-incidence. Also the frequency range studied was 20-100 kHz which corresponds to biological time scales. Tesla discovered in his experiments X rays assignable to the high voltages generated in the Tesla transformer.

Tesla also generated radiation propagating through the Kennelly-Heaviside layer (http://en.wikipedia.org/wiki/KennellyHeaviside_layer) - not yet discovered at that time - making possible radio transmissions: Marconi received Nobel prize for radio sender but Tesla in fact discovered the phenomenon first as was admitted after Tesla's death. Tesla also found the surface of Earth acts as a conductor with resistance roughly 10^{10} times higher than that of Copper. Tesla also discovered Schumann resonance on basis of his measurements. In my opinion the large scale effects related to di-electric breakdown discovered by Tesla are not easy to understand in the framework of Maxwell's electrodynamics and might involve new physics. It is a pity that they are seen only as an entertainment nowadays.

5.1.2 Cold electricity

Tesla's findings [H3, H2] (see the book by Lindeman at http://www.teslasociety.ch/info/NTV_2011/free.pdf and the article by Akai at http://www.slashdocs.com/inixhk/longitudinal-waves-cold-electricity.html) led him to propose the existence of "cold electricity" running as a visible current along the surface of the Tesla coil in a local direction orthogonal to the wire of the coil and consisting of charge carriers not detectable by ordinary amp-meter but generating ordinary electrons at the target.

Cold electricity was not accompanied by dissipation. For instance, the vacuum tube serving as a diode (conducting current only in single direction) was not heated by the cold currents although it generated light. In other words, the currents in question were not ohmic. This brings in mind super-conductivity not yet known at the time of Tesla's experiments. Cold electricity was thought to appear as a result of a "traffic jam" with very strong local electric field leading to a generation of high electronic surface charge densities. This suggests that a high density of electrons is necessary for the cold electricity to appear in a phase transition-like manner.

Cold electricity gave rise to a force parallel to its direction of propagation. As a child of his time Tesla identified dark electricity as aether particles. Tesla assigned to the cold electricity also scalar waves - longitudinal photons - manifesting as light emitted in dielectric breakdowns associated with air gap of primary coil and secondary coil of Tesla transmitter. Longitudinal polarization explained the force in the direction of motion of the scalar waves. Another possibility is that the momentum of cold currents transforming to that of matter gave rise to this force.

Tesla estimated the velocity of the aether particles and concluded that it was superluminal. Tesla claimed also the that energies and the voltages at the secondary coil were too large to be explained in terms of ordinary circuit theory: the discrepancy between the observed value of the voltage for bifilar coil was by a factor about 9 percent higher than predicted (http://home.comcast.net/~onichelson/VOLTGN.pdf)

[H5, H4]. This might be understood if the ordinary ohmic dissipation for the cold currents was absent so that the energy of charge carriers was transformed to kinetic or electric energy as a whole. Tesla speculated with an additional energy source as an explanation of the strange energetics.

Cold electricity could be perceived as various bodily sensations for pulse lengths not much shorter than nerve pulse duration of order milliseconds. The accompanying light required very long exposure time to become visible in photos. This would suggest exotic photon-like particles were involved and had to transform to ordinary photons in order to become visible for camera. Human eye was however sensitive to this light.

What was remarkable that the time scale for the di-electric breakdown was measured in milliseconds. This happens to be the time scale of nerve pulse duration associated with the electric field of cell membrane higher than the critical value of electric field for dielectric breakdown in air. This motivates the application o f TGD inspired view about quantum biology in order to understand the findings of Tesla.

5.2 Relating Tesla's work to TGD inspired quantum biology

Skeptics can of course argue that if Tesla were right, his claims would have been verified long time ago. Here I disagree. Dark matter represents the deepest puzzle of modern physics, and all attempts to find dark matter identified as exotic particles of main stream quantum field theories have failed. This suggests that some assumption about the nature of dark matter is badly mistaken. Tesla's experiments tested Maxwell's electrodynamics in extreme situations - typically high voltage pulses generated in switching on of a circuit such as occur in dielectric breakdown over air gap. Interestingly, also cell membrane - another physics mystery - has a very high resting potential generating an electric field stronger than that inducing a dielectric breakdown in air. These situations are different from the extreme situations encountered in high energy elementary particle physics: long wave lengths and low frequencies are combined with high voltages, and this makes possible for the hierarchy of effective Planck constants to make itself manifest if it exist.

My TGD inspired educated guess indeed is that the hierarchy of dark matter phase labeled by the value of effective Planck constant implying macroscopic quantum coherence might have made itself manifest in the experiments of Tesla.

5.2.1 Cold electricity as dark matter in TGD sense

It came as a surprise to me that Tesla's findings - described in [H3, H2] - could be seen as first experimental indications for dark matter in TGD sense.

Consider first dark photons as counterparts of scalar waves of Tesla.

1. Scalar waves could correspond to dark variants of ordinary photons with a high value of effective Planck constant: later an estimate as the ratio $h_{eff}/h = ZeV/f_{AC}$ of Josephson frequency and AC frequency will be discussed. In TGD inspired biology bio-photons result in the transformation of dark photon of same energy to ordinary photon. The low intensity of bio-photons can be explained in terms of low rate for this process. This could also explain why a long exposure time was required to make the light emitted in Tesla's experiments visible. If this

interpretation is correct, living matter would be an optimal detector of dark matter so that subjective experience would provide the most straightforward proof for the existence of dark matter whereas its detection by using conventional detectors would be more difficult!

2. I have earlier considered the possibility of obtaining scalar photons in TGD framework [K5], and the model of gauge bosons as pairs of fermion and anti-fermion at opposite ends of wormhole contact together with p-adic mass calculations [K13] suggests (one might even argue "predicts") the existence of longitudinal photons with very low mass. They need not be relevant for understanding Tesla's findings if the transfer of dark matter momentum is able to explain the longitudinal force reported by Tesla.

