Quantum Model for Bio-Superconductivity: II

M. Pitkänen,

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Email: matpitka6@gmail.com.
http://tgdtheory.com/public_html/.
Postal address: Rinnekatu 2-4 A 8, 03620, Karkkila, Finland. ORCID: 0000-0002-8051-4364.

Contents

Abstract

The models for EEG and its variants and for nerve pulse rely on a general model of high T_c superconductivity. The general vision behind model of cell membrane as super-conductor inspired by the identification of dark matter in terms of hierarchy of Planck constants and the notion of magnetic body was considered in the previous chapter. In this chapter the vision is tested by applying it to various anomalous findings about the behavior of the cell membrane.

The topics discussed are following.

1. There are several findings challenging the standard thermodynamical view about cell membrane. TGD suggests a model in which various transmembrane proteins (receptors, channels, pumps) act as Josephson junction between superconductors assignable to the interior and exterior of cell membrane.

   The most feasible model for cell membrane and charge transfer found hitherto relies on Pollack's observations about fourth gel like phase of water. The model for the findings leads to a generalization of the cell membrane as Josephson junction obtained by adding to Josephson energy the difference of the cyclotron energies of dark ion at two sides of the cell membrane. Cyclotron energy difference replaces chemical potential difference in the generalization of the thermodynamical model inspired by Zero Energy Ontology, and replacing thermodynamical distributions with their quantal "square roots". Charge transfer would be induced by a phase transition changing the value of Planck constant at either or both sides of the membrane. This would induce the change of the equilibrium concentrations of ions and also charge transfer.

2. Water memory, chiral selection of biomolecules, burning of water by radiowaves represent further intriguing effects whose understanding seems to require new physics. Dark matter identified in term of hierarchy of Planck constants and the notion of magnetic body define an attractive candidate in this respect. Scaled up variants of weak physics defined by the hierarchy of Planck constants and p-adic length scale hierarchy could explain chiral selection.

3. Hafedh Abdelmelek and collaborators have found evidence for effective super-conductivity in the sciatic nerves of both endotherms (rabbit) and poikilotherms (frog). The TGD based explanation would be in terms of dark supra currents.

4. DC currents of Becker have been known for a long time. An attractive interpretation is as supra currents. The basic prediction is that the resistance should not depend on he length of the conduction pathway. One can also construct a quantum model for the current.

5. TGD inspires two views about cell membrane which need not be contradictory. For the first model cell is far from vacuum extremal, for the second model nearly vacuum extremal. There are several constraints on the model coming from the TGD based identification of bio-photons, the new view about metabolism. It seem that that the first model might be enough when generalized along lines inspired by Pollack's findings about the fourth phase of water.

Physicists M. Tajmar and C. J. Matos and their collaborators working in ESA (European Satellite Agency) have made an amazing claim of having detected strong gravimagnetism with gravimagnetic field having a magnitude which is about 20 orders of magnitude higher than predicted by General Relativity.

Tajmar et al have proposed the gravimagnetic effect as an explanation of an anomaly related to the superconductors. The measured value of the mass of the Cooper pair is slightly larger than the sum of masses whereas theory predicts that it should be smaller. The explanation would be that actual Thomson field is larger than it should be because of gravimagnetic contribution to quantization rule used to deduce the value of Thomson field. The required value of gravimagnetic Thomson field is however 28 orders of magnitude larger than General Relativity suggests. TGD inspired proposal is based on the notion of gravitational Planck constant assignable to the flux tubes connecting to massive objects. It turns out that the TGD estimate for the Thomson field has correct order of magnitude. The identification $h_{eff} = h_{gr}$ at particle physics and atomic length scales emerges naturally.

A vision about the fundamental role of quantum gravitation in living matter emerges. The earlier hypothesis that dark EEG photons decay to biophotons with energies in visible and ultraviolet range receives strong quantitative support. Also a mechanism for how magnetic bodies couple bio-chemistry emerges. The vision conforms with Penrose's intuitions about the role of quantum gravity in biology.

1 Introduction

The models for EEG and its variants and for nerve pulse rely on a general model of high T_c superconductivity [K9, K10]. In this chapter the general vision behind model of cell membrane as super-conductor inspired by the identification of dark matter in terms of hierarchy of Planck constants and the notion of magnetic body considered in the previous chapter is tested by applying it to various anomalous findings about the behavior of the cell membrane.

1.1 Exotic Charge Transfer Between Cell Interior And Exterior As Fundamental Control Mechanism

The notions of ionic channels and pumps associated with the cell membrane are central for the standard cell biology [I22]. There are however puzzling observations challenging this dogma and suggesting that the currents between cell interior and exterior have quantum nature and are universal in the sense that they not depend on the cell membrane at all [I18, I13, I8, I23, I12]. One of the pioneers in the field has been Gilbert Ling [I18]. who has devoted for more than three decades to the problem, developed ingenious experiments, and written several books about the topic. The introduction of the book [I17]) gives an excellent layman summary about the paradoxical experimental results.

One can imagine several charge transfer mechanisms.

1. Ionic supra currents and Josephson currents define the first candidate for exotic charge transfer. The experimental data led to a model for cell homeostasis as a flow equilibrium in which very small densities of super-conducting ions (also molecular ions) and ionic supracurrents at cellular and other super-conducting space-time sheets dictate the corresponding densities at the atomic space-time sheets.

2. The most feasible model for cell membrane and charge transfer found hitherto relies on Pollack's observations about fourth gel like phase of water. The model for the findings leads to a generalization of the cell membrane as Josephson junction obtained by adding to Josephson energy the difference of the cyclotron energies of dark ion at two sides of the cell membrane. Cyclotron energy difference replaces chemical potential difference in the generalization of the thermodynamical model inspired by Zero Energy Ontology, and replacing thermodynamical distributions with their quantal "square roots". Charge transfer would be induced by a phase transition changing the value of Planck constant at either or both sides of the membrane. This would induce the change of the equilibrium concentrations of ions and also charge transfer.

3. I have also considered the exchange of exotic W bosons as a non-local charge transfer mechanism involving quantum entanglement in an essential way. Z^0 super-conductivity possible for almost vacuum extremals in principle allows to generalize the model also to the control of the densities of neural atoms and molecules at atomic space-time sheets.

   This control mechanism need not be the only one. Magnetic flux tubes serving as colored braid strands connecting different bio-molecules in highly selective way and phase transitions reducing or increasing $\hbar$ could explain the mysterious precision of bio-catalysis as how the prebiotic evolution has led to the known biology [K1]. Magnetic flux tubes could also act as Josephson junctions between widely separated structures.

1.2 Further Experimental Findings

There are further experimental findings giving support for the TGD based vision about living cell. The following findings are discussed.

1. Mainstream scientists refuse often to take seriously water memory and homeopathy using arguments which do not tolerate daylight. There is rich amount of evidence that water is able to store information about diluted molecules even at the limit of vanishing dilution [K19]. The explanation is of course that water somehow stores the information about molecules instead of molecules (this kind of explanation should be easy to discover at the computer era but the

simplistic argument of skeptics is that those taking seriously water memory are crackpots not able to realize that the density of molecules after the preparation of homeopathic remedy is vanishingly small!). The notion of magnetic body and Pollack's findings about fourth phase of water inspired TGD based model of water memory. The emergence of vertebrate genetic code in the model of dark proton and nuclei allows even the possibility that exclusion domains of Pollack define primitive life forms.

2. Chiral selection of bio-molecules is one of the basic mysteries of biology. Dark matter realized in terms of a hierarchy of Planck constants suggests that electroweak physics could appear as scaled up dark and also ordinary copies in various preferred p-adic length scales. Below the Compton lengths dark and p-adically scaled-up weak bosons would behave like massless particles implying that weak interactions have same strength as electromagnetic interactions so that parity breaking effects caused by the axial couplings of weak bosons would be large and could explain chiral selection.

3. The observation that the irradiation of water by radiowaves "burns" water by inducing a visible flame is not easy to understand ins standard physics framework. If the radio waves involves dark photons with large enough Planck constant, the high energy of radiowave photons induce large energy transfer to the water and can induce the effect.

1.3 Evidence For Axonal Supra Currents

Hafedh Abdelmelek and collaborators [J10] have found evidence for effective super-conductivity in the sciatic nerves of both endotherms (rabbit) and poikilotherms (frog). The basic finding is that the resistance of the sciatic nerve is reduced by a factor of about ten below a critical temperature at the lower edge of the range of the physiological temperatures. The reduction of the temperature occurs inside a narrow temperature range ΔT, $\Delta T/T_c \sim .04$. This suggests effective super-conductivity. Furthermore, the critical temperature T_c for the breaking of the effective super-conductivity raises from 240 K to 300 K in the transition from poikilotherms (say frog) to endotherms (say rabbit). A TGD inspired model for these currents is discussed.

1.4 DC Currents Of Becker

Robert Becker [J7] proposed on basis of his experimental work that living matter behaves as a semiconductor in a wide range of length scales ranging from brain scale to the scale of entire body. Direct currents flowing only in preferred direction would be essential for the functioning of living way in this framework.

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

A TGD inspired model for quantal direct currents is proposed and its possible implications for the model of nerve pulse are discussed.

1.5 Two Views About Cell Membrane

I have considered two possible views about cell membrane. First view might apply to sensory receptors and involves in an essential way the classical Z^0 fields which could be present even in cellular length scales if the hierarchy of Planck constants is realized. Second view is inspired by Pollack's findings.

1.5.1 Could cell membrane correspond to almost vacuum extremal?

The question whether cell membrane or even cell could correspond almost vacuum extremal of Kähler action (in some cases) was the question which led to the realization that the frequencies of peak sensitivity for photoreceptors correspond to the Josephson frequencies of biologically important ions if one accepts that the value of the Weinberg angle equals to $sin^2(\theta_W) = .0295$ instead of the value .23 in the normal phase, in which the classical electromagnetic field is proportional

to the induced Kähler form of CP_2 in a good approximation. It has however become clear that the argument fixing the value of Weinberg angle is however rather weak. The assumption that the membrane potentials through receptors are different for biologically important ions and their Cooper pairs allows to reproduce the photon energies which are absorved maximally by photoreceptors.

Another implication made possible by the large value of Planck constant is the identification of Josephson photons as the counterparts of bio-photons one one hand and those of EEG photons on the other hand. These observation in turn led to a detailed model of sensory qualia and of sensory receptor.

1.5.2 Pollack's findings about fourth phase of water

Pollack and Zheng discovered what they call exclusions zone in water. Exclusion zone is negatively charged and has rather intriguing properties suggesting its biological relevance. I have considered this finding in TGD context for few years ago and decided to keep the proposed model as an example about how ideas develop. I also discuss the recent model inspired by the lecture of Pollack [L10] about the fourth phase of water.

The discovery of negatively charged exclusion zone formed in water bounded by gel phase was the motivation for Pollack to propose the notion of gel like fourth phase of water.

The TGD inspired proposal is that the fourth phase corresponds to negatively charged regions - exclusion zones - with size up to 100-200 microns generated when energy is fed into the water - say as radiation, in particular solar radiation. The stoichiometry of the exclusion zone is $H_{1.5}O$ and can be understood if every fourth proton is dark proton residing at the flux tubes of the magnetic body assignable to the exclusion zone and outside it. This leads to a model for prebiotic cell as exclusion zone. Dark protons are proposed to fork dark nuclei whose states can be grouped to groups corresponding to DNA, RNA, amino-acids, and tRNA and for which vertebrate genetic code is realized in a natural ways [K19, L2]. The voltage associated with the system defines the analog of membrane potential, and serves as a source of metabolic energy as in the case of ordinary metabolism. The energy is liberated in a reverse phase transition in which dark protons transform to ordinary ones. Dark proton strings serve as analogs of basic biopolymers, and one can imagine analog of bio-catalysis with enzymes replaced with their dark analogs. The recent discovery that metabolic cycles emerge spontaneously in absence of cell support this view.

