

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.

1 Introduction

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.

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* (see **Fig.** <http://tgdtheory.fi/appfigures/manysheeted.jpg> or **Fig. 9** in the appendix of this book) 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 (see **Fig.** <http://tgdtheory.fi/appfigures/wormholecontact.jpg> or **Fig. ??** in the appendix of this book) 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 μ m] containing as many as four electron Compton scales assignable to 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 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 inspired 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 $h \rightarrow h_{eff}$ E_c is scaled up by a factor $h_{eff}/h = n$ 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 constants. 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 $\Delta\Phi(t) = \int ZeVdt/h$ 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 $h \rightarrow h_{eff}$ 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) [K21] is very simple and leads to a connection between negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book), 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 $h_{eff} = n\hbar$ 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 embedding 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 function reduction at it but necessarily forcing the de-localization 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 chapter

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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The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at <http://tgdtheory.fi/tgdglossary.pdf> [L4].

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 coming as square roots of powers of two and defining a hierarchy transition energies which are not identifiable as ordinary molecular transition energies [K5]. 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 [K22]. The excitation energy would be defined by cyclotron energy $E = \hbar_{eff} f_c$, $f_c = qB/4\pi m$: 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 bio-photons [I12]. Extraction mechanism allows interpretation in terms of sending of negative energy photons, which can also be dark. In TGD Universe bio-photons would result as dark photons decay in energy conserving manner to ordinary photons [K6]. The decay rate could be very small so that the intensity of dark photons could be quite high.
3. Sleightdogs (see <http://tinyurl.com/zg9j3p9>) [I3] 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://tinyurl.com/y7unnw4>) seriously [I1] and the first national conference on Bigu state was held at the Pennsylvania State University in 2000, with presenters such as as Rustom 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 $\text{ATP} \rightarrow \text{ADP}$ fill energy reservoirs at magnetic body?

The best manner to test this is by studying cells under metabolic deprivation. Ling [I8] 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 [K9] 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 [I8] by exposing cell to a cocktail 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.

2.3 Gut cells without mitochondria can survive: proof for the notion of remote metabolism?

Gut cells can survive without mitochondria (see <http://tinyurl.com/hqq79th>)! There are many other strange findings. Visible and IR light energize human skin cells transferring energy for the cells- the analog of photosynthesis. Some spiritual groups and also traditionally the people called saints are reported to survive by using only sunlight as their source of metabolic energy. NASA has studied sleigh dogs able to run for days without eating and showing no signs of getting tired.

Could photosynthesis work also in animal mitochondrial cells? The basic mechanism could be essentially the same: electron transfer chain providing energy to pump protons through cell membrane against potential gradient. This is the key step of both photosynthesis and cellular respiration. After that protons flow spontaneously back through ATP synthase and liberate energy to build ATP from ADP. This is like power plant. In plants solar photons provide the energy for electrons. In the animal cells dark photons with large $h_{eff} = n \times h$ (transforming now and then to biophotons) could do it. In the case of IR lmetabolism electrons could send to the energy source dark negative energy IR photons, which decay to ordinary IR photons. This would be an active variant of metabolism and time reversal of the usual mechanism: I have called it quantum credit card mechanism or remote metabolism [L5].

Now even mitochondria are missing! Could remote metabolism work also without mitochondria? ADP→ATP transformation should occur since ATP is the universal energy currency. Could it take place as remote metabolism by sending negative energy photons to the cells having the mitochondria. The electron transfer chain is preceded by Krebs cycle extracting the energy from nutrients: could the absorption of negative energy photons induce the decay of nutrient without transfer of energy to electron chain of the mitochondria. The hungry gut cell without mitochondria would be allowed to eat in the table of the luckier ones. Again one quantum objection against vulgar darwinism. This would be like kicking laser from population reversed state to ground state by phase conjugate negative energy irradiation.

3 Confirmation of Santilli's detection of antimatter galaxies via a telescope with concave lenses:really?

I encountered in Facebook a really bizarre sounding title reading *The incredible pictures scientists say prove invisible alien entities ARE here on Earth* (see <http://tinyurl.com/hvsqbjh>) and just for curiosity decided to add one click to the web page in question (means higher income from ads) knowing that this is just what they want me to do! The story involves aliens spying us so that the street credibility index of the story reduced zero. The tool to detect the spies would be Santilli's telescope using concave lenses. Santilli, who is familiar to me, also talks about two types of invisible terrestrials detected by his telescope. It would be easy to ridicule but let us be patient.

An earlier article with title *Apparent detection of antimatter galaxies via a telescope with convex lenses* [H11] (see <http://tinyurl.com/hmkhm16>) reports a detection of antimatter galaxies. There is also an article with title "Confirmation of Santilli's detection of antimatter galaxies via a telescope with concave lenses" published in American Journal of Modern Physics [H3] claiming an independent observation of antimatter galaxies, antimater asteroids, and antimatter cosmic rays by Santilli's telescope (see <http://tinyurl.com/hezdys2>). These articles say nothing about aliens spying us.

Since I suffer from a pathological trait of taking half-seriously even the weirdest stories, I decided to learn what Santilli's telescope using concave lenses might mean. Ordinary telescope uses convex lenses (see <http://tinyurl.com/oqfjsly>). The light rays coming from the other side converge to form a picture of the source. For concave lens the light rays coming from the other side diverge so that concave lens does not sound like a good idea for detecting light coming from distant objects.

It is however claimed that Santilli's telescope detects light sources in darkness. This is only possible if the index of refraction $n = c/v$ characterizing the medium via the ratio of light velocity in vacuum to the velocity of light in medium changes sign. From Snell's law $n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$ follow the basic facts about lenses (see <http://tinyurl.com/ybpdwweo>). It is possible to construct lenses which have negative index of refraction so that concave lens behaves like convex one. Presumably this is not the case now since according to the existing theory, ordinary light would have the negative index of reflection (unless it is somehow transformed when arriving to the lens).

Concerning the theoretical arguments Santilli makes several claims, which do not make sense to me.

1. The photons are identified as antimatter photons assumed to have negative energies. These antimatter photons are assumed to have repulsive gravitational interaction with ordinary matter. The claim is that this implies negative index of refraction. This does not make sense since gravitational interaction is quite too weak to cause refraction. Electromagnetic interaction must be in question. Antimatter photons are claimed to propagate with superluminal speeds and arrive instantaneously from remote galaxies. The assumption is in dramatic conflict with what we know about antimatter.
2. Refractive index is claimed to be a property of light. This does not make sense: refractive index characterizes medium. Its sign however changes when the energy of photon changes sign. From Snell's law the sign of refractive index must change sign as the light enters to the concave lens. This would require that Santilli's antimatter photons transform to ordinary photons.

These arguments are more than enough for dooming the claims of Santilli as pseudoscience but what if there is something in it? The experimental finding is so simple that if it is not an artefact of poor experimentation, some interesting - possibly new - physics could be involved. So let us look the situation from different point of view forgetting the theory behind it and taking seriously the claimed observations. Could one explain the findings in TGD framework?

Zero energy ontology (ZEO) is one of the cornerstones of TGD and could indeed explain the claims of Santilli and colleagues. In ZEO zero energy states are pairs of positive and negative energy states at opposite light-like boundaries of causal diamonds (CD) forming a scale hierarchy. Zero energy states are counterparts of physical events in standard ontology.

1. ZEO predicts that the arrow of time can have both directions. In ZEO based quantum measurement theory state function reductions occur at either boundary of CD. Conscious entities correspond to sequences of reductions leaving everything unaffected at the boundary (Zeno effect) but changing the situation at the opposite boundary, in particular increasing its distance from the fixed boundary, which gives rise to the experienced flow of time. The first reduction to opposite boundary replaces the zero energy state with time reversed one. This can happen also for photons.
2. The particles with non-standard arrow of time are not antimatter (I have considered also this possibility since it might explain the experimental absence of antimatter) but propagate in reverse time direction and have negative energies. There is a considerable evidence for this notion. Phase conjugate laser beams known to obey second law in reverse time direction would be one example. There are also old observations of Akimov and Kozyrev [H6, H5] claiming that the instrument of Akimov gives three images of distant astrophysical objects: one would be from past, one from recent, and one from future. I do not know about the construction of Kozyrev's instrument but one can ask whether it involved concave lenses. Also the notion of syntropy introduced by the Italian physicists Fantappie [J5] conforms with this picture. In biology syntropy is in central role since in biology time reversed radiation would play a key role.
3. Since the sign of the energy is negative for phase conjugate photons, their refractive index is negative. n_2 for concave lens and n_1 for the medium behind lens must have opposite signs to explain the claims of Santilli and colleagues. This happens if the incoming negative energy photons from the geometric future are transformed to positive energy photons at the

surface of the lense. This process would represent time reflection of the incoming negative energy photons to ordinary positive energy photons propagating inside lense.

The claimed results could be an outcome of a bad experimentation. What however remains is a test of ZEO - or more precisely, the notion of time reversed photons - using telescopes with convex lenses. The implication would be possibility to see to the geometric future using telescopes with concave lenses! An entire geometric future of the Universe would be open to us! This possibility is a good enough reason for seeing the trouble of proving experimentally that Santilli is (and I am) wrong! Negative index of refraction as a function of frequency is a real phenomenon in condensed matter physics (see <http://tinyurl.com/ybpdwweo>), and one can of course ask whether also it involves the transformation of positive energy photons to negative energy photons.

4 Comparison Of Ling's Vision Of The Cell To TGD View

Gilbert Ling (<http://tinyurl.com/ygsbhejz>) has proposed a theory of cell and living systems which challenges some basic assumptions of standard cell biology [I13, I8, I9, I10, I4, I5, I6]. This theory has several points of contact with the TGD view about living matter and it is interesting to compare the two approaches.

4.1 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 [I6] 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 [I9] 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 [I8] is summarized in the article "Main principles of Ling's physical theory of the living cell" (<http://tinyurl.com/y7rz5twy>) by Vladimir Matveev [I13]. 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 [I8] 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://tinyurl.com/ycok9n4>) 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 $\text{C}=\text{O}$ and $\text{N}-\text{H}$ 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 naïvely 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 [I4] differs from than in standard theory. The polypeptide backbone of any completely unfolded protein has a geometrically regular order of positive ($\text{N}-\text{H}$) and negative ($\text{C}=\text{O}$) 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.

4.2 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.

4.2.1 The new view about metabolism

More than 15 years ago I used [K5] Ling's finding [I9] 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 [I5], 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 many 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.

4.2.2 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 [K1]. 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 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 $\hbar \rightarrow \hbar_{eff}$, or more generally by $\hbar_{eff,2}/\hbar_{eff,1}$ in the phase transition $\hbar_{eff,1} \rightarrow \hbar_{eff,2}$. 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 [K2] 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 de-localized 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 $m_i \hbar_{eff,i}$ in the initial state ($i = 1$) and final state ($i = 2$). Conservation of the magnetic flux gives $m_1 n_1 = m_2 n_2 = m$ 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 (see <http://tinyurl.com/y7z69e8p>) [L1] [K15] 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 [K22, K15].

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 penduli. Nerve pulse would correspond to a propagating perturbation analogous to that obtained by kicking one pendulum to rotate in opposite direction. The detailed modelling 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 .

4.2.3 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 modelling of ion concentrations in chemi-osmotic theory [16]. 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 [14]. 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.

4.3 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 (NE) (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book) would be transferred in the process. The NE 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 representations defining the reflective level of consciousness giving rise to memories, predictions, sensory and cognitive representations, etc [K10].

2. My own view have been that ATP either carries and provides, generates, or induces a transfer of NE . 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 NE forced by Negentropy Maximization Principle [K21] is very simple and leads to a connection with dark matter hierarchy, p-adic physics, and quantum criticality [K21] [L2]. The NE 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. NE 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 NE 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 NE is indeed in question. The exchange of the flux tube $A - - - P$ can take place using reconnection process as the basic process.
5. NE 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 NE 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 Kähler-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 thin 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 NE 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 [I9]) 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.

4.4 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.

5 Capacitor-Like Josephson Junctions As Systems With Large h_{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.

5.1 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

$$J = J_0 \sin\left(\frac{Ze \int V(t) dt}{h_{eff}}\right) \quad (5.1)$$

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

$$J = J_0 \sin(\omega t) \ , \ \omega = 2\pi f_J \ . \quad (5.2)$$

a current oscillating with the Josephson frequency

$$f_J = \frac{ZeV_{rest}}{h_{eff}} . \quad (5.3)$$

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 [K13].

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

$$f_J = f_{AC} \quad (5.4)$$

One can also consider also sub-harmonics:

$$f_J = \frac{f_{AC}}{l} , \quad l = 1, 2, \dots \quad (5.5)$$

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

$$\frac{h_{eff}}{h} = l \times \frac{ZeV_{rest}}{hf_{AC}} = n = 1, 2, \dots , \quad l = 1, 2, \dots \quad (5.6)$$

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 h_{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.

- 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://tinyurl.com/y8czhhpm>) 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 $l_i \rightarrow l_f$ 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.

5.2 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} :

$$\Delta \left(\frac{h_{eff}}{h} \right) = l \frac{Ze \Delta V_{min}}{hf_{AC}} = lr \frac{Ze^2}{Chf_{AC}} = k . \quad (5.7)$$

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

$$\frac{Ze^2}{Chf_{AC}} = s = 1, 2, \dots . \quad (5.8)$$

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

$$\lambda_{AC} = \lambda_{min} = \frac{\hat{C}}{2Z\alpha} , \quad \alpha = \frac{e^2}{4\pi\hbar\epsilon_0 c} \simeq 1/137 . \quad (5.9)$$

$$\hat{C} = \frac{C}{\epsilon_0} , \quad \epsilon_0 = 8.854 \times 10^{-12} F/m$$

Equivalently, one would have

$$f_{AC} = f_{max} = \frac{c}{\lambda_{min}} = \frac{2Z\alpha c}{\hat{C}} . \quad (5.10)$$

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

$$\hat{C} = \frac{\epsilon_r A}{d} . \quad (5.11)$$

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

$$\lambda_{min} \simeq \frac{\hat{C}}{m} \times 67.5 , \quad f_{max} \simeq \frac{1}{\hat{C}/m} \times 4.4 \times 10^6 Hz . \quad (5.12)$$

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

$$\hat{C} = \epsilon_r \times \frac{4\pi R^2}{R - \frac{R^2}{R+d}} \simeq \frac{4\pi R^2}{d} = \frac{A}{d} . \quad (5.13)$$

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

5.3 Constraint On Cyclotron Frequency

The TGD inspired model of EEG [K13] 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

$$f_J = \frac{f_c}{l} , \quad f_c = f_{max} = \frac{2Z\alpha c}{\hat{C}} . \quad (5.14)$$

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 $L_B = \sqrt{\hbar/eB}$ this gives rise to the following equivalent correspondences

$$\begin{aligned} L_B &= \sqrt{\frac{r_C \hat{C}}{\alpha}} l , \\ \hat{C} &= \frac{\alpha L_B^2}{l r_C} . \end{aligned} \quad (5.15)$$

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 $L_B = 14.4 \mu\text{m}$. 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 $\hat{C} \simeq 12.6$ m² 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 $\hat{C} \simeq 1.3 \mu\text{m}$, 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.