3. Massless extremals (MEs)/topological light rays represent TGD counterparts for Maxwellian radiation fields. Their special feature is that they can carry light-like current and therefore also charge. Local polarization ϵ and light-like momentum vector k are orthogonal to each other ($\epsilon \cdot k = 0$), and the expression for the current in terms of the induced gauge field demonstrates that non-Abelian character of field makes possible charge current. In the Maxwellian case ϵ should be non-orthogonal to k. Hence charged MEs cannot correspond to Tesla's scalar waves. As in standard model, *all* particles look massless in sufficiently short length scales in TGD Universe, and all particles - including also electron - should have MEs as space-time correlates. MEs would therefore naturally correspond to dark electrons behaving like massless particles below Compton length scale of scaled up by h_{eff}/h.

In TGD framework Cooper pairs of dark electrons could thus serve as counterparts of Tesla's aether particles.

1. In TGD framework cold electricity could correspond to Cooper pairs of superconducting dark electrons with a high value of effective Planck constant. This would explain the non-ohmic character of dark currents. If the value of h_{eff} is same for dark photons and dark electrons (this is not necessarily true), the Compton wave length of dark electrons would be by a factor E_{photon}/m_e smaller than that for dark photons. For a photon energy of 2 eV this would give a reduction factor of order 4×10^{-6}. This wave length is still macroscopic (of order of 1 m) for the needed values of $h_{eff}/h = n \sim 10^{13}$. The large value of the Compton length implies that the overlap criterion for electron wave functions is satisfied so that the formation of electronic Cooper pairs is possible and lead to a generation of supra currents which do not dissipate. The absence of ohmic dissipation could explain why the vacuum diode serving as a diode was not heated and also why energetics could not be understood in terms of ordinary circuit theory. One cannot of course exclude the possibility of remote metabolism as an additional energy source.

2. If supra currents are formed, they give rise to a path of smallest resistance so that by standard circuit theory of by hydrodynamical analogy the ohmic current along highly resistive winding of the Tesla coil is effectively replaced with the supra current flowing along its surface.

3. One must make a distinction between supra currents which can run even without any potential difference and oscillatory Josephson currents running in presence of voltage. The first guess is that the supra current runs along the surface of the coil and possible Josephson current runs between the coil and ground and is assignable to the sparks generated by the coil. The generation of supra currents and Josephson currents would be favored by the formation of very high electron densities at the locations of the coil in which the normal value of electric field was very high. Using axon as an analogy, the supra currents would flow along axon and Josephson currents between the lipid layers of the axon.

   In the case of DC voltage the emerge of Josephson current with frequency determined by the DC voltage looks natural. For AC voltage the first guess is that dark Josephson current oscillating with the AC frequency (or its harmonic or sub-harmonic as will be proposed later) is established. This however requires a constant shift V_J of the Josephson voltage so that only current would remain strictly sinusoidal. V_J might explain why the observed voltage in the secondary coil of Tesla transformer is roughly 10^3 times higher than the estimated one. V_J could reflect the proposed accumulation of charge ("traffic jam") interpreted as a breakdown of the conductivity of the coil and its transformation to a capacitor carrying a constant charge. The claimed loss of the conductor property for the coil for a time interval of few milliseconds could correspond to the generation of supra current along coil and V_J between coil and ground generating Josephson current and direct Ohmic currents.

4. If super-conducting space-time sheets emerge as dark space-time sheets identifiable as n-furcations of space-time sheets at quantum criticality and if each sheet carries a Cooper pair of electrons one has the analog of Bose-Einstein condensate. One can assume that the area S of the critical region of the surface of conductor is that of the partonic 2-surface. The guess is that at criticality the electric flux decomposes into sum of smaller electric fluxes over the sheets of n-furcation such that the small fluxes are equal to charge $2e$ of the Cooper pair.

   Using $2e$ as a unit the charge the electric flux over the partonic 2-surface at criticality equals to the value of $h_{eff}/h = n$ identifiable as the total number of Cooper pairs so that one obtains an estimate for Planck constant in terms of the critical electric flux:

$$\frac{E_{cr}S}{2e} \quad = \quad n = \frac{h_{eff}}{h} \quad . \tag{5.1}$$

   This allows a pseudo-continuum of critical fluxes.

5. It would seem natural to assume "traffic jam" at some critical value of voltage between the ends of the coil implies Bose-Einstein condensate-like state of large h_{eff} Cooper pairs, Josephson currents, and supra currents. In principle this critical electric field has nothing to do with the critical field E_d for the di-electric breakdown of air. The needed phase transition would be forced by the "traffic jam" reducing the ordinary conductivity along the wire of the coil. The traffic jam would occur for some critical voltage V_{cr} between the ends of the coil.

(a) One especially interesting value of voltage corresponds to the Compton energy of electron:

$$eV_{cr} = m_e \simeq .5 \text{ MeV} \ . \tag{5.2}$$

Also higher voltages than this were encountered in Tesla's experiments. This condition is non-local condition. One should not confuse V_{cr} with V_J, which however can be assumed to emerge in the phase transition.

Later a justification for the condition will be considered. It is also encouraging that in Modanese-Podkletnov effect [H6] involving a capacitor for which the second plate is high T_c super conductor, radiation pulses allowing no interpretation in standard physics framework are generated above the proposed critical voltage $eV_{cr} = m_e$: the TGD inspired explanation of the effect is discussed in [K17].

(b) Combining this condition with Eq. 5.1 one would have

$$E_{cr} \ = \ \frac{V_{cr}}{L} \ . \tag{5.3}$$

Here L the total length of the wire of the coil if the electric field is constant along the wire. Hence di-electric breakdowns would occur as an undesired side effect due to the very strong fields forced by the Eq. 5.2. In the case of cell membrane this side effect is used for neural communications using nerve pulses. Conditions of Eqs. 5.1, 5.2, and 5.3 would allow to fix the model to a rather high degree. Already earlier additional assumptions correlating Josephson frequency, AC frequency and the geometric characteristics of the system were considered.