This leads to a model of cell membrane as a generalized Josephson junction. Generalized Josephson energy is identified as the sum of the Coulombic part and difference of cyclotron energies at the two sides of the cell membrane. Zero energy ontology inspires a model of cell membrane defined as "square root" of the thermodynamical model of cell membrane. This leads to the identification of EEG and its variants in terms of dark photons with generalized Josephson energies. Biophotons would result as decay produces of these dark photons. This model allows generalization to the case of almost vacuum extremal.

1.6 Implications Of Strong Gravimagnetism For TGD Inspired Quantum Biology

Physicists M. Tajmar and C. J. Matos and their collaborators working in ESA (European Satellite Agency) have made an amazing claim of having detected strong gravimagnetism with gravimagnetic field having a magnitude which is about 20 orders of magnitude higher than predicted by General Relativity.

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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` [L7].

2 Exotic Charge Transfer Between Cell Interior And Exterior As Fundamental Control Mechanism

The notions of ionic channels and pumps associated with the cell membrane are central for the standard cell biology [I22]. There are however puzzling observations challenging this dogma and suggesting that the currents between cell interior and exterior have quantum nature and are universal in the sense that they not depend on the cell membrane at all [I18, I13, I8, I23, I12]. One of the pioneers in the field has been Gilbert Ling [I18], who has devoted for more than three decades to the problem, developed ingenious experiments, and written several books about the topic. The introduction of the book [I17]) gives an excellent layman summary about the paradoxical experimental results.

It was a pleasant surprise to find that these experimental findings give direct support for the existence of an exotic charge transfer between cell interior and exterior.

Ionic supra currents and Josephson currents or the exchange of exotic W bosons could be in question. For the first option, the experimental data led to a model for cell homeostasis as a flow equilibrium in which very small densities of super-conducting ions (also molecular ions) and ionic supercurrents at cellular and other super-conducting space-time sheets dictate the corresponding densities at the atomic space-time sheets. Z^0 super-conductivity possible for almost vacuum extremals in principle allows to generalize the model also to the control of the densities of neural atoms and molecules at atomic space-time sheets.

This control mechanism need not be the only one. Magnetic flux tubes serving as colored braid strands connecting different bio-molecules in highly selective manner and phase transitions reducing or increasing $\hbar$ could explain the mysterious precision of bio-catalysis as how the prebiotic evolution has led to the known biology [K1]. Magnetic flux tubes could also act as Josephson junctions between widely separated structures.

2.1 Strange Behavior Of The Intracellular Water

The basic strange feature of cellular interior is related to its gelatinous nature and is in fact familiar for everyone. Although 80 percent of hamburger is water, it is extremely difficult to extract this water out. Ling [I13] has demonstrated this at cellular level by using a centrifuge and cells for which cell membrane is cut open: centrifugal accelerations as high as 1000 g fail to induce the separation of the intracellular water.

The assumption that cytoplasm behaves like gel explains these findings. Egg is very familiar example of gel phase so that this proposal could have been made already by the pioneers. The dipolar nature of bio-molecules and induced polarization are basis prerequisites for the formation of gels. Ling raises the cohesion between water and protein molecules caused by electric dipole forces as a fundamental principle and calls this principle association-induction hypothesis [I18]. This cohesion gives rise to liquid [F2] [D2] like structure of water implying among other things layered structures and internal electric fields orthogonal to the plane of the layers [I21, I20, I18] . For instance, cell membranes can be understood as resulting from the self-organization of liquid crystals [K11]. The fundamental importance of electret nature of biomatter was also realized by Fröhlich [I19] and led him to suggest that macroscopic quantum phases of electric dipoles might be possible. This concept, which is in central role in many theories of quantum consciousness, has not been established empirically.

2.2 Are Channels And Pumps Really There?

Standard neurophysiology relies strongly on the concepts of what might be called hydro-electrochemistry. The development of the theory has occurred through gradual improvements saving the existing theory.

The development began from the basic observation that cells are stable gelatinous entities not mixing with the surrounding water. This led to the hypothesis that cell membrane takes care that the contents of the cell do not mix with the cell exterior. It was however soon found that cell membrane allows some ions to flow through. The interaction between theory and experiment led gradually to the notions of ion channel and ion pump, which are still central for the standard paradigm of the cell [I22]. Note that also "electric pump" taking care that membrane potential is preserved, is needed.

These notions developed gradually during the period when cell was seen as a bag containing water and a mixture of various biochemicals. If cell biology would have started to develop during the latter half of this century and after the discovery of DNA, cell as a computer metaphor might have led to a quite different conceptualization for what happens in the vicinity of the cell membrane. Also the notion of liquid crystals [D2] would have probably led to different ideas about how homeostasis between cell interior and exterior is realized [I21, I20, I18].

For me it was quite a surprise to find that pump-channel paradigm is not at all so well-established as I had believed as an innocent and ignorant outsider. The first chapter of the book "Cells, Gels and the Engines of Life" of Gerald Pollack [I17] provides a summary about the experimental paradoxes (the interested reader can find the first chapter of this book from web).

The standard theoretical picture about cell is based on the observation that cell exterior and interior are in a relative non-equilibrium. The measured concentrations of various atomic ions and organic molecules are in general different in the interior and exterior and cell membrane seems to behave like a semi-permeable membrane. There is also a very strong electric field over the cell membrane. In standard approach, which emerged around 1940, one can understand the situation by assuming that there are cell membrane pumps pumping ions from cell interior to exterior or vice versa and channels through which the ions can leak back. Quite a many candidates for proteins which seem to function like pump and channel proteins have been identified: even a pump protein for water [I17] ! This does not however prove that pumping and channelling is the main function of these proteins on the case of basic biological ions or that they have anything to do with how ionic and molecular concentrations in the interior and exterior of the cell are determined. It could quite well be that in the case of basic ions pump and channel proteins are receptors involved with the transfer of information rather than charges and only effectively act as pumps and channels.

There are several serious objections of principle against the vision of cell as a bag of water containing a mixture of chemicals. Even worse, the hypothesis seems to be in conflict with experimental data.

2.2.1 Selectivity problem

Cell membrane is extremely selective and this leads to an inflation in the complexity of channels and pumps. The problem might be christened as a dog-door problem: the door for dog allows also cat go through it. Channels cannot be simple sieves: it is known that channels which let some ions through do not let much smaller ions through. There must be more complicated criteria than geometric size for whether the channel lets the ion go through. Quite generally, channels must be highly selective and this seems to require complicated information processing to decide which ion goes through and which not. As a consequence, the models for channels inflate in their complexity.

The only reasonable way to circumvent the problem is to assume that there is kind of binary coding of various chemical compounds but it is difficult to see how this could be achieved in the framework of the standard chemistry. The notion of fractional atom proposed in [K15] to give rise to the emergence of symbols at the level of biochemistry could however allow this kind of coding. Channels and pumps (or whatever these structures actually are) could be also generated by self-organization process when needed.

2.2.2 Inflation in the number of pumps and channels

Channels and pumps for atomic ions and channels and pumps for an astronomical number of organic molecules are needed. The first question is where to put all those channels and pumps? Of course, one could think that pumps and channels are constructed by the cell only when they are needed. But how does the cell know when a new pump is needed if the cell as never met the molecule in question: for instance, antibiotic or curare molecule?

To realize how weird the picture based on channels and pumps is, it is useful to imagine a hotel in which there is a door for every possible client letting only that client through but no one else. This strange hotel would have separate door for every five point five milliard humans. Alternatively, the building would be in a continual state of renovation, new doors being built and old being blocked.

There is however an TGD based objection against this slightly arrogant argument. In TGD framework cell is a self-organizing structure and it might be that there is some mechanism which forces the cell to produce these pumps and channels by self-organization. Perhaps the basic characteristic of quantum control in many-sheeted space-time is that it somehow forces this kind of miracles to occur.

2.2.3 Why pumping does not stop when metabolism stops?

One can also wonder how metabolism is able to provide the needed energy to this continual construction of pumps and channels and also do the pumping. For instance, sodium pump alone is estimated to take 45-50 per cent of the cell's metabolic energy supply. Ling has studied the viability of the notion of the ionic pump experimentally [I18] by exposing cell to a coctail of metabolic poisons and depriving it from oxygen: this should stop the metabolic activities of the cell and stop also the pumping. Rather remarkably, nothing happened to the concentration gradients! Presumably this is the case also for the membrane potential so that also the notion of metabolically driven electrostatic pumps seems to fail. Of course, some metabolism is needed to keep the equilibrium but the mechanism does not seem to be a molecular mechanism and somehow manages to use extremely small amount of metabolic energy.

2.2.4 How it is possible that ionic currents through silicon rubber membrane are similar to those through cell membrane?

A crucial verification of the channel concept was thought to come in the experiment of Neher and Sakmann [I24] (which led to a Nobel prize). The ingenious experimental arrangement was following. A patch of membrane is sucked from the cell and remains stuck on the micropipet orifice. A steady voltage is applied over the patch of the membrane and the resulting current is measured. It was found that the current consists of discrete pulses in consistency with the assumption that a genuine quantum level current is in question. The observation was taken as a direct evidence for the postulate that the ionic currents through the cell membrane flow through ionic channels.

The later experiments of Fred Sachs [I23] however yielded a complete surprise. Sachs found that when the patch of the cell membrane was replaced by a patch of silicon rubber, the discrete currents did not disappear: they remained essentially indistinguishable from cell membrane currents! Even more surprisingly, the silicon rubber membrane showed ion-selectivity features, which were essentially same as those of the cell membrane! Also the currents through synthetic polymer filters [I12] were found to have essentially similar properties: as if ion selectivity, reversal potential, and ionic gating would not depend at all on the structure of the membrane and were more or less universal properties. Also experiments with pure lipid-layer membranes [I8] containing no channel proteins demonstrated that the basic features – including step conductance changes, flickering, ion selectivity, and in-activation– characterized also cell membranes containing no ionic channels.

The in-escapable conclusion forced by these results seems to be that the existing 60-year old paradigm is somehow wrong. Ionic currents and the their properties seem to be universal and depend only on very weakly on the properties of the membrane. This conclusion need not apply to the currents of polar molecules for which genetically coded pump and channel proteins certainly exists. Neither does it imply that pumps and channels could not be used to achieve a more

efficient transfer of ions. Pump - and channel proteins seem to be a well-established notion and TGD approach suggests that they serve as Josephson junctions.

This however requires a generalization of the ordinary thermodynamical approach to cell membrane by starting from zero energy ontology and replacing Boltzmann weight with the complex square roots. Chemical potentials giving dominant part to the change of energy as it goes through cell membrane is replaced with the difference of cyclotron energy which is in visible and UV range from the condition that dark EEG photons have energies of bio-photons [K14]. One ends up with a generalization of Josephson junction: the generalized Josephson energy includes besides Coulombic energy difference also the cyclotron energy difference. Dark cyclotron contribution raises the energy scale of.05-.1 eV associated with cell membrane to.5-10 eVs and one can understand the nominal value.5 eV of metabolic energy currency.

2.3 Cytoplasm As Gel

The solution to the above described anomalies proposed by Pollack is that cytoplasm is gel phase [I17]. Pollack describes in detail various aspects of cytoplasm as a gel phase and here only short summary can be given.

1. Cytoplasm can be regarded as a network consisting of cross-linked negatively charged proteins. Water is condensed around the proteins to form structured water. If protein is hydrophilic, water self-organizes around it as a multilayered structure: the number of molecular layers can as high as 600 and the thickness of the layered structure is a considerable fraction of micrometer. If the protein is hydrophobic, water forms another structured phase known as clathrate water: in this case the number of hydrogen bonds between water atoms is large. These phases can be regarded as intermediate between ice and water. Also ordinary ions have this kind of layered structure around them. Chemical cross-links tend to be stable with heat, pH, and solvent composition whereas physical cross-links formed by intermolecular interactions are sensitive to environmental interactions and are of special interest from the point of view of phase transitions.