5.4 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 h_{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 $E_E \simeq 100 \text{ V/m}$ 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

$$\frac{h_{eff}}{h} = \frac{ZeV_E}{hf_{AC}l} = n \quad , \quad l = 1, 2, 2, \dots \quad , \quad n = 1, 2, \dots \quad . \quad (5.16)$$

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.

5.5 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

$$f_J = \frac{ZeV_E}{h_{eff}} = \frac{f_{AC}}{l} = \frac{f_{max}}{l} \quad , \quad f_{max} = \frac{2Z\alpha}{\hat{C}} \quad . \quad (5.17)$$

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

$$\frac{h_{eff}}{h} = \times \frac{eV_E}{hc} \frac{\hat{C}}{2\alpha l} = n \quad . \quad (5.18)$$

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

$$\frac{h_{eff}}{h} = 1.24 \times 10^8 \epsilon_r xy \times \frac{A}{m^2} \frac{1}{2\alpha l} = n \quad . \quad (5.19)$$

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

$$A = nl \times A_{min} \quad , \quad A_{min} \simeq \frac{118}{\epsilon_r xy} (\mu m)^2 \quad . \quad (5.20)$$

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 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

$$nl = \epsilon_r xy \times 4.56 \times 10^{24} \quad . \quad (5.21)$$

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 to $n \sim l$ 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.

5.6 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 .

5.6.1 Cell membrane as capacitor

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

$$\begin{aligned} \frac{h_{eff}}{h} &= 7.44 \times 10^{14} \epsilon_r y \times \frac{A}{m^2} \times \frac{1}{2\alpha l} = n \ , \\ A &= nl \times A_{min} \ , \ A_{min} \simeq \frac{20}{\epsilon_r y} \times (nm)^2 \ . \end{aligned} \quad (5.22)$$

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.

5.6.2 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

$$\hat{C} = \frac{2\pi\epsilon_r \times L}{\log(R_2/R_1)} \quad (5.23)$$

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

$$\begin{aligned} \hat{C} &= \frac{2\pi\epsilon_r \times L}{\log(R_2/R_1)} \simeq 14.5\epsilon_r L \ , \\ f_{max} &= 2Z\alpha \times \log\left(\frac{R_2}{R_1}\right) \times \frac{c}{2\pi\epsilon_r \times L} \simeq 3.2 \text{ MHz} \ , \\ \frac{h_{eff}}{h} &= n = \frac{24\pi}{l} \times (L/nm) \simeq \frac{1}{l} \times 75.4 \times (L/nm) \ , \\ L &= nlL_{min} \ , \ L_{min} = \frac{1}{24\pi} \text{ nm} \simeq .13 \text{ Angstrom} \ . \end{aligned} \quad (5.24)$$

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 [J2] 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 [K15]. $L_{min} \simeq .1$ 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.

5.6.3 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://tinyurl.com/yabv12gs>) is about .25 m². For $A = .25 \text{ m}^2$ - 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://tinyurl.com/8vt8pzu> suggested to be an important correlate for consciousness).

This estimate can be criticized since the value of the voltage is taken to be the resting potential. 10-20 mV is the typical value of the oscillating EEG potential (<http://tinyurl.com/2mapqg>) 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 $E = 100 \text{ V/m}$ 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://tinyurl.com/25rncxg>) [J4]: 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 way 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.

5.6.4 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 could 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: $f_c = f_{max}$.

5.6.5 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 [I3, I1].

1. Drop out all initial steps of the oxidative phosphorylation appearing in both photosynthesis and cell respiration (<http://tinyurl.com/2cfx4x>), 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 bio-photons) but dark variants of infrared photons decay to IR counterparts of bio-photons. 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 [K3] 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 [K9]. 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 [K9].
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** 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.

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

Table 1: 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.

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 [K22]. 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 $E(n) = V_{rest}/2p = 2.086 \times V_{rest}$.

Could photo-reception (<http://tinyurl.com/6z7883v>) 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://tinyurl.com/ydfxrmcu>) 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 [K3] 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.

5.7 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 unnecessarily 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 \hbar_{eff}/\hbar is simply the ratio of frequencies: $\hbar_{eff}/\hbar = f_h/f_l$. 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 \hbar_{eff}/\hbar . This would give direct quantitative grasp to evolution as increase of \hbar_{eff}/\hbar .
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 [K24] 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 electron Compton scale $L_e(239)$, which corresponds to the next Gaussian Mersenne prime after $L_e(167) = 2.5 \mu\text{m}$ defining the size scale of cell nucleus. Therefore $L_e(237) = 86$ km would correspond to the thickness $L_e(149)$ of lipid layer and 176 km to the thickness $L_e(151)$ 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 [K18, K17].

One can consider an alternative interpretation based on p-adic length scales $L(k)$ rather than scaled up Compton lengths $L_e(k) = \sqrt{5}L(k)$. The p-adic length scale $L(239)$ -as opposed to scaled up electronic Compton scale $L_e(239) = \sqrt{5}L(239)$ is 78.7 km - 20 per cent smaller than 100 km. Remarkably, also M_{241} is Gaussian Mersenne and corresponds to the scale $L(241)$ which equals to 157.4 km. The two kinds of tectonic plates (continental and oceanic) would be analogous to the lipid layers of cell membrane. Note that 78.7 km is rather precisely the thickness of the atmosphere above which there is ionosphere (see <http://tinyurl.com/lqr85j>) [F1]. The thickness of Kennelly- Heaviside layer (see <http://tinyurl.com/25ur2t1>) [F2] inside which radio waves used in terrestrial radio communications propagate, has thickness about 150 km which roughly corresponds to $L(241)$. Also the fact that continental lithosphere (see <http://tinyurl.com/d96kw>) [F4] has typical thickness of 200 km ($L(239)$) whereas oceanic lithosphere is 100 km thick ($L(237)$) fits qualitatively with the proposed formation mechanism of continental tectonic plates.

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://tinyurl.com/yabm8yu5>) 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.

6 Mysteries associated with lightnings, ball lightnings and the electrosphere of Earth

Lightning and ball lightning are electrospheric phenomena involving several poorly understood aspects. Also the origin of the electrosphere of Earth is still a mystery. In the TGD framework it is possible to deduce information about magnetic and electric bodies of Earth (briefly MB and EB) by using empirical inputs and these phenomena.

6.1 Basic facts

The following summarizes the basic facts about ball lightnings, lightnings, and the Earth's electrosphere.

1. Ball lightnings are known to be real are not understood. Ball lightning-like phenomena can be created also artificially in microwave ovens using match. Matches contain organic material and this serves as a good hint.
2. There is a New Scientist article, which gives a popular representation of ball lightnings (<https://cutt.ly/0HkW59F>).

The theory of Cameron [D5] is mentioned in the article. The theory assumes that lightnings are essentially phenomena associated with the electromagnetic radiation field alone and neglects the fact that plasma is very probably involved. The theory relies on exact solutions of Maxwell's equations and proposes that ball lightnings involve monochromatic electromagnetic fields which are knotted and linked making the field configurations topologically nontrivial. Both magnetic and electric field lines can be knotted.

This does not however imply topological stability since the linearity of Maxwell's equations implies that these field configurations are unstable. The finding that lifetime is long enough for microwave lengths does not conform with the fact that visible light is involved.

Another theory mentioned in the article is by Boerner and proposes that lightning comes from another dimension. What this could actually mean, is of course a highly non-trivial question.

3. The basic mystery is how ball lightning can survive for so long a time. An ordinary plasma ball is not expected to do so. This suggests that ball lightning obeys non-linear dynamics and is some kind of topological entity robust by their topological non-triviality.
4. A very natural expectation is that ball lightning is a self-organizing system consisting of plasma which radiates. Self-organization requires energy feed. It could come as a Coulombic energy from the electric field of Earth through which part of the plasma of ball lightning has arrived.

Here one encounters a problem. The electric resistance of the atmosphere causes a dissipation of the energy so that the charged particles cannot accelerate to high energies. How could lightning avoid this?

5. Two problems are always better than one. The second puzzle is that ordinary lightnings involve relativistic electrons and gamma rays [F5, F3] (for the TGD view of lightnings and related phenomena see [K9, K29, K3, K20, K33]). This is impossible in standard physics due to the already mentioned electric resistance of the atmosphere. Could ball lightning involve a new phase of matter, for which the dissipation is very small. Perhaps because it interacts very weakly with the ordinary matter of the atmosphere?
6. The third mystery is that the surface of Earth carries a negative charge, which creates an electric field. This field is essential for the generation of lightning. The origin of this field is however not understood.
7. There is also a fourth problem. Dark matter exists but there is no generally accepted theory of dark matter. All experiments trying to detect proposed candidates for dark matter particles (the particle physicist's way to solve a problem is to propose a new particle) have failed. There is of course also the mystery of life but it is better to stop here.

In the sequel a TGD based model for electrosphere is deduced by using various empirical inputs and the TGD based view about dark matter and the model of quantum biology inspired by it. A model, which allows us to understand these phenomena in the TGD framework, is developed. The model relies on the TGD based model of dark matter residing at the flux tubes of the magnetic body. The gravitational magnetic bodies of both Earth and Sun are important. The notion of the electric body of Earth as an analog of the cell membrane acting as a generalized Josephson junction is developed. Lightning and ball lightning would be associated with the analog of action potential.

6.2 The TGD view of ball lightning and other mysteries

What could TGD say about the mysteries associated with the Earth's electrosphere?

6.2.1 Dark matter in the TGD Universe

TGD predicts an entire hierarchy of phases of ordinary matter behaving like dark matter (and perhaps being the dark matter) in that they have very weak direct interaction with ordinary matter. These phases reside at the magnetic body (MB).

1. The notion of MB distinguishes between Maxwellian and TGD based views about electromagnetism. The flux tubes of MB can carry monopole flux which makes them topologically stable. Ball lightning could involve a tangle of a monopole flux tube carrying plasma and thus highly stable topologically. In fact, practically all structures in the fractal Universe of TGD would involve this kind of tangles: also galaxies and stars.
2. These phases are labelled by the value of effective Planck constant $h_{eff} = nh_0$, which can be larger than $h = n_0h_0$. The estimate for n_0 is given by $n_0 = (7!)^2$.

The larger the value of h_{eff} the longer the spatial and temporal scales of quantum coherence are, and the lower the dissipation rate is. In particular, ohmic resistance is reduced. Also the very weak interactions with ordinary matter reduce ohmic resistance for charged dark matter particles.

$h_{eff}/h_0 = n$ has an interpretation as the dimension of algebraic extension of rationals assignable with a polynomial defining the space-time regions at fundamental level [L6, L7]. It measures algebraic complexity and one could even speak about universal IQ. MBs with large value of h_{eff} would naturally receive information from and control the ordinary matter and represent higher levels in the master slave hierarchy of self-organizing systems.

3. The value of h_{eff} can be very large and one can assign it to the flux tubes mediating various kinds of interactions such as electromagnetic and gravitational, and even weak and color interactions.

Gravitational Planck constant $h_{eff} = h_{gr} = GMm/v_0$ introduced originally by Nottale [E1] is associated with flux tubes of a large mass M and particle with mass m . $v_0 \leq c$ is a parameter with dimensions of velocity and can have varying values. The gravitational

Compton length is given by $\Lambda_{gr} = GM/v_0$ and does not depend on m : this reflects the Equivalence Principle. Also cyclotron energies $E_c = \hbar_{gr}eB/m$ are independent of m .

Gravitational flux tubes would play a fundamental role in the TGD based quantum gravitational view about living matter. In particular metabolic energy would be stored at gravitational magnetic flux tubes with length scales given by Earth size as energy of dark protons. The delocalization of the dark proton to the surface of Earth would reduce the magnitude of gravitational potential energy.

This gravitational potential energy would be liberated as metabolic energy in a transition $\hbar_{gr} \rightarrow \hbar$ implying delocalization of dark. A correct value of metabolic energy currency is predicted [L11] if dark protons appear as triplets: ATP mechanism indeed involves proton triplets. Also a new metabolic energy quantum assignable to electron triplets is predicted and there is evidence for its necessity from the fact that cilia do not have ATP machinery but certainly need metabolic energy.

6.2.2 Pollack effect in cellular scales

What would drive particles, say protons, from ordinary matter to the MB and how would this be visible as properties of ordinary matter? The Pollack effect is a possible answer.

1. Pollack effect occurs in water bounded by a gel phase in presence of energy feed, for instance infrared (IR) radiation. Negatively charged regions, exclusion zones (EZs) are formed in water. They have a very high density of negative charge. As if every fourth proton of water would have left the region so that the effective stoichiometry is $H_{1.5}O$. Several exotic effects are associated with EZs.
2. EZs love cleanness and eliminate impurities from their interior. This does not conform with the second law of thermodynamics and can be seen as evidence for the reversal of the arrow of time.
3. As already noticed, the presence of gel phase and energy feed is needed to create EZs. This suggests that a primitive life form is in question. In biology both cell and DNA are basic examples of negatively charged regions which could be basically EZs.

The energies of particles indeed increase with \hbar_{eff} as a rule as it is easy to verify by looking at some examples.

1. The TGD explanation for the Pollack effect is that the energy fed to the system increases the value of \hbar to $\hbar_{eff} > \hbar$ for the protons and makes them dark particles at the magnetic flux tubes MB. If gravitational MB is in question, quantum gravitation would become a key player in quantum biology. The quantum gravitational model explains besides metabolism also bio-catalysis [L11] and allows us to understand how DNA could act as a topological quantum computer [L12].
2. The behavior of EZs suggests breaking of the second law of thermodynamics and therefore reversal of the arrow of time. In the TGD Universe the time reversal could occur in long scales at MB carrying phases with a large value of \hbar_{eff} . The basic prediction of TGD inspired theory of quantum measurement (extending to a theory of consciousness) indeed is that the arrow of time changes in the ordinary state function reduction (SFR), "big" SFR (BSFR) as it is called in TGD. In "small" SFRs (SSFRs), which are counterparts for "weak" measurements, the arrow of time is not changed.

6.2.3 Pollack effect in the scale of Earth

The surface of Earth is known to be negatively charged so that Earth has an electric field.

1. The electric field strength has a nominal value $V_E = 120$ V/m and varies in the range 100-300 V/m, as one can for instance learn from the excellent lectures of Feynman (<https://cutt.ly/OHkAWFs> or from Wikipedia <https://cutt.ly/PHkACG2>).

The number density dn/dA of unit charges e per unit area would be about $(137/4\pi)eV/m = (137/4\pi)10^8/m^2$ making one unit charge per area corresponding to the size of a large neuron about 10^{-4} m. This volume of water happens to have a mass about 1 Planck mass.