(c) In air the critical field for di-electric breakdown is $E_d \simeq 3$ MeV/m. For higher field strengths a complete di-electric breakdown (meaning that air becomes a conductor) takes place. E_d gives for 17 cm long coil $eV \simeq m_e$ so that one can understand why dielectric breakdowns tend to occur unless coil is longer than this. Also dielectric breakdowns between subsequent turns of the coil are possible and can be seen as a nuisance. The estimate $E_{cr} = E_d$ together with the condition 5.1 gives for $S \in \{ \ 1 \ \mu\text{m}^2, \ 1 \ \ \text{cm}^2, \ 1 \ \text{m}^2\}$, $n \in \{3, 3 \times 10^8, 3 \times 10^{13}\}$. Note that the size scale of the cell nucleus defines the smallest area for which the dielectric breakdown becomes possible.

(d) The millisecond duration of the current is same as for nerve pulse. Nerve pulse however occurs when the resting potential is reduced *below* the critical value so that the two phenomena do not obey identical physics. The current however decreases as a function of the voltage above criticality (negative resistance): does this mean that oscillating Josephson currents become dominant charge carriers above criticality and that for cell membrane this dominance is taken to extreme meaning that ohmic currents are practically absent?

(e) One cannot completely exclude the presence of Josephson currents also below V_{cr} but due to the absence of V_J they would not contain the dominating purely sinusoidal component but would have the form

$$J_0 sin(\frac{f_J}{f_{AC}} cos(2\pi f_{AC} t)) \ , \quad f_J = \frac{ZeV}{h_{eff}} \ ,$$

and periodicity defined by f_{AC}. The sine term would oscillate between values

$$\pm J_0 sin(\frac{f_J}{f_{AC}}) = \pm J_0 sin(\frac{1}{l}) \ , \ l = 1, 2, ...$$

if the condition $f_J = f_{AC}/l$ holds true.

6. The cold currents induce electronic effects - generation of ordinary electrons - at the target. This can be understood if a phase transition to ordinary matter occurred when the criterion for the presence of the multi-furcation is not satisfied anymore. An explosion of a copper wire as it received cold electricity was reported by Tesla. This could be understood if the proposed criticality criterion was not satisfied so that the dark current was transformed to ohmic current heating the copper wire.

7. Tesla reported that dark electricity flowed with superluminal velocity and even determined this velocity. This is in principle possible in TGD Universe: submanifold gravity implies that the light velocity determined operationally from the time for the signal to travel between two points along light-like geodesics defined with respect to the induced metric depends on space-time sheet. In TGD inspired cosmology this light velocity is lower than the light velocity empty Minkowski space (geodesics of M^4 instead of those of space-time surface X^4). If the dark space-time sheets are nearer to M^4 than ordinary space-time sheets, the effective super-luminality follows.

8. Cold currents were not seen by amp-meter but caused subjective sensations and were visible. This conforms with TGD view about the role of dark matter in biology.

This scenario leads to concrete (almost -) predictions.

1. If amplitude modulation is the mechanism generating dark photons, the values of Planck constants involved should come as ratios of frequencies involved: only integer ratios for the frequencies can produce dark photons.

2. The energies of ordinary photons generated form a continuum such that highest frequencies correspond to frequencies assignable to photons with energy of order eV_{max}, where V_{max} is the highest voltage generated by the transmitter. Therefore the energies can be in X-ray region (keV region) and even in MeV region. The frequencies of radio waves used were in the range 20-100 kHz so that the range of values of effective Planck constants can be estimated as frequency ratio if amplitude modulation is the mechanism producing dark photons.

3. There is also the amplitude modulation of radio frequency by a frequency associated with the periodic switching of the current through the air gap caused by the di-electric breakdown. This modulation could transform the radio wave photons to dark photons with same energy but frequency considerably below kHz and these dark fields could in turn modulate the ordinary higher energy photons to dark ones so that one would obtain dark photons with frequencies below kHz and energies up to the eV_{max}.

5.2.2 Isn't $eV_{cr} = m_e$ condition rather ad hoc?

The first objection against the condition $eV_{cr} = m_e$ is that it looks rather ad hoc. The study of Dirac equation shows that for $V > V_{cr}$ the sign of the energy of electron changes from positive to negative so that the roles of electron and positron change. One can argue that something dramatic must happen in this kind of situation and the phase transition transforming electrons to their dark counterparts is good candidate in this respect.

An analogous situation was expected to result in atomic physics of very heavy atoms as the energy of electron changes sign in the strong electric field of heavy nucleus. It however turned out that something different takes place. In heavy ion collisions exotic pion-like states decaying to electron and gamma pairs with energy very near to $2m_e$ was observed and this led to a TGD inspired model as lepto-pions identified as bound states of colored excitations of electron [K18]. Darkness in TGD sense had to be assumed since otherwise they would be produced in the decays of weak bosons. Could something similar happen also now?

In zero energy ontology (ZEO) the natural assumption is that the scale of causal diamond (CD) is determined from the condition that the quantity $E - ZeV$ preserves its sign. This would give $m_e = eV_{cr}$ condition for the state at rest. The standard quantization condition analogous to the quantization of magnetic flux but applied to 2-surface with Minkowskian signature has the following equivalent forms:

$$\begin{aligned} \frac{ZeVT}{h_{eff}} &= n \ , \\ \frac{ZeV}{h_{eff}} &= nf \ , \ f = \frac{1}{T} \ . \end{aligned} \tag{5.4}$$

The time interval T corresponds naturally to the time scale of CD (temporal distance between its tips). The condition for $n = 1$ is consistent implies the quantization condition proposed in previous section and motivated by the model of dark EEG:

$$\frac{ZeV}{h_{eff}} = \frac{f_{AC}}{l} \ . \tag{5.5}$$

The reason is that f_{AC} in general is harmonic of f: $f_{AC} = lf$, $l = 1, 2, ...$ Recall that the identification of f_{AC} as cyclotron frequency for some charged boson is natural and requires that ions for which cyclotron frequencies (atomic weights in good approximation) are not multiples of each other cannot appear on the space-time sheet corresponding to same CD. One cannot however exclude the possibility that space-time

sheets continue outside the CD and therefore the possibility that same space-time sheet is contained partially to sub-CD of CD.