2. Pollack proposes that the formation of polymers takes place in an environment containing layered water for the simple reason that monomers cannot diffuse to the layered water so that the probability of association with the end of the growing polymer increases.

3. Cell interior is populated by micro-tubules, various filamentary structures, and the so called micro-trabecular matrix. Micro-trabecular network divides cell into a compartments in such a manner that the typical distance between two proteins in water is about 5 nm: this corresponds to the p-adic length scale $L(149)$, the thickness of the lipid layer of cell membrane. This is probably not an accident and the micro-trabecular network might be closely involved with the highly folded network of intracellular membranes. There would be a layer of thickness of about 6 water molecules per given protein surface so that a dominating portion of intracellular water could be structured.

4. The layered water has several tell-tale signatures that have been observed in gels. It freezes at much lower temperature than ordinary water; various relaxation times are shorter since the energy transfer to the water lattice occurs faster than to non-structure water; the diffusion rates of particles into the structured water are much slower than to ordinary water by entropy argument; a simple geometric argument tells that the larger the size of the hydrated ion the lower the diffusion rate; strong gradients of ionic concentrations can form in gel phase as has been observed.

The identification of the cytoplasm as a gel has profound implications for the standard views about cell.

1. The original motivation for postulating semipermeable cell membrane, channels, and pumps was the need to hinder the diffusion of various ions between cell interior and exterior taking place if cytoplasm is ordinary water into which molecules are dissolved. If cytoplasm is in gel phase, cell membrane need not perform pumping and channeling anymore except perhaps in situations involving the formation of a local sol phase. This raises the question about the proper functions of the cell membrane.

2. It is possible to drill to cell membrane holes with size of order 1 μm without an appreciable effect on the functioning of the cell and also show that these holes remain as such for long periods of time [I17]. It is also possible to splice cells into pieces continuing to function for days. That K^+ flux through cell membrane does not change when lipids are partially removed. These findings force to ask whether the assumption about the continuity of the cell membrane might be too strong [I17]. Electron micrographs however demonstrate the presence of the bi-layered structure. What is intriguing that this structure is seen even in the absence of lipid layers. In TGD framework this paradoxical finding might be understood in terms of a presence of space-time sheets corresponding to p-adic length scales $L(k)$, $k = 149, 151$ as vacuum structures predicted also by TGD inspired model of high T_c super-conductivity [K9].

3. There is also the strange finding that water flux through cell membrane is much higher than the flux through isolate lipid bi-layer as if some unidentified channels were present. In TGD framework this might be seen as an evidence for the presence of (wormhole) magnetic flux tubes as carriers of water molecules.

4. The fundamental assumptions about ionic equilibrium must be reconsidered, and the Hodkin-Huxley model for the generation of nerve pulse becomes more or less obsolete. Indeed, it has been found that action potentials can be generated even in absence of Na^+ and K^+ ions playing a key role in Hodkin-Huxley model. Rather remarkably, the high concentration of K^+ ions and low concentration of Na_+ ions in cytoplasm could be understood on basis of gel property only. Also new view about cell (note membrane-!) potential emerges. The standard paradigm states that the resting potential is over the cell membrane. Potentials of same order of magnitude have been however seen in de-membraned cells (50 mV in slight excess of action potential and critical potential), colloidal suspensions, and gels which suggest that larger part of cell than mere cell membrane is involved with the generation of the action potential and one should thus speak of cell potential instead of membrane potential.

5. Pollack suggests that the phase transitions of the gel phase make possible to realize various functions at molecular and cellular level and represents empirical evidence for the phase transition like aspects assigned to these functions including sensitivity to various factors such as pH, temperature, chemical environment, electromagnetic fields, mechanical forces, etc... and the threshold behavior [I17]. Also the responses are typical for phase transitions in that they involve dramatic changes in volume, shape, di-electric constant, etc.. With these motivations Pollack discusses phase transition based models for contraction, motility, secretion, transport or molecules, organized flow of particles during cell division, cell locomotion, contraction of muscle, generation of action potentials, etc.. For instance, the transport of bio-molecules along micro-tubule could involve propagating gel-sol-gel phase transition meaning also propagating melting of the layered water around micro-tubule.

6. Divalent ions, such as Mg^{+2} and Ca^{+2} can act as cross links between negatively charged proteins binding them to form networks. Monovalent ions cannot do this. Peripheral cytoskeleton is this kind of network consisting of micro-tubules and actin molecules cross-linked - according to Pollack- by Ca^{+2} ions. On the other hand, it is known that Mg^{+2} (Ca^{+2}) ions dominate in the cell interior (exterior) and that the presence of Ca^{+2} ions in the cell exterior is crucial the for generation of nerve pulse. The influx of Na^+ ions having higher affinity to proteins can induce a phase transition to sol-like phase. Pollack suggests a model of nerve pulse based on this mechanism of gel-sol phase transition for peripheral cytoskeleton: this model does not actually explain why Ca^{+2} ions in the exterior of axon are necessary.

2.4 TGD Based Vision Inspired By The Findings

The vision about dark matter and the model of nerve pulse formulated in terms of Josephson currents brings an additional perspective to the role of pumps and channels and allows to achieve harmony with the standard views about their role.

1. In long length scales visible matter forms roughly 5 per cent of the total amount of matter. In TGD Universe the dark matter would correspond to matter with large Planck constant including dark variants of ordinary elementary particles. In living matter situation could

be the same and visible matter could form only a small part of the living matter. Dark matter would be however visible in the sense that it would interact with visible matter via classical electromagnetic fields and photon exchanges with photons suffering Planck constant changing phase transition. Hence one can consider the possibility that most of the biologically important ions and perhaps even molecules reside at the magnetic flux quanta in large $\hbar$ phase.

2. Bosonic ions could form Bose-Einstein condensates at the flux tubes in which case supra currents flowing without any dissipation would be possible. The model for high T_c superconductivity suggests that only electronic and protonic super-conductivity are possible at room temperature. If so, Cooper pairs of fermionic ions are excluded. New nuclear physics predicted by TGD could however come in rescue here. The TGD based model for atomic nucleus assumes that nuclei are strings of nucleons connected by color bonds having quark and antiquark at their ends. Also charged color bonds are possible and this means the existence of nuclei with anomalous charge. This makes possible bosonic variants of fermionic ions with different mass number and it would be interesting to check whether biological important ions like Na^+, Cl^-, and K^+ might actually correspond to this kind of exotic ions.

This leads to the following TGD inspired vision about cell as a gel.

1. DNA as TQC hypothesis and cell membrane as sensory receptor provide possible candidates for the actual functions of the cell membrane and ionic channels and pumps could act as kind of receptors. That standard physics is able to describe gel phase is of course a mere belief and (wormhole) magnetic flux tubes connecting various molecules (DNA, RNA, amino-acids, biologically important ions) would be "new physics" cross-links could explain the strong correlations between distant molecules of the gel phase.

2. Dark ionic currents are quantal currents. If the dark ions flow along magnetic or wormhole magnetic flux tubes connecting cell interior and exterior, their currents through cell membrane would be same as through an artificial membrane.

3. Pumps and channels could serve the role of sensory receptors by allowing to take samples about chemical environment. One cannot exclude the possibility that proteins act as pumps and channels in sol phase if magnetic flux tubes are absent in this phase since also in TGD Universe homeostasis and its control at the level of visible matter in sol phase might requires them. The metabolic energy needed for this purpose would be however dramatically smaller and a reliable estimate for this would allow an estimate of the portion of dark matter in living systems.

4. Quantum criticality suggests that the phase transitions for the gel phase are induced by quantum phase transitions changing the value of Planck constant for magnetic flux tubes and inducing the change of the length of the flux tube. Macroscopic quantum coherence would explain the observed co-operativity aspect of the phase transitions. Concerning locomotion and transport mountain climbing using pickaxe and rope inspires a guess for a general mechanism. For instance, a packet of molecules moving along actin molecule or a molecule carrying a cargo along micro-tubule could repeat a simple basic step in which a magnetic flux tube with large $\hbar$ is shot along the direction of the electric field along micro-tubule and stuck to a rachet followed by a phase transition reducing the value of $\hbar$ and shortening the flux tube and forcing the cargo to move forward. The metabolic energy might be provided by the micro-tubule rather than molecular motor.

5. The reconnection of flux tubes would be a second phase transition of this kind. This phase transition could lead from a phase in phase proteins are unfolded with flux tubes connecting amino-acids to water molecules and thus possessing a large volume of layered water around them to a phase in which they become folded and flux tubes connect amino-acids to each other in the interior of protein. The phase transition could be associated with the contraction of connecting filaments of muscle cell. The phase transitions are also seen in "artificial protein" gels used for drug delivery applications, and are built from polymers arranged in alpha helices, beta sheets and common protein motifs [I17]. If wormhole magnetic flux are taken are taken

as a basic prerequisite of life, one must ask whether these "artificial proteins" represent artificial life.

6. The fact that cytoskeleton rather than only cell membrane is involved with the generation of action potential conforms with the idea that nerve pulse propagating along axon involves also axonal micro-tubules and that Josephson currents between axon and micro-tubules are involved in the process.

7. Di-valent ions (Ca^{+2} ions according to Pollack) serve as cross links in the peripheral cytoskeleton. The influx of monovalent ions from the exterior of axon induces gel-sol phase transition replacing di-valent ions with monovalent ions. One can consider two models.

   (a) The minimal assumption is that this phase transition is induced $\hbar$ increasing phase transition the flow of the monovalent ions like Na^+ from the cell exterior along the magnetic flux tubes connecting axonal interior and interior. Suppose that in the original situation the flux tubes end to axonal membrane (this is not the only possibility, they could also end to Ca^{+2} ions). The flux tubes extending to the axonal exterior could result by $\hbar$ increasing phase transition increasing the length of the flux tubes connecting peripheral cytoskeleton to the axonal membrane so that they extend to the exterior of axon. This option is rather elegant since gel-sol phase transition itself can be understood in terms of "standard chemistry". In this model the very slow diffusion rate of the ions to gel phase would have explanation in terms of new physics involving dark matter and (wormhole) magnetic flux tubes.

   (b) One can consider also an option in which divalent ions such as Ca^{+2} or Mg^{+2} are connected by two flux tubes to amino-acids of two negatively charged proteins whereas monovalent biological ions like Na^+ would have single flux tube of this kind and could not act as cross links. In the phase transitions removing the cross links the replacement of divalent ion with two monovalent positively charged ions would take place. If one believes in standard chemistry, Na^+ ions would flow in automatically. First the increase of Planck constant would induce the lengthening of the magnetic flux tubes and thus the expansion of the gel phase making possible the influx of monovalent ions. If Na^+ ions are dark, flux tubes connecting peripheral cytoskeleton to the axonal exterior are required and the mechanism of option i) is also needed.

8. The mechanisms i) and ii) could be fused to a single one. The hint comes from the presence of Ca^{+2} ions in the exterior of axon is necessary for the generation of action potential. The simplest possibility is that the flux tubes connecting proteins to intracellular Ca^{+2} cross links in gel phase connects them after the length increasing phase transition to extracellular Ca^{+2} ions and Na^+ ions flow along these flux tubes.

9. The increase of the Planck constant would induce the expansion of the peripheral cytoskeleton making possible the inflow of Na^+ ions, and divalent ions binding negatively charged actin molecules to a network would be replaced with inflowing Na^+ ions. After this a reverse phase transition would occur. Both phase transitions could be induced by a quantal control signal (Josephson current) inducing quantum criticality and a change of Planck constant.