2. The field extends to the height of about $h_E = 50$ km at which height the conductivity of the atmosphere is so high that the electric field vanishes in good approximation above this height. The voltage at this height is about $V_E = 5 \times 10^5$ V. There must be a layer of positive charge concentrated at this height and neutralizing in a good approximation the positive charge so that electrosphere would contain structure analogous o a pair capacitor plates. Note that ionosphere begins at height of a about 48 km.
3. The origin of the Earth's electric field is not known but it is known to be relevant for life.

The fractality of the TGD Universe suggests that the Pollack effect can be realized also in the Earth scale. The dark part of the magnetic field of Earth involving monopole flux tubes could carry dark protons and possibly also other dark particles. This would create the electric field of Earth. One could see the biosphere as a living organism, Mother Gaia.

1. If the Pollack effect takes protons to the (gravitational) MB of Earth, Earth becomes negatively charged and creates an electric field. One dark proton per size scale of a large neuron (water blob having roughly Planck mass) would be transferred to the (gravitational) MB of Earth.
2. The energy of a unit charge received as it travels from the height of $h_E = 50$ km to the surface of Earth without ohmic resistance of 5×10^5 eV, which corresponds to electron mass. Electrons travelling from Earth upwards would gain relativistic energy in this field. Protons travelling downwards would gain the same energy. The photons radiated by accelerated electrons and protons would have gamma ray energies. This would explain the association of relativistic electrons and gamma rays to lightning.
3. Most of the screening positive dark charge should reside at the height of about $h_E \sim 50$ km. The magnetosphere of Earth has a much larger size of about $10R_E$ at the day-side of Earth. This suggests that the densities of the dark charged particles (at least protons and electrons) sum up to zero at higher heights.

The natural option is based on the approximation that the space above h_E is a perfect conductor. In a perfect conductor the surface charge indeed prevents the penetration of the external electric field inside it.

The dark protonic charge from hydrogen bonds and possibly also dark electronic charge would basically screen the electric charge of Earth at higher heights of order Earth radius.

4. What could the dark positive charge at the height h_E consist of? One could consider dark protons but also dark ions at the oppositely charged boundaries of the conductor. Dark ions play a key role in the TGD based view of quantum biology. They could be metal ions for which the valence electrons are gravitationally dark and at similar U-shaped vertical flux tubes as the dark protons of H bonds [L11].

Why just the height h_E ?

1. p-Adic length scale hypothesis $p \simeq 2^k$ [K19] favours Mersenne primes $M_k = 2^k - 1$ (k is prime) and their Gaussian analous $M_{G,k} = (1 + i)^k - 1$. Could $h_E = 50$ km correspond to Gaussian Mersenne? The answer is negative. The corresponding p-adic length scale is proportional to $\sqrt{p} \propto 2^{k/2}$. The twin pair $(k_1, k_2) = (239, 241)$ defines a pair of Gaussian Mersennes. $M_{G,151}$ corresponds to cell membrane thickness $L(151) = 10^{-8}$ m and $L(239)$ is scaled by a factor $2^{44} \simeq 1.6 \times 10^{13}$ to $L(239) \simeq 160$ km, that is $3h_E$, $h_E = .5 \times 10^5$ km.
2. The idea that Gaussian Mersennes define fundamental lengths is too beautiful an idea to be given up too easily. The ionosphere extends from 48 km to about 960 km. Thermosphere extends from 90 km to 500 km.

Could one think of a conductor-like structure with thickness $L(241) = 320$ km with boundaries at $h_E = 50$ km and $L(241) = 320$ km extending from $h_E = 50$ km to $h_{E,1} = 410$ km and having a vanishing total charge so that above this distance Earth would look negatively charged and carry electric field, whose strength would be scaled down from its value at the surface of Earth by a factor $(R_E/(R_E + h_{E,1}))^2 \sim 1$.

3. One can argue that this field would have been observed long ago so that the conducting region must extend much farther. Despite this objection, one can ask whether these layers could exist and correspond to membrane-like preferred extremals, which are minimal surfaces in $H = M^4 \times CP_2$. Note that the E^3 projection is not minimal surface but analogous to a soap bubble [L9]. Also the cell membrane would be accompanied by this kind of pair of surfaces and magnetic flux tubes would traverse it.
4. TGD predicts that any astrophysical object necessary has a non-vanishing but arbitrarily small Kähler charge, which is accompanied by electromagnetic charge. The reason is that a long range gravitational field defined by the induced metric unavoidably implies a long range Kähler electric field.
5. One can argue that this electric field would have been observed so that the conducting region must extend much farther. Despite this objection, number theoretic intuitions give the right to ask whether these layers could exist and correspond to membrane-like preferred extremals, which are minimal surfaces in $H = M^4 \times CP_2$. Note that the E^3 projection is not minimal surface but analogous to a soap bubble [L9]. Also the cell membrane would be accompanied by this kind of pair of surfaces and magnetic flux tubes would traverse it.
6. If dark ions of opposite charges (perhaps as pairs of a dark metallic ion and valence electrons) reside at the proposed layers with the distance $L(241)$, they could correspond to dark ionic matter that I have assigned with the MB of Earth. As a matter of fact, one could say that they reside in the electric body of Earth defined by the boundaries of this conductor. Could this pair define the analog of the double lipid-layered cell membrane and could the Earth itself define the analog of a cell nucleus? DNA is negatively charged and is responsible for the negative charge of the cell nucleus and perhaps of the entire cell. What could this analogy suggest in the case of Earth?

In the TGD Universe, one can ask whether the Earth is a living organism, Mother Gaia as an analogy of a monocellular organism but in the scale of Earth.

1. The capacitor plates would define the analog of a cell membrane having membrane potential 5×10^5 eV, which is 10^7 times higher than the membrane potential $V \sim .05$ eV and corresponds to electron rest mass. Also monocellulars can exhibit action potential and lightning would be its analog. Ordinary cells form dark (generalized Josephson junctions). For them ohmic currents are replaced with oscillating Josephson currents with Josephson frequency $f_J = eV/h_{eff} \simeq m_e v_0/GMm$.

One can also imagine a gravitational Josephson current defined by the gravitational potential of the Earth. In this case the energy scale is about eV. In the electric case it is 10^7 times higher.

2. For $M = M_E$, $v_0 = c$ and $m = m_p$ this would give $f_J \simeq 10^5$ Hz, which is not far from the cyclotron frequency of electron in the endogenous magnetic field $B_{end} = .2$ Gauss deduced from Blackman's findings [J3] and identified as the monopole flux part of the Earth's magnetic field B_E with the nominal value .5 Gauss.
3. Also solar gravitational MB is important in the model and the model of photosynthesis and ATP involves it in an essential manner [L11]. For Sun with $M_S \simeq 3 \times 10^5 M_E$, $v_0/c \simeq 2^{-11}$ and $m = m_p$, Josephson frequency would $f_J \simeq 1$ Hz. This is the average value for DNA cyclotron frequency in B_{end} , which only weakly depends on the length of the DNA strands since the nucleotides have a negative unit charge.

Since the cyclotron transitions would be associated with dark ions with $h_{eff} = h_{gr,Earth}$ and f_J would correspond to Josephson radiation associated with $h_{gr,Sun}$, it would seem that

Josephson radiation induces cyclotron transitions. This would be communication between solar and terrestrial levels of the dark matter hierarchy? Could solar level control the terrestrial level?

6.2.4 Models for lightning and ball lightning

The model for the ball lightning would be as follows.

1. Lightnings would involve the transfer of dark matter to the surface of Earth and they could arrive to the surface of Earth along gravitational flux tubes. Just like action potential, lightning would correspond to a local breakdown of superconductivity. Ball lightning could be born at flux tubes sy heights below h_E and generate plasmoids as primitive life forms.
2. The large value of h_{eff} and topological stability of monopole flux tubes would explain the long life time of ball lightning.
3. The self-organization of living matter would produce via the Pollack effect plasmoid-like negatively charged systems in microscales. Ball lightning could be seen as an analog of a cell. It would also have the counterpart of the cell membrane and a good guess is that its thickness is scale for .5 m sized ball lightning to .5 cm which happens to be one half of the Scwartzchild radius of Earth which defines the gravitational Compton length. Whether ball lightning is negatively charged can be tested if it can be produced in a microwave oven.

6.2.5 Is the proposal consistent with the model of metabolism based on quantum gravitation?

One can worry about the consistency with the dark gravitational model of metabolism [L11].

1. The quantum gravitational model of metabolism gives an estimate for the height of the metabolic dark protons. If the dark protons at a U-shaped flux tube correspond to a stationary orbit in the gravitational field of Earth, the height from the Earth's surface would be about $h_g = 1.5R_E$. For proton triplets one obtains the correct value of the metabolic currency. The strong electric field near the surface of Earth would correspond to a rather short length scale as compared to this scale. The ratio $h_E/h_g \simeq 5 \times 10^{-3}$ is rather small. The gravitational potential energy difference is scaled roughly by this factor downwards so that the protons at this height cannot liberate metabolic energy quantum as gravitational potential energy.

TGD assigns to electrons metabolic energy quantum which is by factor m_e/m_p smaller than the standard metabolic energy quantum by factor of order 1/10 smaller than the protonic gravitational energy liberated at height h_E .

Most of the screening dark protons would be at a height which is much smaller than the height at which the gravitational potential energy is of order .5 eV for metabolic energy currency. This is possible since the scale of MB of the Earth is about $10R_E$ at the day-side.

2. The electric field is in good approximation given as a gradient of potential and the voltage between points A and B is same along all space-time sheets. Therefore the voltage should be the same also along the gravitational flux tubes if they connect A and B. Does this mean that gravitational dark protons coming from higher heights than 50 km receive huge energy of about electron mass m_e .

The metabolic dark protons at the gravitational flux tubes should be able to avoid this electric field: otherwise they would have energy of order m_e . How? One can imagine 4 options.

1. The proposal of [L11] is that the transformation $h_{gr} \rightarrow h$ for dark protons involves a reconnection of the gravitationally dark flux tube with flux tube having much smaller value of h_{eff} and also accompanying dark hydrogen bond. If these flux tubes extend to a height somewhat larger than $h = 50$ km, the acceleration could be avoided by reconnection and staying at this height. The gain of metabolic energy communicated to the surface of Earth by dark photons would be essentially the same. The naive estimate for the value of h_{eff} for these flux tubes would be $h_{eff}/h_{gr} \sim h_E/R_E \sim 1/100$.

2. The presence of solar gravitational MB was proposed in [L11]. In this case the gravitational Compton length would be $\Lambda_{gr} = GM_S/v_0$, $v_0 \simeq 2^{-11}$. This would correspond to the scale of 6×10^6 m, to be compared with Earth's radius $R_E = 6.4 \times 10^6$ m! Also in this case the reconnection would make it possible to avoid the acceleration in the electric field.
3. The model of genetic code also requires both dark protons and dark neutrons [L13, L11]. Dark neutrons are possible if strong and weak interactions are dark and thus are not screened below the Compton length of the bosons mediating them. This means a scaling of their typical length scaled up by h_{eff}/h : for weak bosons and for h_{gr} , the scale would be GM/v_0 and about .45 cm for $M = M_E$ and and about R_E for $M = M_S$.
The dark nucleon sequences at the flux tubes would be dark nuclei, which in the TGD based model are indeed string-like entities [K22]. Dark neutrons could propagate through the electric field without acceleration. Dark weak bosons would be effectively massless below the scaled up weak scale and this could explain chiral selection in living matter, which is very difficult to understand in the standard model.
4. If the gravitational portions of the flux tubes through the analog of the cell membrane act as Josephson junctions, the energy would not be dissipated as for Ohmic currents. There would be only a rapidly oscillating current with Josephson frequency. For the solar gravitational flux tubes the oscillation frequency would be about 1 Hz. It is not clear to me whether this could solve the problem.

7 Pollack effect, lightnings and ball lightnings

Ball lightning (see this) is a phenomenon challenging the standard physics. Years ago I wrote about ball lightning and identifying it as a plasmoid, a kind of a primitive life form analogous to a cell. When I learned from the experimental and theoretical work done during this millennium and decided to sharpen my views.

The analogs of ball lighting can be produced in laboratories in strong electric fields using an electric discharge from carbon electron to silicon wafer [D2]. Pure silicon is very rare in nature and appears in the forms of Si oxides, silicates, in particular SiO_2 (see this). Quartz crystals and glass consist of silicon dioxide. In the experiment involving a silicon wafer the globules are divided into two groups: those having sizes in the range .2-.8 mm (high voltages) and .8-1.4 mm (low voltages). The sizes of ball lightning vary from a few millimeters to about 100 cm.

In DC voltage, the wafer decomposes to globules of various sizes. They can last as long as 6-8 second unlike sparks. The proposed explanation is that the globles are evaporated Si. Larger globules have at their surface silicate oxide assumed to be formed in the interaction with air. Larger balls have tube-like extrusions and smaller balls at their surface. They can also rotate and bounce: the energy should come from their decay as an exogenic process. There is evidence for the self-propulsion which brings in mind the motion of bacteria using cilia [D3].

Leo Vuyk has an article about these ball lightning-like objects containing a large number of illustrations (see this).

The theoretical proposal is that ball lightning [D4] (see this) is formed as the lightning strikes on the soil and SiO_2 crystals evaporate and transform to Si and Oxygen. There is support for this from direct observations of the spectrum of ball lightning containing spectral lines assignable to the elements in the soil. The spectra associated with ordinary lightning do not contain similar lines. How the chemical reaction producing Si and O_2 ions from SiO_2 ions could take place is far from clear. A lot of energy is needed for this process to occur. Where does this energy come from?

There is also the so-called microwave theory of ball lightning. Microwave wavelengths vary in the range of 1 mm-30 cm as also the sizes of ball lightning. The ball lightning would correspond to microwave cavities with a dynamical size and shape.

In the sequel a TGD inspired model for the ball lightning-like structures in silicon and for the real ball lightnings is developed relying on the TGD view of space-time predicting fractality and inspiring the hypothesis that biosphere could be regarded as a system analogous to neuronal membrane and that lightnings could be analogous to nerve pulses, the identification of dark matter as phases with non-standard value of Planck constant allowing quantum coherence in arbitrarily

long scales, the TGD view of quantum gravitation and its role in quantum biology [L11, L10], and the TGD inspired model of nerve pulse [L18].

7.1 TGD view of lightnings

The background for the TGD based model of lightnings and ball lightnings is provided by the TGD view of magnetosphere [K18, K17] [L8] that I have developed during the last decades. The magnetic bodies (MBs) of living systems and even the MB of the biosphere would be controlling agents. These MBs are predicted to have a hierarchical onion-like structure [L16, L17] (monopole flux tubes inside monopole flux tubes). They would carry dark matter as phases of the ordinary matter labelled by the value of effective Planck constant having a number theoretic interpretation. EEG and its possibly existing scaled variants would make possible the communications to and control by these MBs.