5.2.3 An objection against $eV_{cr} = m_e$ condition from biology

One can invent another objection against the identification $eV_{cr} = m_e$. For cell membrane the critical membrane potential for nerve pulse generation is .055 eV rather than .5 MeV so that the criticality condition would not apply in this case. Does this mean that electronic super-conductivity is not possible? Should one give up the criticality condition or generalize it appropriately in this case?

The correct solution of the problem comes from the answer to the question "What happens as voltage becomes higher than the critical value V_{cr}?". The conjecture is that h increases to $h_{eff}/h = n$ and n-furcation replaces space-time sheet with its n-sheeted covering. But what does this mean physically?

To answer it is best to make first clear what we want and see whether we can get it.

1. We want criticality condition in the form $eV_{cr} = m_e/n$ with such an n that V_{cr} corresponds to cell membrane resting potential. Therefore mass is scaled down by $1/n$. Somehow particle splits to n fractions so that the total quantum numbers, in particular mass, remain unchanged.

2. We want p-adicity. Since p-adic length scale hypothesis allows besides standard mass corresponding to the p-adic prime $p \simeq 2^k$ characterizing the particle also mass values scaled by powers of $\sqrt{2}$, the natural guess is that p-adic length scale is increased by a factor $n = 2^{\Delta k}$.

3. We want a connection with dark matter in TGD sense: $h_{eff}/h = n$ should hold true for the resulting state. The resulting state must be interpreted as a many-sheeted structure defined by n-furcation and all quantum numbers are fractionized so that a given sheet carries q/n if total quantum number is q. A longstanding issue has been what this fractionization could mean.

   By Maxwell's equations stating that potential difference is same along any path with same end points, the potential along each sheet is the same $eV_{cr,new} = M/n$. The new version of the criticality condition $eV_{cr,new} = M/n$ for single sheet of the n-fold covering is the analog of the original condition $eV_{cr} = M$ for single sheeted space-time surface. This interpretation also allows to understand the formula $E_c = h_{eff}ZeB/M$ for cyclotron energy as a formula for single sheet of covering carrying mass M/n and charge Z/n. The charge-to-mass ratio Z/M remains unchanged but summation over sheets yields the factor h_{eff}/h to the formula of E_c. Hence everything is consistent with the original motivation for dark matter hierarchy.

4. One can imagine two alternative mathematical realizations. The dark particle could correspond to a tensor product of n fractional tensor factors or to a direct sum with a complete delocalization of single fractionalized particle to various branches. For a delocalized fractional single particle state the total quantum numbers would be equal to q/n rather than the desired q whereas for tensor

product of fractional single particle states the total quantum numbers are q as desired. Therefore tensor product option seems to be the correct one. The fractionized particle is analogous to a full Fermi sphere with all fractional single particle states filled.

5. One can consider also states for which any number $1 \leq m \leq n$ of single particle states are filled. $m = 1$ corresponds to the option with a complete delocalization and $m = n$ to the states proposed above. I have earlier proposed [K15] that this kind of states - I have called them N-atoms, N-molecules, etc... - might allow to understand emergence of symbolic dynamics in living matter. Fractional second quantization for n-furcations of space-time sheet seems naturally lead to to these kind of states. These states allow a natural conjugation operation. A state with m sheets with each of them containing fractional particle contains holes at the remaining $n - m$ empty sheets. By replacing holes with particles and particles with holes one obtains a conjugate state. The wild proposal is that the pairing of states and their conjugates by entanglement with maximal entanglement entropy defines the molecular analog of sex. State function reduction would automatically lead to this kind of states having negentropic number theoretic entanglement and Negentropy Maximization Principle [K11] would stabilize them.

This picture is highly predictive. From the knowledge of the membrane critical potential one can calculate the value of h_{eff} and from the integer quantization of $h_{eff}/h = n$ gets constraints on the possible values of membrane potential: this constraint is unfortunately rather weak since the values of n are rather large. Situation changes if the values of n correspond to powers of 2: $n = 2^{\Delta k/2}$ so that the mass of the dark particle at given sheet of covering equals to the mass predicted by p-adic mass calculations but in p-adic scale $k_{eff} = k + \Delta k$. Note that Δk must be an even number unless one replaces the condition with the approximate condition $n \simeq 2^{\Delta k/2}$. This hypothesis might mean that the p-adic physics associated with the sheet of covering indeed corresponds to $p \simeq 2^k_{eff}$. The hypothesis predicts the p-adic prime associated with the cell membrane and also restricts strongly the value of the threshold potential of the cell membrane.

1. In the case of electron p-adic length scale hypothesis predicts the value of the threshold potential: $V_{crit}/V_{cr} = V_{crit}/m_e = n = 2^{\Delta k/2}$. For $\Delta k = 46$ one obtains $eV_{crit} = .060$ eV not too far from the nominal value .055 eV of the threshold potential. The p-adic length scale of scaled up electron would correspond to $k = 127 + 46 = 173$, which is 20 μm - a size scale of cell - and longer than the Mersenne scale $L(167)$. Note that the ratio $L(173)/L(151) = 2^{11}$ is approximately the same as the ratio of proton and electron masses. I have also introduced an ad hoc hypothesis that powers of 2^{11} represent preferred values of h_{eff}.

2. For biologically important ions one can find the values of membrane critical potential for which n is power of 2. Since the mass of the ion is in good approximation proportional to mass number in good approximation it is easy to get reasonable estimates for the effective (or maybe real) p-adic length scales associated with ions and for the precise value of the threshold potential. The values of k_{eff} and electrostatic energy E in threshold potential are given in Table 2 below.