10. A propagating Ca^{+2} wave inducing the gel-sol-gel phase transition of peripheral cytoskeleton would accompany nerve pulse. Quite generally, Ca^{+2} waves are known to play a fundamental role in living matter as kind of biological rhythms. Irrespective of whether one believes option a) or b), this might relate to the cross-linking by flux tubes and gel-sol-gel phase transitions induce by phase transitions increasing Planck constant temporarily. The velocities and oscillation periods of Ca^{+2} waves vary in an extremely wide range: this can be understood if the flux tubes involved correspond to a very wide spectrum of Planck constant.

Besides basic ions cell membrane is non-permeable to various polar molecules such as the basic building bricks of DNA and amino-acids. The safest assumption is that genetically coded pump and channel proteins make possible the transfer. One must of course consider the possibility that channels and pumps are used to make the transfer of basic ions more effective. Taking this into

account, the proposed vision does not differ so radically from the standard one as one might think first and only the model for nerve pulse generation must be modified radically.

To sum up, the strange discoveries about the behavior of cell membrane provide direct experimental evidence for the presence of dark matter in living systems, for the prediction that it interacts with ordinary matter via classical electromagnetic fields, and for the assumption that it does not dissipate appreciably and could therefore have large value of $\hbar$ and form macroscopic quantum phases.

3 Further Experimental Findings

In this section I discuss further experimental findings giving support for the TGD based vision about living cell.

3.1 Genes And Water Memory

After long time I had opportunity to read a beautiful experimental article about experimental biology. Yolene Thomas, who worked with Benveniste, kindly sent the article to me. The freely loadable article is *Electromagnetic Signals Are Produced by Aqueous Nanostructures Derived from Bacterial DNA Sequences* by Luc Montagnier, Jamal Aissa, Stephane Ferris, Jean-Luc Montagnier, and Claude Lavall'e published in the journal Interdiscip. Sci. Comput. Life Sci. (2009) [I14].

3.1.1 Basic findings at cell level

I try to list the essential points of the article. Apologies for biologists: I am not a specialist.

1. Certain pathogenic micro-organisms are objects of the study. The bacteria Mycoplasma Pirum and E. Choli belong to the targets of the study. The motivating observation was that some procedures aimed at sterilizing biological fluids can yield under some conditions the infectious micro-organism which was present before the filtration and absent immediately after it. For instance, one filtrates a culture of human lymphocytes infected by M. Pirum, which has infected human lymphocytes to make it sterile. The filters used have 100 nm and 20 nm porosities. M. Pirum has size of 300 nm so that apparently sterile fluids results. However if this fluid is incubated with a mycoplasma negative culture of human lymphocytes, mycoplasma re-appears within 2 or 3 weeks! This sounds mysterious. Same happens as 20 nm filtration is applied to a a minor infective fraction of HIV, whose viral particles have size in the range 100-120 nm.

2. These findings motivated a study of the filtrates and it was discovered that they have a capacity to produce low frequency electromagnetic waves with frequencies in good approximation coming as the first three harmonics of kHz frequency, which by the way plays also a central role in neural synchrony. What sounds mysterious is that the effect appeared after appropriate dilutions with water: positive dilution fraction varied between 10^{-7} and 10^{-12}. The uninfected eukaryotic cells used as controls did not show the emission. These signals appeared for both M. Pirum and E. Choli but for M. Pirum a filtration using 20 nm filter canceled the effect. Hence it seems that the nano-structures in question have size between 20 and 100 nm in this case.

   A resonance phenomenon depending on excitation by the electromagnetic waves is suggested as an underlying mechanism. Stochastic resonance familiar to physicists suggests itself and also I have discussed it while developing ideas about quantum brain [K38]. The proposed explanation for the necessity of the dilution could be kind of self-inhibition. Maybe a gel like phase which does not emit radiation is present in sufficiently low dilution but is destroyed in high dilutions after which emission begins. Note that the gel phase would not be present in healthy tissue. Also a destructive interference of radiation emitted by several sources can be imagined.

3. Also a cross talk between dilutions was discovered. The experiment involved two tubes. Donor tube was at a low dilution of E. Choli and "silent" (and carrying gel like phase if the

above conjecture is right). Receiver tube was in high dilution (dilution fraction 10^{-9}) and "loud". Both tubes were placed in mu-metal box for 24 hours at room temperature. Both tubes were silent after his. After a further dilution made for the receiver tube it became loud again. This could be understood in terms of the formation of gel like phase in which the radiation does not take place. The effect disappeared when one interposed a sheath of mu-metal between the tubes. Emission of similar signals was observed for many other bacterial specials, all pathogenic. The transfer occurred only between identical bacterial species which suggests that the signals and possibly also frequencies are characteristic for the species and possibly code for DNA sequences characterizing the species.

4. A further surprising finding was that the signal appeared in dilution which was always the same irrespective of what was the original dilution.

3.1.2 Experimentation at gene level

The next step in experimentation was performed at gene level.

1. The killing of bacteria did not cancel the emission in appropriate dilutions unless the genetic material was destroyed. It turned out that the genetic material extracted from the bacteria filtered and diluted with water produced also an emission for sufficiently high dilutions.

2. The filtration step was essential for the emission also now. The filtration for 100 nm did not retain DNA which was indeed present in the filtrate. That effect occurred suggests that filtration destroyed a gel like structure inhibiting the effect. When 20 nm filtration was used the effect disappeared which suggests that the size of the structure was in the range 20-100 nm.

3. After the treatment by DNAse enzyme inducing splitting of DNA to pieces the emission was absent. The treatment of DNA solution by restriction enzyme acting on many sites of DNA did not suppress the emission suggesting that the emission is linked with rather short sequences or with rare sequences.

4. The fact that pathogenic bacteria produce the emission but not "good" bacteria suggests that effect is caused by some specific gene. It was found that single gene - adhesin responsible for the adhesion of mycoplasma to human cells- was responsible for the effect. When the cloned gene was attached to two plasmids and the E. Choli DNA was transformed with the either plasmid, the emission was produced.

3.1.3 Some consequences

The findings could have rather interesting consequences.

1. The refinement of the analysis could make possible diagnostics of various diseases and suggests bacterial origin of diseases like Alzheimer disease, Parkinson disease, Multiple Sclerosis and Rheumatoid Arthritis since the emission signal could serve as a signature of the gene causing the disease. The signal can be detected also from RNA viruses such as HIV, influenza virus A, and Hepatitis C virus.

2. Emission could also play key role in the mechanism of adhesion to human cells making possible the infection perhaps acting as a kind of password.

The results are rather impressive. Some strongly conditioned skeptic might have already stopped reading after encountering the word "dilution" and associating it with a word which no skeptic scientist in his right mind should not say aloud: "homeopathy" ! By reading carefully what I wrote above, it is easy to discover that the experimenters unashamedly manufactured a homeopathic remedy out of the filtrate! And the motivating finding was that although filtrate should not have contained the bacteria, they (according to authors), or at least the effects caused by them, appeared within weeks to it! This is of course impossible in the word of skeptic.

The next reaction of the skeptic is of course that this is fraud or the experimenters are miserable crackpots. Amusingly, one of the miserable crackpots is Nobelist Luc Montagnier, whose research group discovered AIDS virus.

3.1.4 How TGD could explain the findings?

Let us leave the raging skeptics for a moment and sketch possible explanations in TGD framework.

1. Skeptic would argue that the filtration allowed a small portion of infected cells to leak through the filter. Many-sheeted space-time suggests a science fictive variant of this explanation. During filtration part of the infected cells is "dropped" to large space-time sheets and diffused back to the original space-time sheets during the next week. This would explain why the micro-organisms were regenerated within few weeks. Same mechanism could work for ordinary molecules and explain homeopathy. This can be tested: look whether the molecules return back to the diluted solution in the case of a homeopathic remedy.

2. If no cells remain in the filtrate, something really miraculous looking events are required to make possible the regeneration of the effects serving as the presence of cells. This even in the case that DNA fragments remain in the filtrate.

   (a) The minimum option is that the presence of these structures contained only the relevant information about the infecting bacteria and this information coded in terms of frequencies was enough to induce the signatures of the infection as a kind of molecular conditioning. Experimentalists can probably immediately answer whether this can be the case.

   (b) The most radical option is that the infecting bacteria were actually regenerated as experimenters claim! The information about their DNA was in some form present and was transcribed to DNA and/or RNA, which in turn transformed to proteins. Maybe the small fragment of DNA (adhesin) and this information should have been enough to regenerate the DNA of the bacterium and bacterium itself. A test for this hypothesis is whether the mere nanoparticles left from the DNA preparation to the filtrate can induce the regeneration of infecting molecules.

The notion of magnetic body carrying dark matter quantum controlling living matter forms the basic element of TGD inspired model of quantum biology and suggests a more concrete model. The discovery of nanotubes connecting cells with distance up to 300 μ [I6] provides experimental support for the notion.

1. If the matter at given layer of the onion-like structure formed by magnetic bodies has large $\hbar$, one can argue that the layer corresponds to a higher evolutionary level than ordinary matter with longer time scale of memory and planned action. Hence it would not be surprising if the magnetic bodies were able to replicate and use ordinary molecules as kind of sensory receptors and motor organs. Perhaps the replication of magnetic bodies preceded the replication at DNA level and genetic code is realized already at this more fundamental level somehow. Perhaps the replication of magnetic bodies induces the replication of DNA as I have suggested.

2. The magnetic body of DNA could make DNA a topological quantum computer [K1]. DNA itself would represent the hardware and magnetic bodies would carry the evolving quantum computer programs realized in terms of braidings of magnetic flux tubes. The natural communication and control tool would be cyclotron radiation besides Josephson radiation associated with cell membranes acting as Josephson junctions. Cyclotron frequencies are indeed the only natural frequencies that one can assign to molecules in kHz range. There would be an entire fractal hierarchy of analogs of EEG making possible the communication with and control by magnetic bodies.

3. The values of Planck constant would define a hierarchy of magnetic bodies which corresponds to evolutionary hierarchy and the emergence of a new level would mean jump in evolution. Gel like phases could serve as a correlate for the presence of the magnetic body. The phase transitions changing the value of Planck constant and scale up or down the size of the magnetic flux tubes. They are proposed to serve as a basic control mechanism making possible to understand the properties and the dynamics of the gel phases and how biomolecules can find each other in the thick molecular soup via a phase transition reducing the length of flux tubes connecting the biomolecules in question and thus forcing them to the vicinity of each other.

Consider now how this model could explain the findings.

1. Minimal option is that the flux tubes correspond to "larger space-time sheets" and the infected cells managed to flow into the filtrate along magnetic flux tubes from the filter. This kind of transfer of DNA might be made possible by the recently discovered nanotubes already mentioned.

2. Maybe the radiation resulted as dark photons invisible for ordinary instruments transformed to ordinary photons as the gel phase assignable with the dark matter at magnetic flux tube network associated with the infected cells and corresponding DNA was destroyed in the filtration.

   This is not the only possible guess. A phase conjugate cyclotron radiation with a large value of Planck constant could also allow for the nanostructures in dilute solute to gain metabolic energy by sending negative energy quanta to a system able to receive them. Indeed the presence of ambient radiation was necessary for the emission. Maybe that for sufficiently dilute solute this mechanism allows to the nanostructures to get metabolic energy from the ambient radiation whereas for the gel phase the metabolic needs are not so demanding. In the similar manner bacteria form colonies when metabolically deprived. This sucking of energy might be also part of the mechanism of disease.

3. What could be the magnetic field inducing the kHz radiation as a synchrotron radiation?

   (a) For instance, kHz frequency and its harmonics could correspond to the cyclotron frequencies of proton in magnetic field which field strength slightly above that for Earth's magnetic field (750 Hz frequency corresponds to field strength of B_E, where B_E =.5 Gauss, the nominal strength of Earth's magnetic field). A possible problem is that the thickness of the flux tubes would be about cell size for Earth's magnetic field from flux quantization and even larger for dark matter with a large value of Planck constant. Of course, the flux tubes could make themselves thinner temporarily and leak through the pores.