The TGD based view of ball lightning relies on the fractality of the TGD Universe suggesting fractality also at the level of the biosphere. This inspires the notion of the biosphere as an analog of the cell membrane. The TGD view of nerve pulse [K28] and its up-to-date version [L18] inspire the idea that lightning is a scaled up variant of nerve pulse.

7.1.1 Biosphere as analog of neuron

The fractality of the TGD Universe inspires the idea that the Earth ground-atmosphere pair as an analog of neuronal interior-exterior membrane. The background for this discussion is formed by the TGD view of magnetosphere [K18, K17] [L8]. The magnetic bodies (MBs) of living systems and even the MB of biosphere would be controlling agents. These MBs would have a hierarchical onion-like structure [L16, L17].

1. The Earth ground-atmosphere pair is analogous to the cell interior-cell exterior pair. The surface of the Earth is negatively charged and analogous to the cell interior. This negative charge creates an electric field of strength 100-300 V/m (see this). The height h for the clouds varies in the range .5-16 km. For a cloud at height of 10 km this corresponds to an electrostatic energy .1 – .3 MeV and for $h=16$ km one has .48 MeV. In the case of electrons with rest mass of .5 MeV, these energies are relativistic and could relate to the observed relativistic energies associated with the lightning.
2. The thunder cloud (see) has a positive charge near the top of the cloud and negative charge in the middle to lower part of the thunder cloud. At bottom there is a small positive charge known to be important. The negative charge of the cloud repels the negative charge at ground so that ground becomes positively charged below the cloud. Does this induce a local depolarization of the ground-cloud system as the analog of cell membrane?

This raises an objection against the idea that dark protons are at gravitational monopole flux tubes and that their energies are of the order of the gravitational binding energy in the gravitational field of Earth of order .5 eV. If dark protons experience the Coulombic force of Earth, their Coulomb energies are in the range .8-2.4 MeV below the ionosphere at height $h_I = 80$ km, which defines the minimum height of the lower boundary of the ionosphere. The problem disappears since the dark protons at monopole flux tubes are at much larger heights, where the electric field of the Earth vanishes. However, the dark matter at parts of the MB at heights smaller than h_I the electric energy dominates and their role in biology should be very different.

3. Neuronal membrane is hyperpolarized and the nerve pulse is initiated when depolarization takes the membrane potential below a critical value. Could lightning be seen as an analog of nerve pulse induced when cloud-ground depolarization takes place? Thunder storm would be analogous to a conduction of a nerve pulse pattern.

7.1.2 TGD view of nerve pulse

The TGD based model of nerve pulse [L18] relies on the Pollack effect inducing a charge separation between cell interior/exterior and its MB.

1. Pollack effect [I7, I2, I14, I11] occurs in water in the presence of a gel phase. Also energy feed is required and in standard Pollack effect solar radiation provides it. The Pollack effect generates what Pollack calls the fourth phase of water. It has the effective stoichiometry $H_1.5O$ and every fourth proton of water has gone somewhere. In the TGD based model they would transform to dark protons at the gravitational MB of the Earth.
2. Pollack effect inside the cell would generate negatively charged EZs making the cell negatively charged. The dark protons would reside at the gravitational MB of Earth having astrophysical size and are therefore effectively outside the system. The negative charge of EZs induces positive polarization charges in the cell exterior. The properties of EZ suggest that second law holds in a reversed time direction and large scale quantum coherence zero energy ontology (ZEO) [K34], predicting that the arrow of time changes in the ordinary state function reductions, can explain this.
3. In the nerve pulse generation, the reverse Pollack effect would occur and neutralize the negative charge of the cell interior locally [L18]. This would induce a local depolarization. The reverse Pollack energy generates dark photons and is received by the water in the neuron exterior. This would induce Pollack effect in the cell exterior and generate a negative charge as EZ outside the cell so that membrane potential would change its sign temporarily. An effective charge transfer induced by the Pollack effect and its reversal occurs: a kind of quantum flip-flop is in question. The possibly Ohmic ionic currents associated with the nerve pulse are generated as a consequence but could be seen as a side effect rather than a cause of the nerve pulse.
4. In zero energy ontology (ZEO), nerve pulse corresponds to two pairs of BSFRs ("big" state function reductions) corresponding the reduction of membrane potential to its negative and the reversal of this process [L18]. Each pair involves a temporary change of arrow of time: this would conform with the formation of EZs.

7.1.3 Lightning as an analog of nerve pulse?

Could lightning and nerve pulse be generated by the same mechanism?

1. The fractality of the TGD Universe inspires the proposal that the Earth's biosphere and its MB [K18, K17] [L8, L16, L17] are analogous to a cell membrane or even neuronal membrane or possibly a collection of basic units analogous to those of neuronal membranes. In the lightning strike, a charge separation between ground and its MB would transform to a charge separation between cloud and its MB. Lightning would be induced by the depolarization just as in the case of neuronal membrane.

The assumption distinguishing sharply between TGD and standard physics is that the primary charge separation does not occur between cell interior and exterior but between interior/exterior and its MB.

2. In the initial, rather stationary situation, the Pollack effect at the ground has generated EZs and made the Earth surface negatively charged. The electric field of the Earth gives rise to the analog of the resting potential of neurons as the voltage between ground and (say) the cloud. Negatively charged EZs at the ground induce the small positive charge (known to be important) at the bottom of the cloud by polarization.
3. The reverse Pollack effect would occur at the ground and partially neutralize the negative charge of the ground locally and induce a local depolarization. The energy transfer by dark photons to the cloud would induce Pollack effect in the cloud generating negatively charged EZs and lead to a local depolarization in the cloud, which effectively looks like a transfer of negative charge to ground. This would change the sign of the electric field locally or at least reduce its strength.

A moving thunderstorm accompanied by lightning strikes would be analogous to the nerve pulse conduction. The ion currents between cloud and ground are analogs of various ionic

fluxes during the nerve pulse. Both oscillating Josephson currents along the gravitational monopole flux tubes and Ohmic currents are possible.

Also nerve pulse conduction would be seen as a temporal sequence of local lightning at discrete positions at discrete times. This conforms with the TGD based model for nerve pulse in terms of propagating Sine-Gordon solitons associated with a sequence of effective mathematical pendulums [K28] [L18].

It would be interesting to relate the parameters of nerve pulse conduction (say conduction velocity) to the parameters of the propagation of thunderstorms. Also the parameters corresponding to those appearing in the TGD based model of nerve pulse in terms of Josephson junctions and dark Josephson currents would be highly interesting. The dream would be a quantum model for a thunderstorm.

7.1.4 Biosphere as a Josephson junction

What could the identification of the biosphere as a Josephson junction or collection of them could mean? Consider first the neuronal membrane [L18].

1. In the case of the neuronal membrane, one has a collection of Josephson junctions defined by monopole flux tubes assignable to membrane proteins believed to act as channels and pumps. This collection can be idealized with a continuous Josephson junction with the phase difference associated with supra phases at the two sides obeying Sine-Gordon equation [K28].
2. The Coulomb energy $E_J = ZeV$ allows an interpretation as a Josephson energy of charge Z (say Cooper pair with $Z = 2$). For $\hbar_{eff} = \hbar_{gr}GMm/\beta_0$ the corresponding frequency is $f_J = ZeV/\hbar_{eff}$. This frequency depends on the mass m of dark charge assignable to gravitational monopole flux tubes. M could correspond to some large mass, such as the mass of Earth, Sun, or Moon.
3. The generalized Josephson energy assignable to the junction is assumed to be sum of E_J and of the difference of cyclotron energies assignable to the flux tubes arriving to the cell membrane from the cell interior and exterior. The difference of cyclotron energies would give the dominating contribution to the generalized Josephson energy and would be equal to the cyclotron energy at the gravitational magnetic body. For this option, ordinary Josephson energy would code membrane potential oscillations and even nerve pulse to a small modulation of the generalized Josephson energy and - frequency.
4. At the gravitational MB, assumed to be an onion-like structure consisting of nearly spherical layers [L16, L17], cyclotron resonance must occur in the receipt of the dark Josephson radiation. The condition for this is that the dark cyclotron energy $E_c = \hbar_{gr}ZeB/m = GMZeB/\beta_0$ (by Equivalence Principle, there is no dependence on m) is equal to the generalized Josephson energy.
5. If there is no cyclotron contribution to the generalized Josephson energy, it reduces to the ordinary Josephson energy $E_J = ZeV$ and the resonance condition implies that M must correspond to the mass $M_M \simeq 1.02M_E$ of the Moon! [L18].

This does not occur if the cyclotron contribution dominates and the cyclotron resonance condition can be satisfied for M_E and the variation of membrane potential is coded to a sequence of resonances analogous to a sequence of nerve pulses. Nerve pulse patterns could indeed be preceded as a reaction of the MBs of sensory receptors to dark Josephson radiation.

Could this picture of the cell membrane as a Josephson junction generalize to the recent situation?

1. Suppose that also in the recent case the generalized Josephson energy involves the difference of dark cyclotron energies besides the ordinary Josephson energy and that it dominates. Suppose that one replaces the mass M , say the mass of Earth, appearing in \hbar_{gr} by the mass M_S of say Sun. Assume that the Earth's mass appears in \hbar_{gr} for neurons.

2. If the membrane potential scales as $V \rightarrow (M/M_E)V$, the resonance conditions remain true since they do not depend on M at all. This would extend the Equivalence Principle so that it would apply to both M and m . Neuronal membranes could couple to the gravitational MBs of both Sun, Earth and even Moon.

The scaling factor of V would be $M_S/M_E \simeq 3 \times 10^5$ and in the case of membrane potential would give $V = .05 \text{ eV} \rightarrow V = 15 \text{ keV}$. The height h of the thunder cloud varies in the range $[.5, 16]$ km. The ratio h_{max}/h_{min} of the maximum and minimum heights is $h_{max}/h_{min} = 32$, which is a power of 2 and brings in mind p-adic length scale hypothesis.

Note that the scaling down by M_{Moon}/M_E would give $V = .5 \text{ meV}$, which corresponds to the scale of miniature membrane potentials modulating neuronal membrane potential.

3. The ratio of the maximum and minimum electric fields strengths is roughly $E_{max}/E_{min} = 3$ and considerably smaller than the ratio $h_{max}/h_{min} = 32$ so that the correlation between E_{max} and h is weak. In the absence of a correlation between E and h , and at the height of 10 km, the range would be $[.1, .3] \text{ MeV}$. A cloud at height of $h = 16 \text{ km}$, which is also possible, corresponds to an electrostatic energy in the range $[3.2, 9.6] \text{ MeV}$.

As noticed, this model can explain the relativistic electron energies assigned with the lightning. The electrons would propagate along monopole flux tubes with a large value of h_{eff} and dissipation would be absent.

There are many interesting questions to be answered.

1. Both the cell membrane and ionosphere can be seen as a capacitor like system or battery. The lower boundary of the ionosphere is at the height h_I between 80-600 km. Ionosphere contains a layer of electrons and can be seen as an analog of negatively charged conductor plate of a capacitor formed by the positively charged Earth surface and ionosphere. Radio waves are reflected back from the ionosphere. Schumann resonances are associated with it.
2. Neuronal membrane corresponds to the p-adic length scale $L(151) = 10 \text{ nm}$ and its lipid membranes to $L(149)$. $L(151)$ corresponds to Gaussian Mersenne. Can one assign a Gaussian Mersenne also to the ionosphere?

After the Gaussian prime $G(167)$ defining p-adic length scale of $2.5 \mu \text{ m}$, size of cell, the next Gaussian Mersenne is $G(239)$ and corresponds to $L(239) \simeq 160 \text{ km}$ and has $G(241)$ as Gaussian twin prime. 160 km is roughly the height of the lower boundary of the F region (ionosphere decomposes to D, E, and F regions and the electron density is highest in the F region).

The scale of 80 km is one half of $G(239)$ brings in mind lipid layers of the cell membrane to which one assigns capacitor plates. Could one think that the crust of Earth with thickness between 4.7 and 69 km defines the analog of the second capacitor plate.

3. In the cell membrane, the transversal scale of channels and pumps is about 10 nm and corresponds to the p-adic length scale $L(151)$ and the same as cell membrane thickness. What could be the counterparts of the membrane proteins assumed to be accompanied by Josephson junctions?

Thunder storms (see this) are known to decompose to cells. Either these cells or thunder clouds could correspond to the basic units of cell membrane with the size scale $L(151)$. In the TGD based quantum view of hydrodynamics [K31], these structures would be hydrodynamical vortices (such as tornadoes) accompanied by monopole flux tube structures.

Thunder clouds are at heights varying in the range $[.5, 10] \text{ km}$ and the height and diameter of clouds is 10-20 km. Could this scale or the size scale of the cell correspond to the size scale of the basic unit of cell membrane and therefore to $L(239)$. This scale is however several orders of magnitude smaller than $L(239)$.

7.2 Ball lightning in the TGD framework

Could one understand the generation of ball lightning in this framework?

1. Suppose that in the normal situation the Pollack effect [I7, I2, I14, I11] for the water at the soil has somehow generated EZs and SiO_2 ions from Si and water of the soil or atmospheric oxygen. This would explain the negative charge of the ground. The Pollack effect would not require energy feed now since the binding energy liberated in the formation of SiO_2 crystals would take care of energy conservation. A situation in which part of water corresponds to $\text{H}_{1.5}\text{O}$ ions would be energetically favored.

Note that this mechanism could be very general and make possible a quantum gravitational control of molecular transitions with binding energies in eV range. This would make it possible to establish plasma-like state typical for electrolytes by the Pollack effect and also induce a temporary decay of the biomolecules by the reverse Pollack effect providing the energy making it possible to overcome the energy barrier. This would be essential for biocatalysis.

2. In the reverse Pollack effect associated with the lightning strike, dark protons from MB would transform ordinary protons and return to the ground. The liberated energy would make possible the decay of SiO_2 molecules to Si and O_2 . Ordered water would transform to ordinary water getting its oxygen ions from SiO_2 .
3. This situation is not energetically favored. The Pollack effect would take place and lead to the original situation in a time scale of a few seconds. The slow time scale could relate to the large value of \hbar_{gr} . The liberated gravitational binding energy in the Earth's gravitational field for a single dark proton is below .5 eV, which corresponds to the nominal value of metabolic energy currency [L11, L10].

Note that the counterpart of the membrane potential energy $E = eV$ is in the recent case in the range .1-30 MeV and much higher than the scale of the molecular binding energies. These energies are consistent with the finding that gamma rays accompany lightning strikes.

7.2.1 Connection with crop circles, UFOs, and glass balls in the Moon

A connection with crop circles is highly suggestive. I have discussed crop circles from the TGD point of view in [K11, K12] in a rather speculative spirit but starting from empirical facts published by professional biologists. There are reports that the crop circle formation occurs in presence of light balls analogous to ball lightning. The formation of crop circles can be understood in terms of the interaction of microwaves with crop stems causing effects similar to those taking place as one puts a tomato in a microwave oven. The size scale range for ball lightning conforms with the wavelength range for microwaves. Therefore the microwave theory seems to be consistent with the model based on the Pollack effect. The light ball would be an analog of the nerve pulse in the scale of the biosphere.