3. This picture might allow to understand why nerve pulse is generated when the membrane potential is reduced *below* V_{crit}. The earlier vision about resonant interaction between dark variants of elementary particles and their p-adically scaled up versions with ordinary value of Planck constant and scaled down mass [K8] assumes that dark scaled up Compton length nL_c equals to the p-adically scaled up Compton length: this quantizes the values of $h_{eff}/h = n$ to powers of 2. In the case of electron this gives $n = 2^{\Delta k} = 2^{23}$. The reduction of the membrane potential below the critical value would transform dark electrons to ordinary electrons. Same applies to dark ions. If this is the case, the ordinary ohmic conduction would set on and lead to a generation of nerve pulse as a phenomenon analogous to di-electric breakdown. This picture could make sense also for the neutrino option. What is remarkable that ZEO and dark matter in TGD sense would be essential for understanding the highly non-intuitive fact that cell membrane system becomes unstable as membrane potential is reduced in magnitude.

4. One can try to determine the order in which different charged particles make a transition to non-superconducting phase during nerve pulse from the ordering of the values of E as $(e, p, Cl^-, K^+, Ca^{++}, Na^+)$. The inward flux of ions however begins with Na^+ ions and the outward flux with K^+ ions. That Na^+ rather than K^+ flow initiates nerve pulse is not a catastrophic prediction: the transition to a non-superconducting phase initiates the dissipative ion flow only if the concentration of non-super-conducting ions on the other side is low enough (not true in the case of K^+ in the beginning of the action potential).

5. Voltage gated ion channels are assumed for all ions. Nerve pulse can be also initiated by voltage dependent calcium channels, and in this case its duration is about 100 ms instead of few milliseconds. The TGD counterparts for the ion channels should exist and the following correspondences are suggestive.

   - Voltage gated ion channel characterized by channel protein $\leftrightarrow$ n-furcated dark space-time sheet with n depending on ion.
   - Closed/open ion channel $\leftrightarrow$ the magnitude of the membrane potential above/below the critical potential.

   Voltage gated ion channels would correspond to dark regions of the cell membrane assignable to proteins rather than to the entire membrane as implicitly assumed hitherto. Metabolic economy (minimization of dissipation) would encourage an analogous interpretation in the case of ion pumps. Ionic pumps (`http://en.wikipedia.org/wiki/Ion_transporter`) use the energy provided by ATP or the electrostatic energy $E = ZeV$ (depending on ion only via its charge) provided by the passive transfer of another ion through the cell membrane - the members of the ion pairs might be connected by a magnetic flux tube! The basic mechanism for pumps would be emission/absorption of negative/positive energy Josephson photon kicking the ion or ion Cooper pair to the other side of the membrane and thus same as in the generation of ATP. Quantal ionic pumps dissipate much less than expected, and Ling's approach postulating the absence of pumps is partially inspired by this observation.

There are also questions to be answered. The estimated value of n is same for K^+, Na^+, Ca^{++} so that one might expect them to reside at same n-sheet. Why the channel proteins are different? Do different ions correspond to different cyclotron Bose-Einstein condensates? Could cyclotron frequencies be same or related by powers of two so that local magnetic field strengths would be different and ions should correspond to disjoint parts of magnetic body.

Ion	H^+	Na^+	Cl^-	K^+	Ca^{++}
$\frac{A}{z}$	1	23	35	19	20
E/meV	54.6	38.0	50.0	46.0	44.0
k_{eff}	175	189	191	189	189

Table 2. The values of the threshold potential and effective p-adic length scales $k_{eff} = k + \Delta k$ predicted by assuming $h_{eff}/h = n = 2^{\Delta k}$. A and z denote the mass number and charge of the ion. For electron one has $k_{eff} = 173$ (prime) and $E/meV = 60$. Na^+, Ca^{++} and K^+ all correspond to same p-adic length scale $k_{eff} = 189$ (p-adic length scale of 5 mm) if the ion is assumed to correspond to $k = 113$ for atomic nuclei. Another posssibility is $k = 137$ (atomic length scalle) giving $k_{eff} = 213$ (p-adic length scale of 20 meters) and should be assigned with the magnetic body.

It seems that k_{eff} could characterize genuine p-adicity that is p-adicity in the same sense as ordinary particle obeys it.

1. I have proposed earlier that dark and possibly also p-adic copies of electroweak physics and color interactions are present in living matter for the p-adic length scales corresponding to Gaussian Mersennes $M_{G,k} = (1+i)^k - 1$. $k = 151, 157, 163, 167$ defining four p-adic length scales in the range [$L(151) = 10$ nm,..., $L(167) = 2.5$ μm] [K8]. Weak bosons behave as massless particles below these p-adic length scales for both p-adic and dark copies. The presence of these copies of weak physics is suggested by the large parity breaking effects in living matter (chiral selection), which are still poorly understood.

2. The hypothesis implies a large number of satellite p-adic length scales if one assumes that dark variant of particle can transform to ordinary variant of the particle characterized by a given dark scale characterized $n = 2^{\Delta k}$.

3. The recent conjecture modifies this hypothesis to a statement that given sheet of n-furcation with fractionized quantum numbers - in particular mass - obeys effective p-adic topology characterized by $k_{eff} = k + \Delta k$. In particular, the exotic weak and color physics with massless weak bosons and non-confined color below the p-adic length scale k_{eff} could be obeyed at given sheet of the covering.

5.2.4 Neutrino super-conductivity and cognition

The idea that neutrinos are highly relevant for cognition [K16] is rather attractive in TGD framework. One of the oldest ideas of TGD inspired biology is the notion of cognitive neutrino pair identified as pair of neutrino and antineutrino at opposite throats of wormhole contact, which I have however gave up as unrealistic. In the

recent formulation this state would correspond to a superposition of photon and Z^0 boson coupling only to neutrinos. In standard model framework the idea about the relevance of neutrinos for biology is of course complete nonsense, but p-adic length scale hierarchy and TGD view about dark matter allows to consider this idea at least half-seriously. The observed large breaking of parity symmetry in living matter (chiral selection) indeed encourages to ask whether the p-adically scaled counterparts of weak gauge bosons could appear in the length scales of living matter.