   (b) If the flux tube is assumed to have thickness of order 20-100 nm, the magnetic field for ordinary value of $\hbar$ would be of order.1 Tesla from flux quantization and in the case of DNA the cyclotron frequencies would not depend much on the length of DNA fragment since the it carries a constant charge density. Magnetic field of order.2 Tesla would give cyclotron frequency of order kHZ from the fact that the field strength of.2 Gauss gives frequency of about .1 Hz. This correspond to a magnetic field with flux tube thickness $\sim$ 125 nm, which happens to be the upper limit for the porosity. Dark magnetic flux tubes with large $\hbar$ are however thicker and the leakage might involve a temporary phase transition to a phase with ordinary value of $\hbar$ reducing the thickness of the flux tube. Perhaps some genes (adhesin) plus corresponding magnetic bodies representing DNA in terms of cyclotron frequencies depending slightly on precise weight of the DNA sequence and thus coding it correspond to the frequency of cyclotron radiation are the sought for nano-structures.

4. While developing a model for homeopathy based on dark matter I ended up with the idea that dark matter consisting of nuclear strings of neutrons and protons with a large value of $\hbar$ and having thus a zoomed up size of nucleon could be involved. The really amazing finding was that nucleons as three quark systems allow to realize vertebrate code in terms of states formed from entangled quarks [L2], [L2] described also in this chapter! One cannot decompose codons to letters as in the case of the ordinary genetic code but codons are analogous to symbols representing entire words in Chinese. The counterparts of DNA, RNA, and amino-acids emerge and genetic code has a concrete meaning as a map between quantum states.

   Without any exaggeration this connection between dark hadronic physics and biology has been one of the greatest surprises of my professional life. It suggests that dark matter in macroscopic quantum phase realizes genetic code at the level of nuclear physics and biology only provides one particular (or probably very many as I have proposed) representations of

it. If one takes this seriously one can imagine that genetic information is represented by these dark nuclear strings of nanoscopic size and that there exists a mechanism translating the dark nuclei to ordinary DNA and RNA sequences and thus to biological matter. This would explain the claimed regeneration of the infected cells.

5. Genetic code at dark matter level would have far reaching implications. For instance, living matter - or rather, the magnetic bodies controlling it - could purposefully perform genetic engineering. This forces me to spit out another really dirty word, "Lamarckism" ! We have of course learned that mutations are random. The basic objection against Lamarckism is that there is no known mechanism which would transfer the mutations to germ cells. In the homeopathic Universe of TGD the mutations could be however performed first for the dark nucleon sequences. After this these sequences would diffuse to germ cells just like homeopathic remedies do, and after this are translated to DNA or RNA and attach to DNA.

The findings of both Montagnier and Gariaev suggests that also the representation of genetic code in terms of dark photons is involved. How genetic code could be represented in terms of frequencies? The TGD based model of music harmony [L8] [K36] (see `http://tinyurl.com/zg3aaj7`) relies on the idea that 12-note scale is representable as a closed non-self-intersecting curve (Hamilton's cycle) at icosahedron having 12 vertices. The harmony assignable to a given Hamilton's cycle is characterized in terms of 3-chords assignable to the 20 faces (triangles) of the icosahedron once the 12-note scale is represented as a particular Hamilton's cycle.

Remarkably, the number of amino-acids is also 20! One indeed ends up with a model in which 20+20+20=60 DNA codons are represented by 3-chords for a triplet of harmonies defined by Hamilton's cycles predicting correctly the numbers of DNAs coding for a given amino-acid for vertebrate code. One must however assume that also tetrahedral harmony is present to get 64 DNA codons rather than only 60. TActually two variants of the code are predicted and altogether one obtains the standard 20 amino-acids plus two additional ones identified as Pyl and Sec known to be realized in living matter.

In music realization DNA codons can be represented as 3 dark photons or phonons with appropriate frequency ratios. This representation could explain the findings of Montagnier and Gariaev. There is also a connection with TGD inspired theory of consciousness. Music both expresses and induces emotions. The proposal is that the representation of DNA codons in terms of triplets of sounds or dark photons defines molecular level representation of emotions. There is large number of different harmonies and they could represent different moods.

3.2 A Model For Chiral Selection

Chiral selection of bio-molecules is one of the basic mysteries of biology and it is interesting to see whether the existing bits of data combined with vision about quantum TGD could help to build a coherent picture about the situation. Let us first try to identify the most important pieces of the puzzle.

1. Chiral selection requires parity breaking in the scale of biomolecules. Standard model predicts parity breaking interactions but the effects are extremely small above intermediate boson length scale which is by a factor 10^{-7} shorter than atomic length scale. The proposed solution of the problem is that dark variants of intermediate gauge bosons are in question so that the Compton lengths of intermediate gauge bosons are scaled up by a factor $r = \hbar/\hbar_0$. Below the dark Compton length weak gauge bosons would be effectively massless and above it possess ordinary masses. Large parity breaking effects induced by dark intermediate gauge bosons would be possible.

2. For instance, for $r = 2^{44}$ for which EEG photons have energies just above thermal threshold at room temperature, the effective p-adic length scale would correspond to $L(k)$, $k = 89 + 44 = 133$ of about.2 Angstrom. This scale in turn would scale up to $L(133 + 44 = 177)$. Secondary p-adic length scale assignable to $k = 89$ which is important in zero energy ontology would correspond to $k = 2 \times 89 = 178$ which corresponds to about $L(178) \simeq 100$ μm, the length scale assignable to large cells and the thickness of water layers in the experiment of Pollack.

3. Parity breaking interaction is associated with spin and the interaction energy of form $ks \cdot E_Z$, where s is the spin of particle and E_Z is Z^0 electric field. Classical induced gauge fields are very strongly correlated in TGD since they are expressible in terms of four CP_2 coordinates and their gradients. Hence classical electromagnetic field E is in the generic case accompanied by classical Z^0 field $E_Z = aE$. This means that if there is classical electromagnetic field and charge density at the dark space-time sheet, large parity breaking effect is possible at the level of spin. The induced Z^0 electric field could force the spins to become parallel and in this manner induce also magnetization.

The crucial finding about which I learned three years ago is that L glutamate is more stable than R glutamate in water and that heavy water does not induce this effect [I26]. This suggests a connection with Pollack-Zheng effect [D29]. Heavy water nuclei have vanishing spin whereas hydrogen nuclei have spin 1/2 so that H_2 in water molecules can be in spin singlet or triplet states (para and orto configurations). Could the nuclear spin of water molecules somehow induce parity breaking and the magnetic interaction distinguishing between these molecules?

1. Suppose that bio-molecules in question have magnetic moment and water carries magnetic field, most naturally at dark magnetic flux tubes. The parity breaking interaction energy $-p \cdot E$ with dark electric field remains invariant under reflection and rotation of π changing the orientation of the mirror image of the molecule with respect to electric field. The interaction energy with magnetic field however changes its sign since magnetic moment is not affected by the reflection but changes direction under rotation. The angular momentum of the molecule responsible for the magnetic moment can of course change sign but since the transformation involves acts on angular momenta only, it is not a symmetry of entire system. Indeed, if there is interaction between angular momentum degrees of freedom and geometric degrees of freedom the magnetic interaction energy for the mirror image is different. Suppose that the breaking of reflection symmetry induced by the chirality of the molecule induces internal electric field E_{int}. The parity breaking interaction energy $ks \cdot E_{int}$ would indeed break the symmetry in the transformation changing the directions of angular momenta and spins.

2. It deserves to be emphasize that the parity breaking of the molecule itself would induce the symmetry breaking if molecule possesses dark magnetic body. One can actually imagine a cascade of parity breakings proceeding from shorter to longer length scales in this manner.

3. The mechanism creating electric field could be the charging of water, perhaps by the Pollack-Zheng mechanism and having in TGD framework an interpretation as a basic mechanism storing the energy of sunlight to metabolic energy (kicking of electrons and/or protons to a smaller space-time sheet so that oppositely charge space-time sheets emerge as a consequence). A direct connection with metabolism would be admittedly a highly satisfactory feature of the mechanism.

4. Parity breaking energy $ks \cdot E$ for say dark protons assignable to hydrogen nuclei of bio-molecules in the internal electric field of the molecule or dark protons of water molecules in the electric field induced by Pollack-Zheng effect [D29] does not change sign under the reflection of the molecule so that spin polarization independent of chirality could result form both water molecules in crystal like phase and for bio-molecules possessing dark protons (and dark hydrogen atoms). This could in turn serve as a seed for magnetization essential for the existence of dark magnetic flux tubes.

If water is replaced with heavy water there is no difference between L and R. What distinction H and D could explain this difference?

1. The basic difference between water and heavy water nuclei is that for water nucleus is just proton having spin 1/2 so that H_2 in water molecule can be in spin triplet and singlet states. Fractions of the two states are 3/4 and 1/4 in the absence of external magnetic field.

2. On the other hand, in atto-second time scale (corresponding length scale is 3 Angstroms) water is known to behave effectively as $H_{1.5}O$. A possible explanation is that 1/4: th of H nuclei/atoms are effectively dark having large Planck constant. The dark protons cannot

correspond to H_2 in spin singlet state since the interaction energy $ks \cdot E$ would be small in this case. Dark spin triplet states of H_2 could however induce parity breaking in water and make crystal like water phase both electret and magnet. If the spin $s_z = 1$ with negative interaction energy with E becomes dark then 1/4 of hydrogen atoms would be dark and $H_{1.5}O$ formula would hold true. For D_2O this mechanism would not work.

3. The model for homeopathy led to the idea that dark nuclei consisting of scale up variants of nucleons possibly having size of order atomic length scale could be crucial for understanding living matter. The states of nucleons correspond naturally to those DNA, RNA, and aminocids and vertebrate genetic code emerges naturally with DNA code word replaced with 3 quark state with entanglement between the quarks representing the information. Could it be that dark protons of water combine to form dark nuclei providing a fundamental representation of the genetic code and could the spin of protons induce electro-weak chiral symmetry breaking. Also now this mechanism fails for D_2O.

3.3 Burning Water And Photosynthesis

For a physicist liberated from the blind belief in reductionism, biology transforms to a single gigantic anomaly about which recent day physics cannot say much. During years I have constructed several models for these anomalies helping to develop a more detailed view about how the new physics predicted by quantum TGD could allow to understand biology and consciousness.

The basic problem is of course the absence of systematic experimentation so that it is possible to imagine many new physics scenarios. For this reason the article series of Mae-Wan Ho [D25, D23, D21, D24] in ISIS was a very pleasant surprise, and already now has helped considerably in the attempts to develop the ideas further.

The first article "Water electric" [D25] told about the formation of exclusion zones around hydrophilic surfaces, typically gels in the experiments considered [D29]. The zones were in potential of about 100 meV with respect to surroundings (same order of magnitude as membrane potential) and had thickness ranging to hundreds of micrometers (the size of a large cell): the standard physics would suggests only few molecular layers instead of millions. Sunlight induced the effect. This finding allow to develop TGD based vision about how proto cells emerged and also the model for chiral selection in living matter by combining the finding with the anomalies of water about which I had learned earlier.

The article "Can water burn?" [D21] tells about the discovery of John Kanzius - a retired broadcast engineer and inventor. Kanzius found that water literally burns if subjected to a radio frequency radiation at frequency of 13.56 MHz [D1]. The mystery is of course how so low frequency can induce burning. The article "The body does burn water" [D24] notices that plant cells burn water routinely in photosynthesis and that also animal cells burn water but the purpose is now to generate hydrogen peroxide which kills bacteria (some readers might recall from childhood how hydrogen peroxide was used to sterilize wounds!). Hence the understanding of how water burns is very relevant for the understanding of photosynthesis and even workings of the immune system.