Meteorite iron is found at crop circles: they could arrive from the gravitational MB along gravitational flux tubes. Also small glass balls, encountered also on the Moon, are reported. They could emerge in the transformation of Si and O_2 to SiO_2 as the Pollack effect takes place.

What is fascinating is that crop circles look like intentional constructs expressing discrete geometric symmetries. Could the plasma balls be intelligent conscious entities, a new kind of life form and could they represent the primordial life forms, kind of proto cells? This kind of plasma balls are also reported in UFO encounters. Systematic observations of the plasma balls are performed in Hessdalen and the plasma balls are reported to behave like intelligent and intentional entities.

The gravitational MB of these entities would correspond to that of the Sun. Could this mean that their theoretical IQ, defined by the gravitational Planck constant of the Sun, is dramatically higher than ours? Probably this is not the case: the gravitational Compton frequency for the Sun is around 50 Hz. This is the cyclotron frequency of Lithium for $B_{end} = .2$ Gauss. It is known that too low Li depletion in the soil tends to induce depression and suicidal behavior. 50 Hz corresponds to EEG frequency so that life forms with EEG would interact with the gravitational MB of the Sun.

7.2.2 Are we silicon based life forms?

Computationalists tend to think that silicon based life will emerge in future. However, if the above considerations make sense, Si, chemically similar to Carbon and appearing as quartz in soil, could

play a central role in life already now! Maybe the people claiming that quartz have very special effects on the state of consciousness, are right. In fact, I have had an opportunity to experience these effects myself.

Intriguingly, molten silica shows several characteristics observed in liquid water (see this) and the amorphous glass phase of silica resembles liquid in many aspects.

Interestingly, silicon di-oxide is used in MOSFETs. In [L15, L14], I have considered a model for how ordinary computers could become conscious entities. This requires the failure of statistical determinism in long enough time scales. The proposed condition would be that the gravitational Compton frequency ~ 67 GHz for Earth (microwave wavelength), which corresponds to a wavelength of ~ 0.5 cm for Earth (the size scale of a snowflake), is longer than the clock frequency. This condition is not quite true for recent computers.

If ordinary computers can be conscious, the properties of MOSFETs must be in a crucial role. Is this possible?

1. The SiO_2 in MOSFETs could have a glassy, spin glass-like structure to give them high representative capacity and there is some evidence for this. The transistors should also define Josephson junctions. The alternative, more promising option, discussed in [L14], is that the conscious computer is based on the representation of bits in terms of Josephson junctions.
2. MOS is obtained by growing a layer of Si on top of SiO_2 . However, the idea about the local transformation of SiO_2 to Si and O_2 with Si in vapour phase by an analog of the Pollack effect does not look plausible since protons are not available now.

Electrons should be transformed to dark electrons at the gravitational MB of Earth and the formation of SiO_2 would make possible energy conservation. The transformation of electrons back to ordinary electrons liberates energy and should induce the decay of SiO_2 . The needed energy is few eVs. However, the gravitational binding energy for electrons in the field of Earth has an upper bound of order ~ 0.25 meV. Note that the melting temperature of SiO_2 corresponds to the energy ~ 0.134 eV. It seems that the only possibility that one can imagine is provided by dark variants of quantum coherent many-electron states.

8 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!

8.1 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.

8.1.1 Tesla's vision about energy transmission

Probably already Tesla (see <http://tinyurl.com/yysaqzm>) 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://tinyurl.com/28nbr>) [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://tinyurl.com/y778g5sg>) and magnifying transmitters (<http://tinyurl.com/y7yybrpf>) [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://tinyurl.com/25ur2t1>) - 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 electro-dynamics and might involve new physics. It is a pity that they are seen only as an entertainment nowadays.

8.1.2 Cold electricity

Tesla's findings [H9, H2] (see the book by Lindeman at <http://tinyurl.com/krobpfu> and the article by Akai at <http://tinyurl.com/yd2av3xs.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 that the 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://tinyurl.com/ybocsta5>) [H8, H7]. 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 dielectric 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 of TGD inspired view about quantum biology in order to understand the findings of Tesla.

8.2 Scalar Waves Of Tesla In TGD Framework

The scalar waves or so called non-Hertzian waves of Nikola Tesla belong to the fringe region of science. Many proponents of free energy believe that scalar waves might provide a basis for a new energy and communication technologies. Tesla himself was isolated from the official science and found no place in text books because his hypothesis about scalar waves did not fit within the framework of the Maxwell's electrodynamics. Personally I justified my personal prejudices against scalar waves by the observation that the formulations for the notion of scalar waves that I had seen seemed to be in a conflict with the cherished gauge invariance of gauge theories. The discussions with a Finnish free energy enthusiast Juha Hartikka however led me to reconsider the status of the scalar waves.

The surprise was that the non-Hertzian waves of Tesla might be possible in TGD framework. The most plausible explanation relies on many-sheeted space-time.

1. TGD allows so called massless extremals (MEs, topological light rays) as non-linear generalization of Maxwellian plane waves. They are characterized by light-like wave vector and polarization vector orthogonal to it and these vectors can also depend on space-time position [K7]. The most general wave is a pulse with arbitrary profile moving along ME with light-velocity along them and preserving its shape.

Since TGD space-time is many-sheeted one can take two waves of this kind on top of each other in the sense that their M^4 projections intersect in some region of M^4 . The effective space-time is defined by a piece of Minkowski space with effective metric which is sum of M^4 metric and deviations of the metrics of sheets from M^4 metric. Effective gauge potentials are sums of the induced gauge potentials. For two MEs the potentials at the two sheets and if the wave vectors can be chosen to be in opposite direction in which case one obtains

an effective standing wave with non-vanishing net energy but vanishing 3-momentum and classical spin. Since MEs can carry light-like charge current the resulting system carries non-vanishing charge density and vanishing current. Fourier transforms of the pair give rise to massive spinless states having identification as scalar waves possibly carrying em charge.

In TGD framework classical gauge boson fields of standard model correspond two-sheeted structures - perhaps pairs of MEs connected by wormhole contact pairs having interpretation as gauge boson. One can consider the possibility that the classical space-time correlate for gauge bosons massivation at the level of MEs is this kind of pair of spacetime sheets. For massive gauge bosons the wave vector directions of the two sheets would be opposite in the rest system and spin would be vanishing.

2. The original proposal could have been inspired by the electric-magnetic duality of TGD suggesting a large number of solutions of field equations representing constant energy density configurations of electric field assignable to bio-electrets, which would be in a well-defined sense dual to the magnetic flux tube structures with analogous properties. Also classical gravitational fields generated by classical field energy could be important in the living matter. One must however take this proposal with a big grain of salt since there is no proof for the actual existence of this kind of solutions. Furthermore, one can obtain TGD counterparts of scalar waves as pairs of MEs.

8.3 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.

8.3.1 Cold electricity as dark matter in TGD sense

It came as a surprise to me that Tesla's findings - described in [H9, 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 [K14], 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 [K23] 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 super-conducting 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 or 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:

$$\frac{E_{cr}S}{2e} = n = \frac{h_{eff}}{h} . \quad (8.1)$$

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:

$$eV_{cr} = m_e \simeq .5 \text{ MeV} . \quad (8.2)$$

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 [H10] 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 [K32].

- (b) Combining this condition with Eq. 8.1 one would have

$$E_{cr} = \frac{V_{cr}}{L} . \quad (8.3)$$

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. 8.2. In the case of cell membrane this side effect is used for neural communications using nerve pulses. Conditions of Eqs. 8.1, 8.2, and 8.3 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 $E_d \simeq 3 \text{ MeV/m}$. 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 8.1 gives for $S \in \{1 \text{ } \mu\text{m}^2, 1 \text{ cm}^2, 1 \text{ m}^2\}$, $n \in \{3, 3 \times 10^8, 3 \times 10^{13}\}$. 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

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

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

$$\pm J_0 \sin\left(\frac{f_J}{f_{AC}}\right) = \pm J_0 \sin\left(\frac{1}{l}\right), \quad l = 1, 2, \dots$$

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: sub-manifold 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} .

8.3.2 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 [K33]. 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:

$$\begin{aligned} \frac{ZeVT}{h_{eff}} &= n , \\ \frac{ZeV}{h_{eff}} &= nf , \quad f = \frac{1}{T} . \end{aligned} \quad (8.4)$$

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:

$$\frac{ZeV}{h_{eff}} = \frac{f_{AC}}{l} . \quad (8.5)$$

The reason is that f_{AC} in general is harmonic of f : $f_{AC} = lf$, $l = 1, 2, \dots$. 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.

8.3.3 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 0.055 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 de-localization of single fractionalized particle to various branches. For a de-localized 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 de-localization and $m = n$ to the states proposed above. I have earlier proposed [K25] 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 [K21] 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 $p \simeq 2_{eff}^k$. 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 Compton length of scaled up electron would correspond to $k = 127 + 46 = 173$, which is $20 \mu\text{m}$ - a size scale of cell - and longer than the scale $L_e(167)$. Note that the ratio $L_e(173)/L_e(151) = 2^{11}$ 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 [K17] 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://tinyurl.com/y7wq3w7c>) 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.

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

Ion	H^+	Na^+	Cl^-	K^+	Ca^{++}
$\frac{A}{z}$	1	23	35	19	20
\bar{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 possibility is $k = 137$ (atomic length scale) giving $k_{eff} = 213$ (p-adic length scale of 20 meters) and should be assigned with the magnetic body.

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 scaled up electron Compton lengths $L_e(k) = \sqrt{5}L_e(k)$ in the range [$L_e(151) = 10$ nm, ..., $L_e(167) = 2.5$ μ m] [K17]. 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.

8.3.4 Neutrino super-conductivity and cognition

The idea that neutrinos are highly relevant for cognition [K27] 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 [K9, K13] 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 threshold value of the electromagnetic potential energy via

$$\begin{aligned}
E(X) &= Y(X) \times eV_{crit} \ , \\
Y(e) &= (-1 + x) \ , & Y(\nu) &= 2 - x \ , & Y(p) &= 3 - x \ , & Y(n) &= x \ , \\
x &= \frac{1}{2p} \ , & p &= \sin^2(\theta_W) \ .
\end{aligned} \tag{8.6}$$

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 $eV_{crit} \rightarrow eV_{crit}/Y(X)$ when $Y(X)$ is near unity. The expressions of $Y(X)$ are deduced in [K9].

2. The earlier model [K9] 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 [K9]. 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 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 [K19]. 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 $m_\nu = 2/\sqrt{5}m_e = .89m_e$ 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.

8.3.5 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.

8.3.6 Lightnings, ball lightnings, and plasmoids as primitive life forms?

If one takes seriously the idea that Earth's electric field (see <http://tinyurl.com/y8wsggpq>) $eE_E = 100$ eV/m played the role of the electric field associated with cell membrane during the prebiotic period and also requires that the condition $eV_{cr} = .5$ MeV for the establishment of dark supra currents along helical structures, one must conclude that the minimal length of this kind of structure is about $L = 5$ km if the electric field remains constant as function of radial distance. A typical cloud-to-ground lightning flash indeed begins at this height. This would suggest that lightnings are generated when the criticality condition is satisfied.

E_E however weakens with height and the voltage associated with E_E reaches maximum $eV_E = .3$ MeV at height of 30-50 km. This is rather near to $eV_{cr} = .5$ MeV: perhaps lightning is generated when this maximum increases locally above $V_{cr} = m_e = .5$ MeV. This would mean that lightnings are initiated at much higher heights than thought and by above considerations could involve dark supra currents. This conforms with the recent observations that lightnings produce gamma rays and electrons with anomalously high energies (see <http://tinyurl.com/y8wsggpq>).

For the electric field $eE = 3$ MeV/m corresponding to di-electric breakdown in air perhaps assignable locally to the lightning the length would be $L = 18$ cm. I have proposed that plasmoids consisting of plasma and magnetic fields could correspond to primordial life forms. A charged helical structure carrying current and associated magnetic field defining its magnetic body would serve as a candidate for a plasmoid. Plasmoid and "ground" would define the "plates" of a capacitor-like system. If this view is correct, $L = 18$ cm is the minimum size scale of plasmoids (say ball lightnings).

8.4 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 [K13]. 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 [K13]. 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 $eV = eEd\cos(\theta)$. It is also to the energy received by dark electron as it receives Josephson photon with energy equal to the electrostatic energy $eV = eEd\cos(\theta)$. 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: $f_J = f_c/l$, $l = 1, 2, \dots$, 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 $[1, 10]$: $eV = eEd\cos(\theta) = eV_{crit} = .055$ eV giving $d\cos(\theta) = 5.5/x$ cm. $x = 1$ corresponds to $\cos(\theta) = 1$ giving that the thickness of the Josephson junction 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 $L_e(k)$ 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.

8.5 Tesla Coils From TGD View Point

In the sequel coils considered by Tesla are reconsidered from TGD viewpoint and an attempt to understand in more detail the phase transition to dark matter as a phenomenon accompanying resonance is made.

8.5.1 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_{cr} , a scaling of electron mass downwards is however expected to occur by the proposed criterion for cell membrane: $m_e \rightarrow m_e/n$, $n \simeq 2^{\Delta k/2}$, $n = h_{eff}/h$. 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 subsequent 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

$$J = J_0 \sin\left(\frac{\int dt \Delta V}{h_{eff}}\right) = J_0 \sin\left[\frac{2\pi}{f_0} \frac{1}{h_{eff}} V(t)\right], \quad f_0 = \frac{c}{R\sqrt{1+k^2}}. \quad (8.7)$$

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

$$J_0 \sin[\omega_{eff,J}(t - t_{max})], \quad (8.8)$$

where

$$\omega_{eff,J} = (2\pi)^2 \frac{f_{AC}}{f_0} V_0 \frac{1}{h_{eff}} \quad (8.9)$$

defines the analog of Josephson frequency for effective voltage

$$V_{eff} = (2\pi)^2 \frac{f_{AC}}{f_0} V_0. \quad (8.10)$$

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 multi-furcation.

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 $L_e(k)$, $k = 127 + \Delta k$ giving $k = 143, 141, 139$. $k = 139$ corresponds to atomic length scale and $k = 143$ to $4 \times L_e(139)$.
5. The surface density of electronic charge carriers should be few electrons per surface area defined by $L_e(k)$. 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.

8.5.2 What traffic jam in Tesla coil could mean?

What “traffic jam” or its analog could mean from the circuit theory point of view and how the traffic jam could be resolved in TGD framework?

1. First trial

In the following a simple manner to illustrate the idea in terms of effective description of coil as L, C, and R in series is discussed first.