There is also second wild idea. In [K3, K4] I have considered the possibility that the cell membrane can exist in two states: the first state is far from vacuum extremal and electromagnetic fields dominate whereas the second state is near to vacuum extremal and also classical Z^0 fields are important. The latter option would mean maximal sensitivity to perturbations highly desirable for cells serving as sensory receptors. This leads to a modification of the model of cell membrane resting potential and rather realistic looking estimate for the frequencies for which the retinal sensory receptors have maximum response.

1. For near to vacuum extremal option induced Kähler form is very small and in good approximation electromagnetic and Z^0 potential energies for e, ν, p and n relate to the treshold value of the electromagnetic potential energy via

$$\begin{array}{lll} E(X) = Y(X) \times eV_{crit} \ , & & \\ Y(e) = (-1+x) \ , & Y(\nu) = 2-x \ , \ \ Y(p) = 3-x \ , \ \ Y(n) = x \ , & (5.6) \\ x = \frac{1}{2p} \ , & p = sin^2(\theta_W) \ . & \end{array}$$

   These formulas generalize to ions and allow to calculate the values of V_{crit} for near vacuum extremals from the condition $m(X) \times 2^{-\Delta k} = E(X)$, $X = e, p$ or for an ion with given value of A/z (A is mass number and z is degree of ionization). The modified threshold potential is given by $eV_{crit} \to eV_{crit}/Y(X)$ when $Y(X)$ is near unity. The expressions of $Y(X)$ are deduced in [K3].

2. The earlier model [K3] made the questionable assumption that for near to vacuum extremals the value of the Weinberg angle is $p = .0295$, which is considerably smaller than the value $p = .23$ assumed for the phase far from vacuum extremals [K3]. This assumption was motivated by the condition that the energies of biologically important ions gained in membrane potential correspond to three peak energies associated with visual receptors. It has however turned out that the ordinary value of Weinberg angle can be assumed without losing this prediction if one assumes that Cooper pairs of ions Na^+, K^+, and Cl^- rather than ions themselves are the charge carriers. For $p = .2397$ one obtains $(E(e), E(\nu), E(p), E(n)) = (1.085, -0.0859, 0.914, 2.086) \times V_{rest}$. Except for neutrino, the scaling factors are rather near powers of 2. Note that for proton the scaling factor is in good approximation two.

3. Dropping of two proton Cooper pairs in the production of ATP would liberate total energy of about $4 \times .055 = 0.22$ eV. The problem is that this is roughly one half of the metabolic energy quantum. If two proton Cooper pairs and two neutrino Cooper pairs are dropped, the liberated energy is of the order of the

nominal value of the metabolic energy quantum. Could it be that the step producing ATP takes place in the region of cell membrane near to vacuum extremal and that also two neutrino Cooper pairs are involved in the process? Note that this discrepancy is encountered also in in standard thermodynamical approach and can be overcome by assigning a gradient of chemical potential to the cell membrane. In quantum approach one cannot use this kind of argument.

If one accepts this picture, neutrino super-conductivity with neutrino Cooper pairs as carriers of Z^0 current becomes in principle possible and is even favored by energetics. I have earlier considered the possibility that neutrinos play a key role in cognition but gave up the proposed realization as unrealistic. In the recent situation one must however reconsider a new variant about the idea of cognitive neutrino Cooper pairs. A nice feature of this notion is that cognition would be shielded from electromagnetic perturbations from environment.

1. One can apply the condition $E(\nu) = m_\nu$ to see whether it is consistent with the electron and neutrino masses predicted by p-adic mass calculations in the lowest approximation [K10]. For neutrinos one can identify two options giving $m_\nu \propto \sqrt{s_\nu}$, $s_\nu = 4$ or $s_\nu = 5$. For electron one has $m_e \propto \sqrt{s_e}$, $s_e = 5$. For $s_\nu = 5$ masses are identical for same p-adic length scale. For $s_\nu = 4$ one has $m_\nu = 2/\sqrt{5} m_e = .89 m_e$ in the same p-adic mass scale.

2. Assume the recent Wikipedia value $p = .23970$ for the Weinberg angle. For electron $\Delta k = 46$ giving $k = 173$ (prime) predicts $V_{eff} = 2^{-23} m_e/(-1+x) \simeq .0561$ eV differing by 2 per cent from the nominal value .055 eV of the threshold potential for neurons.

3. For $s = 5$ neutrino $\Delta k = 54$ gives $k = 181$ (prime) and $V_{eff} = 2^{-27} m_e/(2-x) \simeq .044$ eV differing by 10 per cent from the nominal value .040 eV of the threshold potential for photoreceptors in retina. Interestingly, one has $E(p) = eV_{eff}(p) = .040$ eV. These observations provide support for the idea that ordinary neurons/visual receptors correspond to far from/near to vacuum extremals, for the p-adic length scale hypothesis, and for the criterion $m = eV_{eff}$. Note that the p-adic mass scales for neutrinos and the light variant of electron are longer than those associated with Gaussian Mersennes. This is the case also for the ordinary weak bosons.

These considerations allow to take at least half-seriously the possibility that cell membranes correspond to near to and far from vacuum extremals depending on whether the membrane corresponds to neuron (cognition) or sensory receptor (sensory experience) and that electrons are light and dark for the far from vacuum extremals and neutrinos are light and dark for the near vacuum extremal.

5.2.5 Is the model for the resting potential really consistent with the interpretation of Tesla's experiments?

Is the proposed picture consistent with what happens in Tesla's experiments, where very high voltages somewhat above $eV_{crit} = m_e$ were created? In living matter the voltage values are much lower and this determines the value of $n = 2^{\Delta k/2}$. Does this

mean that one has $n = 1$ in Tesla's experiments? This would be rather disappointing but could quite well make sense for the coil-Earth system regarded as capacitor. In both situations very strong electric fields are encountered and the idea about large value of n is very attractive.