3.3.1 Living matter burns water routinely

Photosynthesis burns water by decomposing water to hydrogen and oxygen and liberating oxygen. Oxygen from CO_2 in atmosphere combines with the oxygen of H_2O to form O_2 molecules whereas H from H_2O combines with carbon to form hydrocarbons serving as energy sources for animals which in turn produce CO_2. This process is fundamental for aerobic life. There is also a simpler variant of photosynthesis in which oxygen is not produced and applied by an-aerobic life forms. The article "Living with Oxygen" by Mae-Wan Ho gives a nice overall view about the role of oxygen [D22]. As a matter fact, also animals burn water but they do this to produce hydrogen peroxide H_2O_2 which kills very effectively bacteria.

Burning of water has been studied as a potential solution for how to utilize the solar energy to produce hydrogen serving as a natural fuel [D23]. The reaction $O_2 + H_2 \rightarrow 2H_2O$ occurs spontaneously and liberates energy of about 1.23 eV. The reverse process $2H_2 \rightarrow H_2O_2 + H_2$ in the presence of sunlight means burning of water, and could provide the manner to store solar energy. The basic reaction $2H_2O + 4h\nu \leftrightarrow H_2O_2 + H_2$ stores the energy of four photons. What really

happens in this process is far from being completely understood. Quite generally, the mechanisms making possible extreme efficiency of bio-catalysis remain poorly understood. Here new physics might be involved. I have discussed models for photosynthesis and $ADP \leftrightarrow ATP$ process involved with the utilization of the biochemical energy already earlier [K20].

3.3.2 How water could burn in TGD Universe?

The new results could help to develop a more detailed model about what happens in photosynthesis. The simplest TGD inspired sketch for what might happen in the burning of water goes as follows.

1. Assume that 1/4 of water molecules are partially dark (in sense of nonstandard value of Planck constant) or at least at larger space-time sheets in atto-second scale [D20, D18, D27, D11]. This would explain the $H_{1.5}O$ formula explaining the results of neutron diffraction and electron scattering.

2. The question is what this exotic fraction of water precisely is. The models for water electret, exclusion zones and chiral selection lead to concrete ideas about this. Electrons assignable to the H atoms of (partially) dark H_2O reside at space-time sheet $k_e = 151$ (this p-adic length scale corresponds to 10 nm, the thickness of cell membrane). At least the hydrogen atom for this fraction of water molecules is exotic and findings from neutron and electron scattering suggest that both proton and electron are at non-standard space-time sheets but not necessarily at the same space-time sheet. The model for the burning requires that electron and proton are at different space-time sheets in the initial situation.

3. Suppose all four electrons are kicked to the space-time sheet of protons of the exotic hydrogen atoms labeled by k_p. This requires the energy $E_\gamma = (1 - 2^{-n})E_0(k_p)$ (the formula involves idealizations). At this space-time sheet protons and electrons are assumed to combine spontaneously to form two H_2 atoms. Oxygen atoms in turn are assumed to combine spontaneously to form O_2.

4. For $k_f = 148$ and $n = 3$ minimum energy needed would be $4E_\gamma = 4 \times .4 = 1.6$ eV. For $k_p = 149$ (thickness of lipid layer) and $n = 2$ one would have $4E_\gamma = 4 \times .3462 = 1.385$ eV whereas $H_2O_2 + H_2 \to 2H_2O$ liberates energy 1.23 eV. Therefore the model in which electrons are at cell membrane space-time sheet and protons at the space-time sheet assignable to single lipid layer of cell membrane suggests itself. This would also mean that the basic length scales of cell are already present in the structure of water. Notice that there is no need to assume that Planck constant differs from its standard value.

There is no need to add, that the model is an unashamed oversimplification of the reality. It might however catch the core mechanism of photosynthesis.

3.3.3 Burning of salt water induced by RF radiation

Engineer John Kanzius has made a strange discovery [D1]: salt water in the test tube radiated by radio waves at harmonics of a frequency f=13.56 MHz burns. Temperatures about 1500 K, which correspond to.15 eV energy have been reported. One can irradiate also hand but nothing happens. The original discovery of Kanzius was the finding that radio waves could be used to cure cancer by destroying the cancer cells. The proposal is that this effect might provide new energy source by liberating chemical energy in an exceptionally effective manner. The power is about 200 W so that the power used could explain the effect if it is absorbed in resonance like manner by salt water.

Mae-Wan Ho's article "Can water Burn?" [D21] provides new information about burning salt water [D1], in particular reports that the experiments have been replicated. The water is irradiated using polarized radio frequency light at frequency 13.56 MHz. The energy of radio frequency quantum is $E_{rf} = .561 \times 10^{-7}$ eV and provides only a minor fraction $E_{rf}/E = .436 \times 10^{-7}$ of the needed energy which is $E = 1.23$ eV for single $2H_2O \to H_2O_2 + H_2$ event. The structure of water has been found to change, in particular something happens to O-H bonds. The Raman spectrum of the water has changed in the energy range $[0.37, 0.43]$ eV. Recall that the range of metabolic energy quanta $E(k, n) = (1 - 2^{-}n)E_0(k)$ varies for electron in the range $[.35, .46]$ eV in the model

for the formation of exclusion zone induced by light. Therefore the photons assigned to changes in Raman spectrum might be associated with the transfer of electrons between space-time sheets.

The energies of photons involved are very small, multiples of 5.6×10^{-8} eV and their effect should be very small since it is difficult to imagine what resonant molecular transition could cause the effect. This leads to the question whether the radio wave beam could contain a considerable fraction of dark photons for which Planck constant is larger so that the energy of photons is much larger. The underlying mechanism would be phase transition of dark photons with large Planck constant to ordinary photons with shorter wavelength coupling resonantly to some molecular degrees of freedom and inducing the heating. Microwave oven of course comes in mind immediately.

As I made this proposal, I did not realize the connection with photosynthesis and actual burning of water. The recent experimental findings suggest that dark radio frequency photons transform to photons inducing splitting of water as in photosynthesis so that one should have $r = \hbar/\hbar_0 = E_{rf}/4E$. One could say that large number of radio wave photons combine to form a single bundle of photons forming a structure analogous to what mathematician calls covering space. In the burning event the dark photon would transform to ordinary photon with the same energy. This process would thus transform low energy photons to high energy protons with the ratio $r = \hbar/\hbar_0$.

Therefore the mechanism for the burning of water in the experiment of Kanzius could be a simple modification of the mechanism behind burning of water in photosynthesis.

1. Some fraction of dark radio frequency photons are dark or are transformed to dark photons in water and have energies around the energy needed to kick electrons to smaller space-time sheets .4 eV. After this they are transformed to ordinary photons and induce the above process. Their in-elastic scattering from molecules (that is Raman scattering) explains the observation of Raman scattered photons. For a fixed value of $\hbar$ the process would occur in resonant manner since only few metabolic quanta are allowed.

2. How dark radio frequency photons could be present or could be produced in water? Cyclotron radiation assignable to say electrons in magnetic field comes in mind. If the cyclotron radiation is associated with electrons it requires a magnetic field of 4.8 Gauss the cyclotron frequency is 13.56 MHz. This is roughly ten times the nominal value $B_E = .5$ Gauss of the Earth's magnetic field and 24 times the value of dark magnetic field $B_d = .4B_E = .2$ Gauss needed to explain the effects of ELF em fields on vertebrate brain. Maybe dark matter at flux tubes of Earth's magnetic field with Planck constant equal to $\hbar/\hbar_0 = \frac{1}{4}\frac{E}{E_{rf}}$ transforms radio frequency photons to dark photons or induces resonantly the generation of cyclotron photons, which in turn leak out from magnetic flux tubes and form ordinary photons inducing the burning of water. $E_\gamma = .4$ eV would give $\hbar/\hbar_0 == 1.063 \times 2^{21}$ and $E_\gamma = .36$ eV would give $\hbar/\hbar_0 = .920 \times 2^{21}$.

3. Magnetic fields of magnitude.2 Gauss are in central role in TGD based model of living matter and there are excellent reasons to expect that this mechanism could be involved also with processes involved with living matter. There is indeed evidence for this. The experiments of Gariaev demonstrated that the irradiation of DNA with 2 eV laser photons (which correspond to one particular metabolic energy quantum) induced generation of radio wave photons having unexpected effects on living matter (enhanced metabolic activity) [I9], and that even a realization of genetic code in terms of the time variation of polarization direction could be involved. TGD based model [K8, K43] identifies radio-wave photons as dark photons with same energy as possessed by incoming visible photons so that a transformation of ordinary photons to dark photons would have been in question. The model assumed hierarchy of values of magnetic fields in accordance with the idea about onion like structure of the magnetic body.

There are several questions to be answered.

1. Is there some trivial explanation for why salt must be present or is new physics involved also here. What comes in mind are Cooper pairs dark Na^+ ions (or their exotic counterparts which are bosons) carrying Josephson currents through the cell membrane in the model of the cell membrane as a Josephson junction which is almost vacuum extremal of Kähler action. In the experimental arrangement leading to the generation of exclusion zones the pH of water

was important control factor, and it might be that the presence of salt has an analogous role to that of protons.

2. Does this effect occur also for solutions of other molecules and other solutes than water? This can be tested since the rotational spectra are readily calculable from data which can be found at net.

3. Are the radio wave photons dark or does water - which is very special kind of liquid - induce the transformation of ordinary radio wave photons to dark photons by fusing $r = \hbar/\hbar_0$ radio wave massless extremals (MEs) to single ME. Does this transformation occur for all frequencies? This kind of transformation might play a key role in transforming ordinary EEG photons to dark photons and partially explain the special role of water in living systems.

4. Why the radiation does not induce spontaneous combustion of living matter which contains salt. And why cancer cells seem to burn: is salt concentration higher inside them? As a matter fact, there are reports about [D4]. One might hope that there is a mechanism inhibiting this since otherwise military would be soon developing new horror weapons unless it is doing this already now. Is it that most of salt is ionized to Na^+ and Cl^- ions so that spontaneous combustion can be avoided? And how this relates to the sensation of spontaneous burning [D3] - a very painful sensation that some part of body is burning?

5. Is the energy heating solely due to rotational excitations? It might be that also a "dropping" of ions to larger space-time sheets is induced by the process and liberates zero point kinetic energy. The dropping of proton from k=137 (k=139) atomic space-time sheet liberates about.5 eV (0.125 eV). The measured temperature corresponds to the energy.15 eV. This dropping is an essential element in the ealier of remote metabolism and provides universal metabolic energy quanta. It is also involved with TGD based models of "free energy" phenomena. No perpetuum mobile is predicted since there must be a mechanism driving the dropped ions back to the original space-time sheets.

   In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

6. The electrolysis of water and also cavitation produces what is known as Brown's gas which should consist of water vapour and there might be a connection to the burning of salt water. The properties of Brown's gas [**?**] however do not support this interpretation: for instance, Brown's gas has temperature of about 130 C but is able to melt metals so that some un-known mechanism liberating energy must be involved explaining also the claims about over-unity energy production in water splitting using electrolysis. TGD inspired model for Brown's gas [K21] suggests that activated water and Brown's gas correspond to same phase involving polymer sequences formed from exotic water molecules for which one hydrogen nucleus is dark and defining the analogs of basic biopolymers. The bond binding protons to a polymer like sequence would serve as the counterpart of covalent bond.