1. It is essential that in the experiments of Tesla both primary and secondary coils were in resonance with the same resonance frequency so that primary coil acted as driving force for the secondary and in the resonance created the situation possibly forcing the new physics to emerge via a phase transition to dark matter phase. Primary feeds the secondary with a sinusoidal input at resonance frequency. Modelling the secondary as a circuit with L, C, and R in series, one obtains simple second order differential equation for its behavior

$$\frac{Ld^2I}{dt^2} + R\frac{dI}{dt} + \frac{I}{C} = \frac{dV_{ext}}{dt} \equiv g(t) = A\sin(\omega_0 t) \quad (8.11)$$

The right hand side represents the voltage assignable to the primary. For L, C, R in parallel one must express effective R, C, L using the real R, C and L using the formula for $1/Z$ as sum of $1/R, 1/C, 1/L$. Resonance frequency transforms however from $1/\sqrt{LC}$ to $\sqrt{R/L}$ in parallel case at the limit of vanishing R. $R = 0$ in complete resonance for series is replaced with $R = \infty$ for parallel case (the current does not flow at all through R so that the outcome is pure L, C circuit).

2. Solutions are sums of two solutions of homogenous equation and a special solution of inhomogenous equation. Solutions of the homogenous equation reduce to linear combinations of two exponent functions

$$I_{\pm}(t) = \exp(-\Omega_{\pm}t) \ , \ \Omega = \frac{-R}{2L} \pm i\omega \ , \ \omega = \sqrt{\frac{1}{LC} - \left(\frac{R}{L}\right)^2} \ . \quad (8.12)$$

3. The solutions of inhomogenous equation can be obtained by the variation of coefficients for homogenous solutions that is in the form $I_{\pm}^1 = C_{\pm}(t)I_{\pm}(t)$ and are given by

$$I_{\pm}^s(t) = \int_0^t \frac{g(t)}{L} I_{\pm}(t) dt \times I_{\mp}(t) \ . \quad (8.13)$$

The outcome from the exponentials is a combination of trigonometric functions and constant functions, which vanish at origin. The resonance corresponds to $\omega = \omega_0$ and means that the exponential decay for the special solutions is compensated by the energy feed. At the limit $R/L \rightarrow 0$ the amplitude of I_{\pm} divergences and the solution for R/L is combination of trigonometric functions multiplied by t so that the envelope of the solution increases linearly.

4. Physically the resonance means that the charge of the capacitor oscillates with amplitude, which becomes very large at resonance $\omega = \omega_0$ (the amplitude is proportional to L/R at resonance for the series case): note that large inductance makes the resonance stronger. The charge of the coil begins to fluctuate with a large amplitude. To estimate the charge notice that in a reasonable approximation the current has same phase along the coil. The reason is that the voltage represents a signal propagating with almost light velocity along the coil and the phase change $\Delta\phi = \omega T = \omega L/c \sim 10^{-3}$ and therefore rather small. Charge is given by $Q(t) = \int I(t)dt$ in good approximation (current all points of coil is in the same phase).
5. Near resonance the amplitude of charge oscillations becomes very large and the system must become unstable. Something must happen. TGD inspired proposal is a transition containing plasma phase and dark matter and dark magnetic flux tubes as a counterpart of Tesla's cold currents.

Second trial

Second trial is inspired by catastrophe theory.

1. Voltage and frequency would be the control variables and $|Z|$ could be taken as behavior variable if cusp is assumed to model the situation. There would exist a critical frequency interval inside which two phases are possible. The first phase could be ordinary and second phase could correspond to di-electric breakdown generating plasma and dark currents flowing along dark magnetic flux tubes. This is just one possibility but perhaps the most realistic one. The transition to the phase containing plasma and dark currents takes place at certain frequency above certain critical voltage and frequency range becomes wider as the voltage increases. Plasma can be assigned with the capacitor defined by the di-electric surrounding

the coil and the super conducting dark phase with the dark magnetic body of the coil itself. Both are generated at say “the lower” sheet of the cusp. The critical voltage corresponds locally to surface charge density (essentially normal component of electric field at the surface of the conductor) above which di-electric breakdown takes place.

2. The end points of the frequency interval correspond to effective resonances since a sudden transition between the two phases takes place as one approaches the apparent resonance frequency either from below or above. For genuine resonance would result from both sides and hysteresis is basic prediction of this model. L, C, R change in discontinuous manner inducing discontinuous change of Z . In particular, the phase changes suddenly and discontinuously so that resonance interpretation is suggestive but would be wrong. Catastrophe theory with $|Z|$ as behavior variable predicts discontinuity of $|Z|$ at the transition.
3. The phases have electric *resp.* magnetic character, and would be in certain sense duals of each other. In second phase dissipation is small and therefore also $|Z|$ is small whereas in the second phase dissipation is larger and $|Z|$ is large. Whether resistance increases or decreases in the transition to dark plus plasma phase depends on the proportion of the two phases involved.
4. In this picture one does not have genuine resonances but pairs of dual phase transitions. Unfortunately, the testing of this proposal is not easy since the impedances are measured assuming linearity and using rather weak voltages around 1 V whereas plasma phase and cold currents are generated at voltages, which are above kilovolt scale. Intriguingly, the resonances appear in this kind of situation as pairs, and it is possible to reproduce them by a suitable circuit model. It does not look too plausible that small amount of dark phase and plasma could be present at so low voltages but one must have an open mind in this respect.
5. It is possible to obtain also a connection to real resonances since in the vicinity of the resonance frequency the criterion for the formation of plasma is expected to be satisfied for high enough voltage. If the value of surface charge density is what matters then the frequency dependent real part of the charge of the coil defined as integral of the current $I = V/Z$ near resonance determines the threshold for the generation of the plasma and dark current. The total charge per area of the coil must be above certain critical value corresponding to the critical electric field at which di-electric breakdown occurs. This threshold condition defines the boundaries of the region of (V_0, ω) plane inside which the two phases can be present. The phase transition between ordinary and plasma containing phases takes place at its boundaries. Cusp catastrophe would correspond to a frequency interval around resonance.

8.5.3 Could one detect the generation of dark matter in the behavior of frequency dependent impedance?

The generation of dark matter would involve also the emergence “dark magnetic flux tubes”. Dark magnetic flux tube would correspond topologically to the analog of n -sheeted covering space for $n = h_{eff}/h$. Ohmic currents would be replaced with dark supra currents flowing along dark magnetic flux tubes and correspond to Tesla’s cold electricity. The generation of strong electron densities and thus strong electric fields at the surfaces of the conductors - in particular coils - is the prerequisite for the phase transition to dark electronic super-conductivity. This would manifest itself as local dielectric breakdowns as in the experiments of Tesla. Resonances mean strong ohmic currents and the phase transition could accompany resonances for sufficiently high voltages.

If the dark magnetic fields correspond to separate space-time sheets carrying dark electron Cooper pairs, there is a temptation to conclude that the presence of the dark currents (“cold electricity” of Tesla) is not seen in the description of circuits using ordinary circuit theory applying only for the visible matter. In particular, one can argue that the contribution of the induced dark magnetic fields to the inductance characterizing visible matter becomes vanishing. In the framework of circuit theory this would look like a transition to a state in which the visible part of system - say coil - behaves like a capacitor. Here one must make distinction between two meanings of capacitance: could behaves like a charge reservoirs defining together with ground a capacitor like system or could itself becomes analogous to a pair of capacitor plates. If the second end of the system is grounded, these two views seem to be more or less equivalent.

1. In circuit theory description this kind of transition would be analogous to a resonance since it involves a change of the sign of the phase of the frequency dependent impedance $Z(\omega)$ when the reactance $X(\omega)$ in the expression of impedance

$$Z = R + iX \quad , \quad X = \omega L - \frac{1}{\omega C}$$

vanishes. Note that system is modelled as R, C , and L in series. R, C , and L are assumed to be slowly varying functions of frequency ω and provide effective reparameterization for the frequency response of a complex system.

Also modelling as R, C , and L as parallel is possible and means that inverse of Z is sum of inverses of various contributions. This means a reparameterization giving:

$$\omega_{\pm} = -i \frac{1}{2RC} \pm \frac{1}{2} \sqrt{-\left(\frac{1}{RC}\right)^2 + \frac{4}{LC}} \quad .$$

One can say that these resonances are duals of each other and related by $R/L \leftrightarrow 1/RC$. One can say that the roles of inductance and capacitance are changed in the parallel coupling. Note that at the limit $R \rightarrow 0$ in parallel case second resonance frequency approaches to $\omega_{+} = \sqrt{\frac{R}{L}}$. Note that the limit of very large R gives $\omega_{\pm} = \pm 1/\sqrt{LC}$. The interpretation is that the current does not flow through R and one obtains pure L, C resonance.

2. The resonances of course have interpretation in terms of ordinary circuit theory thinking and possible phase transitions to dark phase only accompany the resonances. The turns of the coil are insulated from each other and same applies to the primary and secondary of a transformer like system as well as components of a system consisting of several coils. The insulation is obtained by using di-electric which polarizes so that one obtains effectively capacitor like systems since insulating material develops a polarization as a reaction to the charge of the coil. One has effectively L and C in parallel. This gives rise to a resonance frequency. Since C behaves like surface area per distance between the plates, and L is proportional to the length of the coil, the resonance frequency decreases with the size of the coil.

Resonance interpretation in strong sense requires also that the values of the phase are near to $\pi/2$ for the inductive phase and $-\pi/2$ for the capacitive phase for R, C, L in series. For R, C, L in parallel the roles of L and C are changed. The strength of the resonance depends on how large the change of the magnitude of the phase angle of Z is. One has two kinds of resonances depending on the sign of the change of the phase angle as ω increases. For R, C , and L in series the transition from capacitive to inductive phase - Φ decreases - would correspond to series resonance in ordinary circuit theory, where capacitance dominates at low frequencies for series configurations. Increase of Φ could be called "antiresonance". Parallel resonance would correspond to the increase of Φ as function of ω and decrease for "antiresonance". In the following I will speak only about resonances. The resonance with a phase transition decreasing/increasing Φ is expected to be followed by a reverse transition increasing/decreasing it in the case that Φ is near $\pm\pi/2$ between resonances (this requires small enough real part of Z).

3. For coils these two kinds of resonances are expected to correspond to different kinds of phase transitions.
 - (a) An obvious and directly observable phase transition occurring at resonance is the generation of plasma phase in di-electric breakdown from the surface of di-electric surrounding coil wire or from the di-electric surrounding entire coil. This phase transition dissipates energy, and one expects that resistance increases in the vicinity of the resonance as function of ω . This means also maximum for reactance. Phase transition like property would suggest sharp peak like maximum instead of a smooth parabolic maximum.
 - (b) The phase transition to dark super-conductivity is expected to be assignable to the coil itself and involve generation of dark magnetic flux tubes and Cooper pairs of dark electrons as current carries at it. This phase transition is expected to reduce dissipation

and induce a peak like minimum in resistance difficult to explain in terms of plasma generation - this assuming that impedance corresponds to the entire current rather than only its visible part. This is the case if the dark current transforms to ordinary one in the measurement of the current-voltage frequency response.

- (c) These two phase transitions have electric *resp.* magnetic character and are could be seen as duals. The data about impedances of certain kind of coils suggests that these phase transitions occur pairwise at nearby frequencies ω_1 and ω_2 spanning a frequency range $[\omega_1, \omega_2]$ inside which the sign of the phase angle Φ between current and voltage remains constant. Even Φ is expected to be approximately constant for small enough values of resistance. The could be also seen as support for the proposal that resistance has maximum/minimum, which could be assigned with the proposed two kinds of phase transitions.
 - (d) There is however a strong objection against this speculative line of thought. Complex circuitry can produce this kind of behaviors without any new physics. This is clear from the rules for the analytic expressions of the circuit parameters as one builds circuit from smaller circuits in parallel or in series. The phase transitions related to new physics should occur for strong electric fields above the threshold for dielectric breakdown. The peaky behavior however occur also for the impedances obtained using low input voltages (actually the only possible manner to determine impedance) so that poor resolution is the natural explanation for it.
4. Since the dark matter resonance could induce (quantum) phase transition and criticality, one expects that various physical observables are in general non-analytic functions of the dimensionless parameter $(\omega - \omega_0)/\omega_0$ near ω_0 . This applies also to the phase transition to plasma phase. ω would be analogous to temperature and ω_0 to a critical temperature. Whereas high temperature super conductivity is in finite temperature range, the dark phase would exist in the recent situation in finite frequency range around the resonance frequency (of course, also the temperature range could be finite).
 5. Typically non-analytic sharp peaks involving functions u^m , where one has $u = |(\omega - \omega_0)/\omega_0|$ and m is so called critical exponent, appear. For $|Z|$ one expects have $m < 1$ meaning divergent and discontinuous derivative at ω_0 . The sides of the curved "V" (possibly upside down) would be convex - in other words, the derivate would decrease in magnitude as one proceeds from the singularity outwards. Ordinary circuit theory predicts a smooth parabolic behavior $|Z| = \sqrt{R^2 + bu^2}$ for which "V" would be replaced with what looks like a bottom of a smooth potential well. For very small resistance R this situation looks in a non-optimal frequency resolution like $Z \simeq R + ku$ having discontinuous but *finite* derivative at ω_0 . These are very general qualitative predictions and easily testable using sufficiently high frequency resolution so that the local diffeo-invariants can be identified reliably.
 6. It could quite well be that the resonances look like smooth parabolic peaks in good enough frequency resolution. This does not mean that the assignment of phase transition to the resonance is physically wrong. In TGD framework the notion of resolution is an essential part of the physical description and different length scale resolutions correspond to different sheets of many-sheeted space-time. At small space-time sheets the description in terms as ordinary resonances could quite well make sense. Of course, already the usual description of critical systems relies on the notion of resolution - in the recent case for frequency and the successes of the conformal field theory justify fully the notion of resolution.

TGD based view about high T_c superconductors provides additional insights about the situation.

1. Since charge carriers are concentrated at the surfaces of conductors, conductors are effectively 2-D systems and since quantum TGD itself describes a universe which is effectively 2-dimensional, 2-D conformal field theories with temperature replaced with frequency as an external parameter could provide a lot of theoretical information about the system both at criticality and in its vicinity. Of course, dark phase could also occur in finite temperature range as the properties of living matter suggest. One should of course test whether linearity is

true or whether also amplitude of the oscillating voltage could a parameter analogous to the dimensionless parameter $(\omega - \omega_i)/\omega_i$ so that dark phase would exist also in voltage windows.

By conformal invariance the observables are scaling covariant at criticality and various correlations functions behave in a simple manner at criticality being characterized by anomalous dimensions. In the vicinity of critical point various observables are simple power functions of $(\omega - \omega_i)/\omega_i$ characterized by critical exponents (<http://tinyurl.com/ybk13c8c>). The anomalous dimensions and critical exponents do not depend on the details of the system, and one characterizes the system by its universality class near criticality.