The solution ansatz assumes generation of light fractional electrons as in the case of cell membrane and starts from from the idea that the subsequent turns of Tesla coil are analogous to the lipid layers of cell membrane and define Josephson junctions. The observed radiation assigned to dark currents could also correspond to Josephson radiation.

1. Since electric voltage propagates with finite velocity of order light velocity along the coil, there is a potential difference between corresponding points of two subsequent turns of the coil. Could it be that super-conductivity sets on and oscillatory Josephson currents flow between the two subsequent turns and the observed light emission can be assigned with dark currents is Josephson radiation? The electric field is very strong at points where charge accumulates and one expects phase transition. Since the maximal value of the oscillating potential difference between subsequent turns above critical voltage $eV_{cr} = m_e$ is smaller than $eV_c r$, a scaling of electron mass downwards is however expected to occur by the proposed criterion for cell membrane: $m_e \to m_e/n$, $n \simeq 2^{\Delta k/2}$, $n = h_{eff}/h$. Electrons would become light.

2. To estimate n one can use a simple estimate for the voltage as function of time and angle variable ϕ along the helical coil of radius R given by equations $z = KR\phi$, $\rho = R$. The distance along coil given by $s = \sqrt{1+K^2}R\phi$. One can express K as the ratio of height to the total length s_{tot} of the coil: $K = h/s_{tot}$. The voltage is given by $V(t,\phi) = V_0 sin[\omega_{AC}(t - \sqrt{1+K^2}R\phi/c)]$. The voltage difference between points of subsequence turns with values of ϕ differing by 2π is $\Delta V \simeq (\partial V/\partial\phi)2\pi = (\partial V/\partial t)2\pi R\sqrt{1+K^2}/c$. Josephson current is given by

$$J = J_0 sin(\frac{\int dt \Delta V}{h_{eff}}) = J_0 sin[\frac{2\pi}{f_0}\frac{1}{h_{eff}}V(t)] \ , \quad f_0 = \frac{c}{R\sqrt{1+k^2}} \ . \tag{5.7}$$

3. Near zeros of V one has in the first approximation $V(t) = V_0\omega(t - t_{max})$ and Josephson current behaves as

$$J_0 sin[\omega_{eff,J}(t - t_{max})] \ , \tag{5.8}$$

where

$$\omega_{eff,J} = (2\pi)^2 \frac{f_{AC}}{f_0} V_0 \frac{1}{h_{eff}} \tag{5.9}$$

defines the analog of Josephson frequency for effective voltage

$$V_{eff} = (2\pi)^2 \frac{f_{AC}}{f_0} V_0 \ . \tag{5.10}$$

If one applies the earlier argument this would mean that the critical voltage $eV_{cr} = m_e$ is scaled down to $V_{eff,cr} = (2\pi)^2 \frac{f_{AC}}{f_0} m_e$ and that electron becomes dark electron with p-adically scaled down fractional mass at each sheet of multifurcation.

4. Using the proposed formulas $h_{eff}/h = n = 2^{\Delta k/2} = V_{cr}/V_{eff,cr}$ one obtains the estimate $n = (2\pi)^{-2} \frac{f_0}{f_{AC}}$. For $R = .1$ m and f_{AC} in the range $[20, 10^2]$ kHz one would have n in the range $[380, 76]$. The condition $n = 2^{\Delta k/2}$ restricts the range to even powers of 2: $\Delta k = \{16, 14, 12\}$. The corresponding p-adic scales would be $L(k)$, $k = 127 + \Delta k$ giving $k = 143, 141, 139$. $k = 139$ corresponds to atomic length scale and $k = 143$ to $4 \times L(139)$.

5. The surface density of electronic charge carriers should be few electrons per surface area defined by $L(k)$. This condition looks reasonable since electron density is about one electron per atomic volume. On the other hand, from the critical value of electric field in air the charge density would be only few electron charges per μm^2 (cell size scale). Electrons should indeed separate to its own dark phase at n-sheet. This would also lead to high charge density for ions inducing dielectric breakdown.

5.2.6 Magnetic body and topological light rays from the point of view of energy storage and transfer

As noticed, in Maxwell's theory the dispersion of EM waves is problematic from the point of view of energy transmission unless geometric optics applies. In TGD Universe topological light rays possibly associated with magnetic flux tubes make possible precisely targeted communication and this difficulty might be circumvented. Remote metabolism possible in zero energy ontology also involves these structures and brings in additional flexibility.

The system using energy could store it temporarily at its magnetic body and transform the energy of cyclotron BE-condensate into various forms of energy assignable to visible matter. Tesla's vision was that energy transfer could take place in planetary scale by reflecting what he called longitudinal scalar waves from the upper boundary of Kennelly-Heaviside cavity. One can even imagine that the part of the magnetosphere associated with atmosphere, ionosphere, the part of magnetosphere rotating with Earth, or even entire magnetosphere could serve as an energy reservoir from which one could receive energy somehow. One can even ask whether solar radiation automatically takes care of the loading of these energy reservoirs. If so, the only problems to be solved would be how to control the magnetic body of the system using energy and generation of negative energy photons. One can also consider the option in which the magnetic body of the system is loaded by irradiating it with dark photons at cyclotron frequencies.

I have proposed that the generation of dark photons with given integer value of $\hbar_{eff}/\hbar = n$ is possible by performing amplitude modulation of high frequency radiation

with frequency f_h using low frequency radiation such that the frequencies are related by $f_h = n \times f_{low}$. I have not been able to give a convincing justification for this proposal. This would generate dark photons with large value of $\hbar_{eff}/\hbar = n$. An open question is whether it automatically also generates dark magnetic flux tubes with accompanying the dark photons or whether they must be generated by a phase transition increasing $\hbar_{eff}$. In previous section a mechanism utilizing very strong electric fields and high voltages to generate dark Cooper pairs and dark photons as Josephson radiation from AC current system was discussed.