   One also ends up with a more detailed TGD inspired view about basic mechanism of metabolism in living matter predicting a tight correlation between p-adic length scale hypothesis and hierarchy of Planck constants. The model differs in some aspects from the rough models considered hitherto assuming that metabolic energy is liberated as zero point kinetic energy when particle drops to a larger space-time sheet or as cyclotron energy when cyclotron quantum number decreases. Now a phase transition increasing the p-adic length scale of the space-time surface would liberate either kinetic energy of cyclotron energy. Quantum numbers would not change: rather, t the scale appearing as a parameter in the expression of kinetic or cyclotron energy would change adiabatically and in this manner guarantee coherence. Also a phase transition in which the changes of scale due to a reduction of Planck

constant and increase of the p-adic length scale compensate each other liberate metabolic energy.

Recall that one of the empirical motivations for the hierarchy of Planck constants came from the observed quantum like effects of ELF em fields at EEG frequencies on vertebrate brain and also from the correlation of EEG with brain function and contents of consciousness difficult to understand since the energies of EEG photons are ridiculously small and should be masked by thermal noise.

3.3.4 Free radicals, expanding Earth, water memory, and Cambrian revolution

The title is intentionally chosen to involve notions which one would expect to have absolutely nothing in common. The purpose is to show that this expectation might be wrong. Consider first the free radical theory [I1]. The theory states that free radical produced in mitochondria are responsible for the ageing since they are highly reactive and cause damage for the DNA. One can however wonder what is the mechanism causing the generation of the free radicals.

A TGD based justification for the free radical theory came as unexpected application of the quantum model for how metabolic batteries are loaded in many-sheeted space-time. The kicking of electrons, protons, or ions to smaller space-time sheet loads metabolic batteries in TGD Universe. A more refined model is based on a phase transition which increases p-adic prime and decreases the value of h_{eff} so that the two length scale changes compensate each other. The zero point kinetic energy or cyclotron energy associated with the magnetic flux tube is reduced in the process and liberate. Therefore this kind of process could liberate metabolic energy.

These processes could occur all the time in ADP$\leftrightarrow$ATP "Karma's" cycle. In this case the transfer or protons through the cell membrane would induce the change of Planck constant and therefore a liberation of metabolic energy stored in roughly the same manner as it is stored in battery. Now however the liberated energy is sum of electrostatic energy and difference of cyclotron energies replacing the difference of chemcical potentials in the case of ordinary battery. The quantitative model for the burning of water producing hydrogen peroxide and hydrogen (this process could provide a mechanism of storing solar energy by a mechanism analogous to photosynthesis) would also rely on this mechanism.

3.3.5 Burning water, photo synthesis, and water memory

The burning of water, photons synthesis and water memory are closely interrelated phenomena in TGD Universe. Recall first what was observed in the experiments carried out by the group led by Luc Montagnie.

1. What was done was filtration of human cells infected by bacteria in sterilization purpose to eliminate the infected cells. Human cells were added to the filtrate. Rather magically, the infection returned to the filtrate within few weeks. Something having size of order of nanoscale leaked through. It was also found that when the filtrate was diluted by water to produce an analog of homeopathic remedy, it produced at multiples of kHz if the dilution factor was in the range $10^{-7} - 10^{-12}$.

2. The second discovery was that if you have two bottles containing a solute of nanostructures such that for the first one dilution factor is small and for the second in the critical range so that it radiates at kHz frequencies. What was found that in the final situation neither radiates but only if the dilutions correspond to the same bacterial species! I proposed two interpretations. The first one was that the nanoscale systems in the highly diluted system are starving and gain metabolic energy by sending negative energy photons to the low dilution system and this makes them possible to replicate and achieve higher dilution after which the process stops.

3. One of the most fascinating possibilities suggested by the discovery is that the nanoscale structures identified as certain gene of the bacteria plus possibly something else (the magnetic body of gene in TGD context) might have been able to regenerate the bacteria themselves! This would require a non-chemical representation of genetic code and its translation to DNA

or RNA. For about year ago I indeed discovered a realization of genetic code in terms of dark nuclei with states of nucleons representing the code words [L2], [L2].

These findings allow a more detailed interpretation of the findings of the experiments of the group of Luc Montagnie.

1. The mysterious burning of water induced by radio waves in GHz range and interpreted in terms of a decomposition of water molecules to hydrogen peroxide and hydrogen: $2H_2 \rightarrow H_2O_2 + H_2$ is closely related to the splitting of water to hydrogen and oxygen occurs also in photosynthesis. The interpretation was that radio waves are resonantly transformed to dark photons with same frequency but with very large value of Planck constant and hence of energy followed by a transformation to ordinary IR photons with much higher frequency but same energy energy around.4 eV [K19, K38]. The finding that Raman scattering (non-elastic scattering of photons on molecules) around this energy occurs in the burning water supports this view. The natural guess is that also in the recent case something similar occurs.

2. This kind of frequency scaling is one of the basic mechanisms of water memory as I learned for the first time from the lecture of Cyril Smith in CASYS conference many years ago. One of the basic findings was that there is an unknown mechanism transforming low frequencies to high ones and vice versa. The low frequencies are scaled up by a factor which has a preferred value $r \simeq 2 \times 10^{11}$ interpreted in TGD framework as the ratio of the dark matter Planck constant to the ordinary one. I christened this correlation as a scaling law of homeopathy.

3. It is interesting to apply the law to kHz frequency. In this case the law would give frequency $f = 2 \times 10^{14} >$ Hz. The corresponding energy is.826 eV, which is essentially twice the energy quantum associated with burning water and thus has interpretation as a p-adically scaled up frequency (by one octave). Interestingly, Mae-Wan Ho states in [D22] that *"to use water as electron-donor, and hence to produce oxygen, requires the creation of the chlorophyll-a in cyanobacteria and green plants that can be boosted to a higher electrochemical potential of 0.82 V"* . Hence.83 eV is very near to a metabolically interesting energy.

4. This finding supports the view that kHz radiation produced by nano-structures corresponds to dark phase conjugate photons with energy equal to a metabolic energy quantum. The interpretation would be that the unidentified nanoscale systems in the highly diluted system are starving and get metabolic energy by sending negative energy quanta in the hope that there are metabolic energy reservoirs around able to absorb them. If bio-photons are Bose Einstein condensates of dark cyclotron photons at the flux tubes of magnetic body acting like population reversed lasers, they could serve as metabolic energy reservoir as suggested in on basis of the discovery described by Mae-Wan Ho in [D25].

5. A continual fight for metabolic resources is raging everywhere in Nature, presumably also at the monocellular level. It would not be surprising if harmful bacteria would try to steal the metabolic energy of other organisms stored (say) as bio-photons by sending phase conjugate light to the bio-photon resources of multicellular organisms. Nor it would be surprising if living organisms would have developed ways to prevent this. The fine tuning of the metabolic frequencies so that only the members of the same species can share the energy could guarantee this. Also password like protocols might have developed and either or both of them might be involved.

   In the two-bottle experiments the nanoscale systems in the highly diluted system would gain metabolic energy by sending negative energy photons received by the low dilution system. The gain of metabolic energy would make possible for the nanosystems to replicate and achieve higher dilution after which the process would stop as was indeed observed. That this took place only for the bacteria of same species supports the interpretation that frequency tuning or password mechanism was involved. This metabolic mechanism (quantum credit card as I have called it) could be a completely general mechanism energy sharing mechanism for cells of the same multicellular organism and perhaps even same species in TGD Universe.

4 A Model For The Effective Electronic Super-Conductivity In Axons

Also the following model for axonal electronic super-conductivity was constructed before the progress induced by the model of DNA as TQC and the inspiration coming from the model of nerve pulse by Danish researches [J12] and is not completely consistent with the new model. I however decided to keep the text because it reflects the development of ideas and with a reasonable amount of work could be modified to the new situation.

Hafedh Abdelmelek and collaborators [J10] have found evidence for effective super-conductivity in the sciatic nerves of both endotherms (rabbit) and poikilotherms (frog). The basic finding is that the resistance of the sciatic nerve is reduced by a factor of about ten below a critical temperature at the lower edge of the range of the physiological temperatures. The reduction of the temperature occurs inside a narrow temperature range ΔT, $\Delta T/T_c \sim .04$. This suggests effective super-conductivity. Furthermore, the critical temperature T_c for the breaking of the effective super-conductivity raises from 240 K to 300 K in the transition from poikilotherms (say frog) to endotherms (say rabbit).

These findings seem to be consistent with the following view.

1. Nerve pulse generation involves a mechanism inducing a flow of ions between axonal interior and exterior and induces at the same time the breaking of super-conductivity [K38] . At too low temperatures nerve pulses cannot be generated because the breaking of the super-conductivity is not possible. Therefore the critical temperature must be below the range of physiological temperatures and explains the difference between poikiloterms and endotherms.

2. In myelin sheathed regions the breaking of the effective super conductivity does not occur or the critical temperature is higher and the signal carried by the nerve pulse is transformed to an effective or genuine supra current. A small pulse like perturbation of the membrane potential could propagate still.

3. Poikilotherms can survive only if nerve pulse conduction is possible down to about 240 K which represents lower bound for the temperature of environment. Endotherms can keep the body temperature above 300 K and so that T_c can be as high as 300 K. This is good for survival purposes since high T_c minimizes ohmic losses related to nerve pulse conduction.

The recent model for nerve pulse generation favors somewhat different view. The melting temperatures T_m of the axon and microtubular surface and quantum critical temperature T_c of high T_c super-conductivity are the critical parameters. The generation of the nerve pulse is possible only if T is slightly above T_m. T_m can vary in a wide range and can be controlled genetically. Same could be true for T_c since external perturbations amplified by quantum criticality are expected to affect it. This would explain different values of T_c for poikilotherms and endotherms. The critical temperature for super-conductivity would pose only an upper bound for the temperatures at which organisms can survive whereas quantum criticality of various membranes would constrain this temperature to a narrow range.

4.1 Many-Sheeted Space-Time And Connection Between Thermal De-Broglie Wavelength And Size Of The Space-Time Sheet

The concept many-sheeted space-time is needed to understand super-conductivity and breaking of super-conductivity. Parallel space-time sheets with distance about 10^4 Planck lengths form a hierarchy. Each material object (..., atom, molecule, ..., cell, ...) corresponds to this kind of space-time sheet. The p-adic primes $p \simeq 2^k$, k prime or power of prime, characterize the size scales of the space-time sheets in the hierarchy. The p-adic length scale $L(k)$ can be expressed in terms of cell membrane thickness as

$$L(k) = 2^{(k-151)/2} \times L(151) \ , \tag{4.1}$$

where the p-adic length scale $L(151)$ and all p-adic length scales above electron length scale $L(127)$ were identified erratically in all writings about TGD before 2014. This deserves some comments.

1. The wrong identification was $L(151) \simeq 10$ nm implying wrong identification of other scales above $L(127)$ since I have calculated them by scaling $L(151)$ by an appropriate power of two. What I have denoted by $L(151)$ is actually obtained by scaling the Compton length $L_e(127) = \hbar/m_e$ by $2^{(151-127)/2}$ and therefore electrons Compton scale if it would correspond to $k = 151$. Since the mass of electron from p-adic mass calculations is given by $m_e = \sqrt{5+X}\hbar/L(127)$, the correct identification of $L(151)$ would be

$$L(151) = 2^{(151-127)/2}L(127) = 2^{(151-127)/2}L_e(151)/\sqrt{5+X} = 10/\sqrt{5+X}\ \ nm\ \ ,\ \ 0 \leq X \leq 1\ \ .$$

   Here X denotes the unknown second order contribution of form $X = n/M_{127}$, n integer, to the electron mass, and in the first approximation one can take $X = 0$ - the approximation is excellent unless n is very large. In the sequel I will try to use the shorthand $L_e(k) = \sqrt{5}L(k)$ but cannot guarantee that the subscript "e" is always present when needed: it is rather difficult to identify all places where the earlier erratic definition appears. I can only apologise for possible confusions.