2. In TGD inspired model of high T_c superconductivity the analog of percolation (say (liquid trickling through a porous material) (<http://tinyurl.com/34nujm>) serves as a basic mechanism of high T_c superconductivity. Magnetic flux tubes with relatively small value of h_{eff} would be present and super-conducting but have short length. In the phase transition to super-conductivity the flux tubes would be scaled up in length and combine to longer ones corresponding to larger value of h_{eff} and supra currents would flow through the entire wire. In 2-D case the phase transition to percolation is believed to be describable by a 2-D conformal field theory.

There exist rather detailed theoretical results about the behavior of the system at criticality and outside it and it might be possible to extrapolate these results to the recent case. One should be however very cautious since in TGD framework the view about renormalization group evolution crucial for the standard view about criticality is not quite the standard one.

3. Continuous coupling constant evolution having continuous scaling parameter as argument is in TGD framework replaced with a discrete evolution with discrete hierarchy of p-adic length scales replacing continuous scale. All physical states corresponds to fixed points of renormalization group for each p-adic length scale. 2-D conformal field theories indeed describe fixed points renormalization group which the effective 2-dimensionality of TGD Universe implied by strong form of holography and general coordinate invariance conforms with this. Various quantum criticalities differ only in the degree of criticality measured by the number of variables which are critical. In catastrophe theory the singularities of potential function provide a visualization of the situation: the simplest situation occurs with potential has extremum. A more critical situation occurs when also the matrix defined by the second derivatives of the potential function has vanishing determinant. This sequence can be continued indefinitely if the numbers of control parameters and behaviour variables are arbitrarily large.

What does this general picture imply in the recent situation? For instance, should one interpret the entire frequency range in which system is dark super-conductor as critical so that the standard thermodynamical picture assigning criticality only to the phase transition point would not apply as such in quantal situation. It seems that self-organized criticality is nearer to the TGD picture although the critical system is not attractor in the ordinary sense in TGD framework. State function reduction generates critical states and negentropic entanglement and Negentropy Maximization Principle guarantees their stability.

What would be remarkable is that the generation of dark matter phase would be directly measurable using standard measurements. For instance, one could study the frequency dependence of impedance for simple coils and transformers to see whether resonance involving minimum of frequency dependent resistance occur and whether they look like phase transitions - being peaked. If this is the case, one could study the properties of the system around resonance and try to identify further signatures for dark matter (say Josephson currents between turns of a coil). The conclusion is that it is better to be very cautious: the exotic phenomena are expected to occur for very high voltages and electric fields for which linear circuit theory fails. Peaking however occurs for weak voltages so that they are probably due to poor resolution.

8.5.4 Could the arrow of time change in electric circuits?

The change of the arrow of geometric time means that dissipation as a loss of energy takes place in reversed time direction. Second law holds still but in a generalized form. In zero energy ontology

(ZEO) the quantum jump sequence corresponds to a sequence of pairs of state function reductions to the opposite boundaries of causal diamonds (CDs) defined as intersections of future and past directed light-cones. The arrow of geometric time would change in each state function reduction since the state is prepared state at either boundary and de-localisation occurs at opposite boundary whose position (and thus the size of CD in quantum superposition) varies.

For large enough CDs the arrow of geometric time as perceived by an observer would remain constant. For short time scales characterizing CD the observer would interpret the change of the arrow of time as thermodynamical fluctuations. In living matter the change of the geometric arrow of time might take place continually. Italian theoretician Fantappie indeed suggested long time ago that this might be the case and introduced the notion of syntropy. Syntropy could be interpreted in TGD framework as time reversed counterpart of entropy [J5].

The reversal of the arrow of geometric time implies that the system becomes apparently an over unity system producing energy instead of dissipating it. Since dissipation power equals to $P = I^2/R$ in circuit theory, time reversal would imply a negative resistance. The concrete signature for the change of the arrow of time is that the magnitude of the phase angle between the current and voltage defined by the impedance would become larger than $\pi/2$.

There are indications for this kind of phenomenon in coil like systems. For instance, the measurements of inductance for a coil reported in the master thesis “Voltage distribution along reactor winding under very fast transients” by Salman Ejaz and Saeed Anwar (<http://tinyurl.com/ydx85jwa.pdf>) demonstrate this kind of effect (Figure 9) [H4]. The graphs of impedance demonstrates also the change of the sign of the phase angle as function of frequency suggesting interpretation as a time reversed resonance. The radical interpretation would be as a temporary change of the arrow of geometric time. Also over-unity effects have been reported - in particular by the free energy community.

The transition to time reversed situation occurs by state function reduction suggesting that it cannot be performed continuously. For a given CD one cannot change the arrow of time in a continuous manner by going through an intermediate frequency for which resistance vanishes. This conclusion does not hold true if the system decomposes a collection of CDs with different arrows of geometric time in the transition.

Skeptic can invent at least the following objections against this interpretation.

1. The system measuring the impedance does not work properly and gives phase whose magnitude exceeds $\pi/2$ predicted by the positivity of resistance.
2. The model of an electric component using LCR parameterization is only an effective description for a complex system which can involve also a generation of plasma phase meaning that the coil is not anymore a closed system since charge carriers leak out. It can happen that the magnitude of the phase difference between current and voltage can become larger than $\pi/2$.

8.5.5 Could remote metabolism work for a Tesla coil acting as a capacitor?

The best manner to demonstrate new phenomenon is to generate it artificially. The previous considerations suggest a possible model for how artificial remote metabolism could be realized in terms of something akin to Tesla coil or magnifying transmitter. Bifilar coil (<http://tinyurl.com/mvweora>) looks like a promising realization of the coil. There are two options corresponding to the possibilities that the currents in the two components of bifilar coil runs in same or opposite directions. In the latter case, the magnetic field generated by the bifilar coil is very weak and coil acts as capacitor.

1. The secondary in Tesla transmitter acts as both inductance and capacitor. The alternating magnetic field associated with the inductance implies magnetic motor activity for topologically quantized magnetic field, and would make it ideal for developing reconnections with the flux tubes of a larger magnetic body providing via remote metabolism the energy and charge to the secondary acting as a capacitor. It is however essential that the strength of the magnetic field at the flux tube is same as that at the larger magnetic body.
2. The model for cold electricity in terms of dark matter suggests that when the voltage along bifilar coil exceeds critical voltage V_{cr} , it becomes charged and together with Earth forms

a capacitor in voltage V_J defining Josephson potential for the resulting Josephson junction. A good guess for V_{cr} is $eV_{cr} = m_e = .5$ MeV. V_J is rather high and above the critical voltage V_d for dielectric breakdown. The generation of charge is due to the "traffic jam" for electrons making also possible the phase transition to dark matter. If this picture is correct, Josephson currents do not appear below V_{cr} and coil or bifilar coil acting as a capacitor is necessary for the remote metabolism. The constant part of voltage would make the resulting coil/capacitor hybrid analogous to cell membrane. Also DNA double strand could serve as a similar coil/capacitor-like system: now the traffic jam would correspond to the presence of two electron charges per nucleotide due to the attached phosphates expected to relate closely to metabolism and therefore also remote metabolism.

3. For general coils or bifilars for which the currents are parallel the transition to the dark phase would have measurable circuit theoretic correlates. The traffic jam for electrons would generate dark supra phase propagating along dark magnetic flux tubes. Only very weak ordinary magnetic fields are generated. Therefore the inductance in visible sector is very small and system becomes capacitive. The resonance like transitions from a situation in which the phase of the frequency dependent impedance $Z = R + i(\omega L - 1/(\omega C))$ (R, L and C depend on ω) characterizing physics in the visible sector suddenly changes sign and changes from almost $\pi/2$ to $-\pi/2$ could be seen as a measurable signature for the generation of dark Cooper pairs (cold currents of Tesla). Dark phases could appear in finite frequency ranges.
4. The interpretation in terms of the credit card mechanism would suggest that the resulting system is able to store energy at its magnetic body and also load it when needed - even from foreign magnetic body. The loading should be a spontaneous process and understandable in terms of the need to survive reducing to Negentropy Maximization Principle [K21]. Hence the system would in this respect act like a living system. Loading means the sending of negative energy signals to the magnetic body as phase conjugate Josephson photons. This involves also the change of the arrow of the embedding space geometric time in the time scale defined by single cycle of the process. Macroscopic quantum phenomenon would therefore be in question.

8.6 Tesla's Findings From A New Viewpoint

Tesla's experiments with induction coils generated strong AC electric fields inducing charge separations leading to di-electric breakdowns through the surrounding air, kind of mini-lightnings. I have proposed that both real and mini-lightnings involve large h_{eff} phase making possible high temperature super-conductivity along pairs of magnetic flux tubes forming possible U-shaped loops which reconnect with the target: this provides a model for high T_c superconductivity. There is evidence that electrons in lightnings travel to the surface of Earth with very low dissipation and also gamma rays are observed. These facts are not consistent with the standard physics models for lightnings since the dissipation in atmosphere does not allow these phenomena.

A concrete model for the Cooper pairs would be as pairs of electrons at neighboring tubes with magnetic fluxes which have same (opposite) directions. The presence of magnetic fields concentrated at flux tubes favors formation of $S = 1, L = 1$ Cooper pairs ($S = 0, L = 2$) Cooper pairs [K8, K30, K26].

To proceed one should try to find a more concrete model for the generation of large value of h_{eff} making possible super-conductivity.

8.6.1 How to understand the value of h_{eff} ?

The basis problem is to understand how h_{eff} depends on the parameters characterizing the situation at the magnetic flux tube connecting two systems. I have considered several mechanisms for the generation of large h_{eff} phase.

1. The model for h_{eff} in systems involving charge separation stimulated by AC current was based on the identification of Josephson frequency with the frequency of AC current: $f_J = E_J/h_{eff} = f_{AC}$ predicting $h_{eff}/h = E_J/hf_{AC}$ [K3].

The findings of Pollack and the difficulties to understand metabolic energy quantum of nominal value .5 eV in the simplest model for cell membrane as Josephson junction as Josephson energy for Cooper pair equal to $ZeV = 10-10.6$ mV inspired the assumption that cyclotron energies at flux tubes traversing cell membrane can be different at the two sides of the cell membrane [K13, K26]. This would lead to a generalization of the notion of Josephson junction associated with the transmembrane protein and generalizes $f_J = f_{AC}$ to $\Delta f_c + f_J = f_{AC}$ predicting $h_{eff}/h = E_J/(h(\Delta f_c - f_{AC}))$ so that h_{eff}/h would get arbitrarily large values near resonance $f_{AC} = f_C$. Note that correct sign requires $\Delta f_C - f_{AC} > 0$.

2. The conjecture $h_{eff} = \hbar_{gr} = GMm/v_0$ could make sense at microscopic level for particle-Earth pair and would predict a universal spectrum of bio-photons if identified as resulting from the decays of dark cyclotron photons to bio-photons. The first guess for the parameter v_0 would be as a rotational velocity associated with the two systems such as Earth and electron rotating with it. In case of planetary orbits $v = v_0$ is not consistent with

$$\frac{v}{c} = \frac{\sqrt{\frac{v_0}{c}}}{4\pi n}$$

following from Bohr rules in $1/r$ potential (n denotes the principal quantum number).

3. $h_{eff} = h_{em} = Z_1 Z_2 e^2 / v_0$ hypothesis is a natural looking generalization in systems involve large charge separations, say the exclusion zones discovered by Pollack providing a model for prebiotic life forms. The philosophy would be that when the coupling strength between systems becomes so large that perturbation theory fails, the value of h_{eff} increases and makes perturbation theory is in powers of $1/h_{eff}$ possible again. At space-time level this means emergence of non-determinism so that 3-surfaces at the future and past boundaries of causal diamond are connected by n-branched space-time surface for which branches fuse at the two ends. Dark matter would be Nature's manner to define what non-perturbative phases are. The strong hypothesis $h_{eff} = h_{em} = h_{gr}$ might make possible reconnection between em and gravimagnetic flux tubes and ATP synthase is here a candidate system.
4. Rotating magnetic systems with high negative charge are also good candidates for generating large h_{eff} at the magnetic flux tubes possibly contain dark proton sequences identifiable as dark nuclei. I have also proposed that a system subject to constant torque allowing description in terms of potential function which is multivalued as function of the angle coordinate ϕ leads rather naturally to generation of large h_{eff} [K16] when one requires internal consistency.

8.6.2 Could dark electrons or protons at magnetic flux tubes serve as current carriers?

There are clearly many options for h_{eff} to choose if one wants to model Tesla's findings. Some options are characterized by AC frequency and some options by rotation velocity. The electrons in the secondary Tesla coil were believed to get stuck which one could take to mean that ohmic AC current does not flow anymore. If this really occurs electrons do not carry any current and high negative local charge density is generated.

One can consider several mechanisms for the super-conductivity.

1. Some fraction of electrons flows as dark Cooper pairs along magnetic flux tubes. The members of the Cooper pair could reside at the flux tubes of the approximately dipolar magnetic field located in the interior of the coil and at the exterior of the coil near its surface and carrying magnetic fluxes in opposite direction. The interaction of spin with magnetic field usually tends to disrupt the Cooper pair but not it stabilizes it. One can consider several guesses for the value of h_{eff} since AC current is in question.
2. If the notion of exclusion zone makes sense also for more general systems than water, one might guess that perhaps dark magnetic flux tubes carrying dark protonic currents along them are generated. The objection is that water is not present now and this option works only if there is source of protons. This option does not look very promising now.

Second challenge is to identify candidates for the supra currents and Josephson currents possibly appearing in the system.

1. Mini-lightnings carrying supra currents could form when U-shaped flux tubes from the secondary coil reconnect with “ground” and dark supra current flows along them. The formula $h_{eff} = Z_1 Z_2 e^2 / v_0$ or even $h_{gr} = M_E m(pair) / v_0$, v_0 rotational velocity of Earth, suggests itself now. Z_2 could be the charge $2e$ of the Cooper pair and Z_1 could be assigned with ground as charge reservoir.
2. One can also consider Josephson currents flowing along flux tube pairs associated with the time-dependent dipole magnetic field accompanying the coil. They would replace the Ohmic AC currents when electrons are “stuck”. Josephson frequency would co-incide with AC frequency.

In the case of Josephson current the problem seems to be that the voltage defining Josephson frequency varies periodically as also the magnetic field for AC current. The sticking of Ohmic charge is however expected to destroy AC current so that one would obtain static voltage if ohmic DC current runs through the coil. Thus DC current seems to be necessary.

Static magnetic fields are also necessary for high T_c super-conductivity. They are achieved if the AC component of the Ohmic current becomes small or vanishing. In Maxwell’s ED also a small DC current present unless the coil contains ferromagnet. In TGD Universe it is also possible that a magnetic field with flux tubes carrying monopole flux requiring no DC current is generated. This kind of monopole magnetic fields could be responsible for the magnetic fields encountered in cosmology and astrophysics (the observed fields are 11 orders of magnitude stronger than the predicted) and could also appear in superconductors and even in ferromagnets.