5.3 How could this picture relate to biofield research?

Various biofield therapies (healing by touch, remote healing, using electromagnetic fields, etc) rely on the observation that weak electromagnetic fields have effects on living matter and the assumption that this can be used for healing purposes. The article "Biofield Research: A Round Table Discussion of Scientific and Methodological Issues" [J1] gives an overall view about the challenges encountered. Biofield therapies represent alternative and complementary medicine and the attitudes of the mainstream are still very hostile. Bio-electromagnetism is a well-established branch of science studying effects of various kinds of electromagnetic fields on living matter and brain. Interestingly, Tesla is the father of the oldest healing method based on pulsed magnetic field generated by Tesla coil. This method is also accepted by standard medicine. The pain relieving effects of this treatment is still poorly understood. Furthermore, the work of the pioneers of bio-electromagnetism like Blackman and Adey revealed that ELF electromagnetic radiation have essentially quantal effects on brain in frequency-amplitude windows and that the field values involved are extremely small: of order 1-10 V/m in typical experiments [K4]. These effects are also poorly understood.

A further idea not accepted by mainstream medicine is the notion of "subtle energy". The concept is often used in a metaphoric sense and it is not clear whether its meaning is nearer to that of information. A more precise meaning for subtle energy could be as some yet unknown form of metabolic energy. Note that in TGD framework metabolic energy is accompanied by negentropic entanglement and conscious information at some level of the self hierarchy.

In the round table discussion some basic theoretical problems of biofield research were summarized. What happens to the physiology of the healer during healing? What are the receptor systems and transduction mechanisms in the healee? What is transmitted between healer and healee?

TGD allows to consider a possible answer to the latter two questions [K4]. The work of Blackman and others encourages the hypothesis that the effects on vertebrate brain are quantal and correspond to cyclotron frequencies for Ca^{++} ions in magnetic field which is 2/5 of the Earth's magnetic field (.3 Gauss). For the ordinary value of Planck constant quantal effects are definitely ruled out - the energy of photons would be ridiculously small when compared with thermal energy. This could be used as a justification for the hypothesis about hierarchy of effective Planck constants $h_{eff}/h = n$ following from the basic structure of TGD, and whose applications are discussed also in this article. If the thickness of the magnetic flux tube can be controlled as one particular magnetic motor action, also the local magnetic field can be varied in certain limits, and the outcome is a narrow frequency window.

The understanding of the amplitude windows for external electric field, call it E, is more difficult and has been a longstanding challenge. This article suggests the reduction of amplitude window to a window for Josephson energy. Denote by θ the angle between the plane of plates of Josephson junction and E. The energy gained by electron as it moves the distance d between the "capacitor plates" of a Josephson junction is $eV = eEdcos(\theta)$. It is also to the energy received by dark electron as it receives Josephson photon with energy equal to the electrostatic energy $eV = eEdcos(\theta)$. One can argue that the momentum gained by the electron in the absorption of Josephson photon and thus also that of Josephson photon must be in good approximation tangential to the membrane layer inside which it is confined. Since the momentum of the Josephson photon is orthogonal to its polarization, $cos(\theta)$ must be rather near to $cos(\theta) = 1$.

1. The first proposed quantization formula proposed in this article is that Josephson frequency $f_J = ZeV/h_{eff}$ is sub-harmonic of cyclotron frequency: $f_J = f_c/l$, $l = 1, 2, ..$, with cyclotron frequency f_c identifiable as the frequency of irradiation. This formula relates the voltage V assignable to the radiation amplitude to its frequency equal to f_c.

2. Josephson junction corresponds to a two-layered structure such that the electrostatic energy in the voltage between the outer surfaces of the structure corresponds to electron mass scaled by the value of Planck constant $h_{eff}/h = n = 2^{\Delta k}$: $eV = m_e/2^{\Delta k}$. This works nicely for cell membrane and the cautious proposal is that it works more generally.

3. A resonant interaction between "large" Josephson junctions and cell membranes is needed and becomes possible by the exchange of Josephson photons if the Josephson energies eV and the value of h_{eff}/h - that is Δk are same for the two systems. This gives a quantization condition for the thickness of the "large" Josephson junction using the value of electric field $E = x$ V/m with x in the range $[1, 10]$: $eV = eEdcos(\theta) = eV_{crit} = .055$ eV giving $dcos(\theta) = 5.5/x$ cm. $x = 1$ corresponds to $cos(\theta) = 1$ giving that the thickness of the Josephson junction is is 5.5 cm: this is roughly the scale of brain hemisphere. Variation of the angle θ gives frequency window via $cos(\theta) = 1/x$. At least two frequency windows are reported and correspond to $x \in [1/2, 1]$ and $x \in [1/10, 1]$. Already in the first case the range for θ would be 60 degrees. It seems that several values of d in the range of $[.55, 5.5]$ cm are required in both cases. They could correspond to p-adic length scales $L(k)$ in the range $k \in [181, 183]$ for the first case and $k \in [177, 183]$ for the latter case.

4. Cell membrane as Josephson junction is only a macroscopic description of the situation. Membrane proteins defining channels and pumps are very natural candidates for a more precise microscopic description of Josephson junctions at cell membrane scale. Ca^{++} channels would be especially interesting in this respect since Ca^{++} is a boson and can form Bose-Einstein condensates as such. The natural question is what are the microscopic counterparts of Josephson junctions in longer length scales.

What would be transmitted between the healer and healee could be dark photons and possibly also dark electrons and even ions. The ability to generate negentropy

would be also transmitted and perhaps a better manner to think about the situation is to regard healer and healee as a single system as long as the flux tube connections generated by reconnection of flux tubes are present. Also remote metabolism in which healee emits negative energy Josephson photons received by healer can be considered.

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