In this situation the formula $h_{eff}/h = E_J/hf_{AC}$ would state that the coil acts as a generalized Josephson junction with AC current replaced with Josephson current with $f_J = E_J/h_{eff} = f_{AC}$. The formula $h_{eff}/h = E_J/(h(\Delta f_c - f_{AC}))$ would require that the magnetic field strengths at the ends of coil are different so that also the cyclotron frequencies are different. AC frequency would be equal to the generalized Josephson frequency: $f_{AC} = \Delta f_c - E_J/h_{eff}$. In this case one can consider even the possibility that there is no DC current so that one has $f_{AC} = \Delta f_c$. This fixes the increment ΔB for the magnetic field.

9 Teslaphoresis in TGD

I found an interesting popular article about a recently discovered phenomenon christened Teslaphoresis [D1] (see <http://tinyurl.com/htyaf4h>). This phenomenon might involve new physics. Tesla studied systems critical against di-electric breakdown and observed strange electrical discharges occurring in very long length scales. Colleagues decided that these phenomena have mere entertainment value and are “understood” in Maxwellian electrodynamics. The amateurs have however continued the experiments of Tesla, and Teslaphoresis could be the final proof that something genuinely new is involved.

In TGD framework these long ranged strange phenomena could correspond in TGD quantum criticality and to large values of Planck constant implying quantum coherence in long length scales. The phases of ordinary matter with non-standard value $h_{eff} = n \times h$ of Planck constant would correspond to dark matter in TGD framework. I have earlier considered Tesla’s findings from TGD point of view and my personal opinion has been that Tesla might have been the first experimenter to detect dark matter in TGD sense. Teslaphoresis gives further support for this proposal.

The title of the popular article is “Reconfigured Tesla coil aligns, electrifies materials from a distance” tells about the effects involved. The research group is led by Paul Churukuri and there is also an abstract about the work in ADS Nano journal [D1] (see <http://tinyurl.com/z3qybx2>). This article contains also an excellent illustration allowing to understand both the Tesla coil and the magnetic and electric fields involved. The abstract of the paper provides a summary about the results.

This paper introduces Teslaphoresis, the directed motion and self-assembly of matter by a Tesla coil, and studies this electrokinetic phenomenon using single-walled carbon nanotubes (CNTs). Conventional directed self-assembly of matter using electric fields has been restricted to small scale

structures, but with *Teslaphoresis*, we exceed this limitation by using the Tesla coil's antenna to create a gradient high-voltage force field that projects into free space. CNTs placed within the *Teslaphoretic (TEP)* field polarize and self-assemble into wires that span from the nanoscale to the macroscale, the longest thus far being 15 cm. We show that the *TEP* field not only directs the self-assembly of long nanotube wires at remote distances (≥ 30 cm) but can also wirelessly power nanotube-based LED circuits. Furthermore, individualized CNTs self-organize to form long parallel arrays with high fidelity alignment to the *TEP* field. Thus, *Teslaphoresis* is effective for directed self-assembly from the bottom-up to the macroscale.

To sum up: what is found that single-walled carbon nanotubes (CNTs) polarise and self-assemble along the electric fields created by capacitor in much longer length scales than expected. Biological applications (involving linear molecules like microtubules) come in mind. CNTs tend to also move towards the capacitance of the secondary coil of the Tesla coil (TC).

In the sequel the TGD counterparts for the Maxwellian em fields involved with Tesla coils are considered in TGD framework and it is found that many-sheetedness of space-time is necessary to understand the standing waves also involved. The fact that massless extremals (MEs) can carry light-like currents is essential for modelling currents classically using many-sheeted space-time. The presence of magnetic monopole flux tubes distinguishing TGD from Maxwellian theory is suggestive and could explain why *Teslaphoresis* occurs in so long length scales and why it induces self-organization phenomena for CNTs. The situation can be seen as a special case of more general situation encountered in TGD based model of living matter.

9.1 What Tesla coils are?

Wikipedia contains a nice description of Tesla coils (<http://tinyurl.com/mh68y7b>). Also the abstract (see <http://tinyurl.com/z3qybx2>) provides an illustration about the Tesla coil used.

Harmonic oscillator serves as an indispensable mechanical analogy for time dependent voltage source $V(t)$ and components (L, C, R) coupled in series to form a closed circuit. The dynamics is governed by differential equation

$$L \frac{d^2 I}{dt^2} + R \frac{dI}{dt} + \frac{I}{C} = dV_{ext}(t) . \quad (9.1)$$

Here L inductance (associated with coils in the illustration) with LdI/dt telling the voltage between ends of the inductance coil, C is the capacitance associated with the metal torus telling the charge of the capacitor ($Q = CV$) in potential V relative to the ground. Also relative capacitance with ground replaced with metal object in constant potential and V with the voltage between the two makes sense. IR is the contribution to the voltage of the circuit. V_{ext} is the external voltage. The mechanical analogy corresponds to $(I, L, C, R, dV_{ext}/dt) \leftrightarrow (x, m, 1/k, K, F_{ext})$ where (x, m, k, K, F_{ext}) are the position, mass force constant, friction, and external force applied on the harmonic oscillator.

The circuit consists of three parts (see <http://tinyurl.com/hetyaac>).

1. The first part has in parallel inductance L_0 and AC source characterized by voltage amplitude V_0 and frequency f acting as external driving force. L_0 corresponds to the outer coil in the figure of abstract.
2. The primary circuit has inductance $L_{1,1}$ and capacitance C_1 in series in the situation in which dielectric breakdown has not taken place so that the current switch defined by the air gap is off. There is also internal resistance R_1 , not included to the illustration. In the simplest model for the situation the voltage U_1 relates to U_0 by $U_1/U_0 = N_2/N_1$, where N_2 and N_1 are in numbers of windings for the two coils. On the other hand, one has $U_1 = Q_1/C_1$ equal to $(N_2/N_1)U_0$.

When the value of the electric field associated with U_1 exceeds critical value (in the range 5-30 kV/m) dielectric breakdown takes place and the current starts to run in the entire primary circuit $(L_{1,2}, R_1, C_1)$ and induces via the coil $L_{1,2}$ a current in secondary circuit (L_2, R_2, C_2) . $L_{1,1}$ corresponds in the illustration of the article to a tunable inductance and L_2 corresponds

to the inner cylindrical coil. C_2 corresponds to the sum of the stray capacitance of L_2 and capacitance C_2 of the metal torus.

The circuits $(L_{1,1}, L_{1,2}, R_1, C_1)$ and (L_2, R_2, C_2) are chosen so that their resonance frequencies are the same and equal to the input frequency to achieve resonance. The frequencies are in radio frequency range and according to Wikipedia article vary in the range 50 kHz to 1 MHz. The duration of the on-period much longer than the corresponding time scales.

What happens during the on-period is that capacitor C_2 develops oscillating charge and oscillating electric field orthogonal to the capacitor at its surface. Also oscillating magnetic field is induced: here the possible current along the electric field lines affects the situation. Also at this dielectric breakdowns can occur of the local electric field near the C_2 exceeds critical value.

The discovery is that the radial oscillating electric fields induces what is christened as Teslaphoresis (for more general phenomenon of dielectrophoresis see <http://tinyurl.com/hgj645q>). What is seen as surprising is that the phenomenon takes place in length scales longer than 30 cm. The wavelengths of the AC photons vary in the range [124 m , 6 km]. The fact that Tesla managed to produce this kind of strange phenomena in a length scale of entire town suggests that the wavelength of the radio waves is the key scale, perhaps quantum scale.

CNTs polarize and self-organize along the field lines of the electric field involved. CTNs can also self organize to form a wiring between LEDs and extract energy from the fields of TC so that the LEDs shine. This would be a partial fulfilment of Tesla's dream about wireless energy transfer. If the length scale involved is that of radio waves, the dream might be realized in rather long scales. Also the tractor effect is observed: CNTs are attracted towards TC along electric field lines. This can be understood if they develop polarization parallel to the electric field of the capacitor C_2 .

9.2 How TGD could be involved?

My earlier attempts to understand what happened in Tesla's circuits [K14, K3] inspired the question whether some new physics could be involved. The presence of effects in unexpectedly long length scales raises the question whether quantum criticality and the hierarchy of Planck constants could be involved. The conjecture has indeed been that quantum criticality leads to a generation of phases of ordinary matter with non-standard value $\hbar_{eff} = n \times \hbar$ of Planck constant and thus quantum coherence in length scales scaled up by factor n from what they are usually [?]. Dielectric breakdown is a critical phenomenon and an essential part of the functioning of TC. The test for the hypothesis is to look whether the effects disappear when the coupling between primary and secondary is not by dielectric breakdown.

Radio wavelengths are used. The experience from quantum biological models [?] encourages to ask whether the photons become dark at quantum criticality and whether their energies $E = \hbar_{eff} \times f$ are above thermal energy. TGD inspired quantum biology would suggest that the energies could be in visible and UV range just as bio-photons identified as decay products of dark photons. Large energy of dark radiowave photons would make possible effective energy transfer along long distances. The transformation of dark photons to ordinary photons would generate energetic photons and could serve as a signature of the effect analogous to bio-photons. The self-organization of CNTs along electric field line should involve macroscopic quantum coherence.

The modelling of time varying electromagnetic fields involves open questions in TGD framework. Consider first the available building bricks [K7, K4].

1. The embedding of any em field locally is possible but the imbeddability to CP_2 implies topological field quantization, which is reasonably well understood for static fields. The preferred extremal property reflecting strong form of holography implying effective 2-dimensionality poses further powerful constraints at the level of single space-time sheet so that extremely restricted repertoire of field patterns is expected to be possible.

At the level of many-sheeted space-time the situation is different. The Maxwellian limit of TGD is obtained by replacing the sheets of many-sheeted space-time with single region of Minkowski space and by summing induced gauge potentials at various sheets (test particle experiences touching space-time sheets experiences the sum of gauge potentials and induced gravitational field identified as sum CP_2 parts of the induced metric).

2. There are excellent reasons to assume that cosmic string solutions $X^2 \times Y^2$ with X^2 minimal surface in M^4 and Y^2 a homologically non-trivial complex surface of CP_2 allow deformations to magnetic flux tubes having 4-D CP_2 projection. One can make Lorentz boosts for the magnetic flux tubes and together with many-sheetedness this makes possible complex repertoire of moving quasi-stationary fields patterns at Maxwellian limit.
3. Deformations of CP_2 type vacuum extremals provide description of Euclidian space-time regions identified as lines of generalized Feynman diagrams. The light-like 3-D boundaries between Minkowskian and Euclidian space-time regions having degenerate 4-metric can equivalently regarded as lines of generalized Feynman diagrams are identified as orbits of 2-D partons performing kind of zitterbewegung with local light-velocity. The average velocity is typically time-like.
4. Massless extremals (MEs) are radiation type solutions but with local directions of polarization and light-like local propagation 4-velocity $(1, v(x))$ with $1 - v \cdot v = 0$. Since the direction can vary the average current is typically time-like.

The first special feature is that MEs allow light-like currents parallel to $(1, v(x))$. Second special feature is that linear superposition is restricted to four-momenta proportional to the local four-velocity $(1, v(x))$ so that one can say that all Fourier components correspond to parallel four vectors ($(1, v)$ and $(-1, -v)$ are regarded as parallel). Field pulses propagate in single direction without change in shape and in precisely targeted manner, which is optimal situation concerning information transfer.

The general linear superposition of Maxwell's theory is lost and one can say that for given space-time sheet the field decomposes to quanta in geometric sense. Linear superposition is however replaced with set theoretic union of parallel space-time sheets: the test particle experiences the sum of gauge potentials associated with different sheets so that nothing is lost in Maxwellian limit.

Consider now what the TGD description could look like for standing waves.

1. Only linearly polarized waves with local wave vector k are possible. Circular polarizations are not representable classically. In many-sheeted space-time the problem can be solved by using two parallel space-time sheets with of orthogonal linear polarizations and suitable phase lag.
2. In circuit systems there are oscillating electric fields associated with the capacitor and also oscillating magnetic fields and electric fields accompanying them. These fields do not propagate although one can assign to them frequency and wave vectors locally. In Maxwellian theory they can be represented as superposition of real waves propagating in opposite directions with light-velocity ($\cos(\omega t - kx) + \cos(\omega t + kx) = 2\cos(\omega t)\cos(kx)$, $\omega = k$ using unit $c = 1$).

In TGD framework standing wave solutions are not possible as radiative solutions since only the waves with parallel local 4-velocities can superpose. At least two parallel space-time sheets representing copies of MEs related by 4-D reflection are needed to describe the fields in the region outside capacitor. Since the electric field is radial at the surface of capacitor C_2 , the MEs should propagate parallel to C_2 near its surface.

Maxwell's theory involves currents in an essential manner although their description involves structural equations and is therefore only phenomenological. These fields have 4-currents as sources. In the recent case the currents are associated with the surfaces of inductances and more or less stationary charge densities with the surfaces of the capacitors.

1. In TGD framework the 4-currents correspond at quantum level to fundamental fermions at string world sheets and together with partonic 2-surfaces string world sheets carry the data needed by the strong form of holography (SH). This microscopic description is quite too far from the practical modelling of Tesla coils. SH guarantees 4-D description and the question concerns the translation of 2-D vocabulary to 4-D one. One question is what the fermionic currents assignable to the ends of fermionic strings correspond in 4-D vocabulary.

2. The field equations for Kähler action do not contain external currents explicitly. MEs however allow light-like currents parallel to them and by using parallel MEs with light-like currents boosted in opposite directions it is possible to obtain time-like net currents at Maxwellian limit.

In particular, one can have stationary charge densities needed at the surfaces of C_2 as well as currents moving with non-relativistic velocities needed at the surfaces of the induction coils. The rule could be that parallel MEs gives rise to net current parallel to microscopic fermionic currents propagating along partonic surfaces: these currents can look stationary in induced metric at partonic 2-surfaces so that it need not expand).

3. String world sheets have their ends carrying fermion number at the 3-D light-like orbits of partonic 2-surfaces. Since monopole fluxes connect wormhole throats, the strings are parallel to monopole flux tubes connect fermions moving along light-like curves of space-time surface. If indeed so, magnetic flux tubes and ME form locally orthogonal network. One cannot therefore neglect the magnetic flux tubes (carrying dark matter). In the recent case this would suggest the presence of dark magnetic flux tubes in directions orthogonal to the capacitor C_2 . These flux tubes would carry monopole flux and no current would be needed to generate this magnetic field: the cross section would be two sheeted closed surface rather than disk with boundary.

The monopole magnetic flux tubes carrying dark matter emanating radially from capacitor C_2 would be essential for new physics effects. In particular, dark supra currents could flow along these flux tubes. Together with MEs they are proposed to play fundamental role in TGD inspired quantum biology.

To sum up, the TGD inspired model of Teslaphoresis could be seen as an application of basic ideas of TGD inspired quantum biology explaining macroscopic quantum coherence and dark matter. If so, Tesla would have observed dark matter and new quantum theory based on the hierarchy of Planck constants already century ago.

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