2. This mistake has no fatal consequences for TGD inspired quantum biology. Its detection however provides a further support for the speculated central role of electron in living matter. Since the scales obtained by scaling the electron Compton scale seem to be important biologically (scaled up Comton scale $\sqrt{5}L(151)$ corresponds to cell membrane thickness), the conclusion is that electrons - or perhaps their Cooper pairs - play a fundamental role in living matter. The correct value of $L(151)$ is $L(151) = 4.5$ nm, which is slightly below the p-adic length scale $L_e(149) = 5$ nm assigned with the lipid layer of cell membrane.

3. I have also assigned to electron the time scale $T = .1$ seconds defining a fundamental biorhythm as a secondary p-adic time scale $T_2(127) = \sqrt{M_{127}}T(127)$. The correct assignment of $T = .1$ seconds is as the secondary Compton time $T_{2,e}(127) = \sqrt{M_{127}}T_e(127)$ of electron: secondary p-adic time scale is $T_2(127) = \sqrt{M_{127}}T(127)$ and corresponds to $T_{2,e}(127)/\sqrt{5} = .045$ seconds and to $f(127) = 22.4$ Hz.

These are so called primary p-adic length scales but there are also n-ary p-adic length scales related by a scaling of power of $\sqrt{p}$ to the primary p-adic length scale.

The characteristic temperature scale for particles of mass M in a thermal equilibrium at the space-time sheet characterized by $L(k)$ is given in terms of the zero point kinetic energy associated with the space-time sheet

$$T(k) \quad = \quad n \times E_0(k) = n \times n_1 \times \frac{\pi^2}{2ML^2(k)}\ \ , \tag{4.2}$$

where n and n_1 are numerical constants not far from unity (for convenience the units $k_B = 1$, $\hbar = 1$, $c = 1$ are used). $T(k)$ decreases very rapidly as a function of the p-adic length scale $L(k)$. This equation relates the p-adic prime of space-time sheet to T and M of particles present in the sheets forming join along boundaries condensate. Of course, the size L of space-time sheet characterized by k can vary in the range $[L(k), L(k_>]$ and $T \propto 1/L^2$ is an attractive guess for the dependence of the temperature on the size of the space-time sheet. One can interpret $T(k)$ as a critical temperature at which the p-adic prime characterizing the space-time sheet changes.

4.2 Magnetic Flux Tubes As Effective Super-Conductors And Breaking Of Super-Conductivity

The model for bio-superconductivity and its breaking relies on the following picture.

1. Magnetic flux tubes of Earth's magnetic field (in particular) characterized by $k = 169$ and having a minimal thickness about 5 μm correspond to tubular space-time sheets. The magnetic flux tubes of endogenous magnetic field $B = .2$ with $n = 5$ characterizing the value of the scaled up Planck constant $\hbar = n\hbar_0$ [K16] and the unit nh_0 of magnetic field magnetic

flux and $k = 169$ characterizing the p-adic length scale define second option consistent with the identification of 15 Hz as cyclotron frequency of Ca^{+2}. In this case the value of magnetic flux is $2h_5$ and the scaled down magnetic field $B_{end}/2$ required by the sleep time EEG would correspond to single flux quantum. Flux tubes would have thickness of about 25 μm corresponding to a size of a large neuron.

In the absence of both larger and smaller space-time sheets, the flux quanta can act as 1-D super-conductors since cyclotron energy scale, which by the quantization of the magnetic flux behaves also as $1/L^2(k)$, is larger than de Broglie temperature for sufficiently high values n of the magnetic flux (implying thicker flux tube). More generally, one can consider the possibility of a hierarchy of magnetic flux tubes inside magnetic flux tubes corresponding to the sequence $k = 167, 163, ...$ as especially interesting candidate since $k = 151, 157, 163, 167$ define Gaussian Mersennes $(1 + i)^k - 1$. Each of these flux tubes can be a super-conductor. Bio-super-conductivity is assumed to be due to this mechanism. Of course, only space-time sheets corresponding to only some of these p-adic length scales could be present and this would be crucial as far as super-conductivity and its breaking is considered. The study of the effects of external magnetic fields on the axonal conductivity might provide valuable information about the role of magnetic fields.

2. Super-conductivity can be broken by a temporal leakage of the Cooper pairs to larger space-time sheets if present. These Cooper pairs are kicked back by thermal photons. System is an effective super-conductor in the sense that Cooper pairs are not destroyed in the breaking of super-conductivity and an effective ohmic conductor in the sense that dissipation is present. Super-conductivity can be also broken by thermal kicking of the Cooper pairs to smaller space-time sheets. In this case there is however a restriction posed by the fact that the zero point kinetic energy of the particle increases from $E_0(k)$ to $E_0(k_<)$, where $k_<$ ($k_>$) is the largest (smallest) the prime smaller (larger) than k. Thermal energy is needed to achieve this. For the leakage to occur, one must have

$$T > nE_0(k) \quad = \quad T(k) \ . \tag{4.3}$$

Some numerical constant n is involved here. Note that the temperature at super-conducting space-time sheets is much lower than the critical temperature and the temperature at atomic space-time sheets.

3. The prediction is that the conductivity decreases in a stepwise manner at temperatures $T = T(k)$ as the temperature increases, and that the smallest value of k for current carrying space-time sheets gradually decreases as $k = 169 \to 167 \to 163 \to 157 \to 151 \to ....$ The behavior of the conductivity in the sciatic nerve seems to represent one particular step of this kind. The primes $k = 167, 163, 157, 151$ are expected to be especially important in living matter since they corresponds to the so called Gaussian Mersennes and p-adic length scales in the range 10 nm-2.56 μm [K9, K10].

4. For a space-time sheet having $k = k_0$, the leakage of supra-current is induced by the formation of flux tubes between $k = k_0$ space-time sheets and $k \geq k_0$ space-time sheets. The leakage to the smaller space-time sheets can be also induced by radiation with frequency corresponding to the increment of the zero point kinetic energy and the transversal electric field involved with radiation can be regarded as inducing the force driving the particles to smaller space-time sheets or back.

5. The strange findings indicating that DNA can behave like a super-conductor [I11], an ohmic conductor [I16], or an insulator could be perhaps understood in terms of the local architecture of the many-sheeted space-time. If only atomic space-time sheet is present, DNA would behave as insulator. If larger space-time sheets are present DNA behaves as an effective ohmic conductor in the sense that dissipative effects are present. If only single larger space-time sheet is present, super-conductivity is possible so that the manufacturing of super-conductors should reduce to space-time engineering.

4.3 Quantitative Model For The Breaking Of Super-Conductivity

The dropping (or leakage) of electronic Cooper pairs from $k = k_0$ (say $k_0 = 151$ corresponding to cell membrane thickness) space-time sheet to larger space-time sheets possibly present and followed by a thermal kicking back to $k = k_0$ space-time sheet is a good candidate for the mechanism causing the breaking of magnetic super-conductivity.

The conductivity as a function $\sigma(k)$ of the p-adic length scale $L(k)$ should characterize the mechanism quantitatively. If the thermal energy $E_{th} = T$ satisfies the condition

$$\begin{aligned} E_0(k) - E(k_>) < T < E_0(k_<) - E(k) \ , \\ E_0(k) = n_1 \times \frac{\pi^2}{4m_e L^2(k)} \ , \end{aligned} \tag{4.4}$$

one can say that the space-time sheet k is the effective carrier of the current.

The mechanism predicts that the increase of the temperature is accompanied by a sequence of phase transitions in which the value of k characterizing the effective carrier of the current decreases in a stepwise manner: $k = 169 \to 167 \to 163 \to 157 \to 151 \to ....$ These transitions occur at temperatures $T(k) = n \times E_0(k)$, n a numerical constant. This picture is consistent with the observation that the reduction of resistance occurs in a very short temperature interval ΔT: $\Delta T/T \sim .04$.

A more concrete picture is obtained by decomposing the friction force to a sum of forces resulting from dropping from say $k = 151$ to $k = 157163, 167, ...$ and being kicked back. This gives

$$\begin{aligned} F &= K(k)v \ , \\ K(k) &= \sum_{k_i > k} \kappa(k_i) = \kappa(k_>) + K(k_>) \ . \end{aligned} \tag{4.5}$$

The condition $F = qE$, $q = 2e$, gives for the conductivity defined by $j = nv = \sigma(k)E$, E electric field, the expression

$$\frac{1}{\sigma(k)} = \frac{K(k)}{nq} = \frac{\kappa(k_>)}{nq} + \frac{1}{\sigma(k_>)} \ . \tag{4.6}$$

What this means that the space-time sheets correspond effectively to resistors in series.

From the experimental findings for frog, for the transition from $k = 157$ to $k = 151$ the term $\kappa(157)$ must be by about a factor 10 larger than the sum of terms term $\kappa(k)$, $k > 157$. The fractal scaling

$$K(k) \propto \frac{1}{L^\alpha(k)} \propto 2^{-\alpha k/2} \tag{4.7}$$

with $\alpha \simeq 1.1$, suggests itself.

The standard classical model for the dissipative force implies that the force is inversely proportional to the free path $l(k)$ of the particle and by naïve scaling symmetry l would be naturally proportional to the p-adic length scale $l \propto L(k)$ giving $\alpha = 1$. $\alpha > 1$ for $K(k)$ means that the free path has a fractal dimension slightly larger than one. The anomalous dimension is due to the many-sheeted nature of the free paths implying the presence of the higher order terms in the expansion of $K(k)$. Indeed, in the lowest order the model based on the naïve scaling dimension -1 for $\kappa(k)$ predicts

$$\frac{\sigma(151)}{\sigma(157)} \simeq 1/8 - 1/64 \simeq .11 \tag{4.8}$$

in consistency with the measured reduction of the resistivity. Needless to say, this prediction provides a strong support for the p-adic length scale hypothesis and the notion of many-sheeted space-time.

4.4 Application At Axonal Level

It is interesting to apply the model for the breaking of super-conductivity in the case of axon.

4.4.1 Understanding the critical temperature

The model for the nerve pulse generation predicts that "bridges" are formed between $k = k_0 > 151$ (say $k_0 = 169$) and $k = 151$ space-time sheets making possible the flow of ions between cell interior and exterior. Super conductivity is broken provided that the temperature is sufficiently high. For electron Cooper pairs ($M = 2m_e$) the zero point kinetic energy at the cell membrane space-time sheet is from Eq. 4.4

$$E_0(k = 151) = n_1 \times 312.25 \text{ K} \ . \tag{4.9}$$

n_1 is some numerical constant not too far from unity. $n_1 = 1$ corresponds to a temperature 42.25 C. The identification as the critical temperature gives quite satisfactory agreement with the experimental values varying from 240 K to 300 K. Note that the requirement $T > T_{cr}$ for the physiological temperatures means that $k = 151$ cell membrane space-time sheet is the effective current carrier in the presence of larger space-time sheets.

If the flux tube connecting $k = 169$ and $k = 151$ space-time sheets contains a strong enough transversal electric field, the supra current can flow only in one direction. It seems that in the case of cell membrane the leakage of electronic Cooper pairs to the negatively charged cell interior is forbidden by this mechanism. The absence of the flux tubes between cell membrane and cell exterior assumed to be generated during the nerve pulse in the TGD based model of the nerve pulse [K38] in turn implies that the leakage cannot occur to or from $k = 169$ space-time sheets at all. Therefore both $k = 151$ and $k = 169$ space-time sheet might be genuinely super-conducting and only nerve pulse conduction would be accompanied by the breaking of super-conductivity.

4.4.2 Predictions for the critical temperature and resistance

Fractality allows to make definite quantitative predictions for the critical temperature.

1. For $k = 163$ conductivity the critical temperature is predicted to be by a factor $2^{157-151} = 64$ lower than for $k = 157$ conductivity. This gives $T_c(163) = 4.9$ K for $T_c(157) = 300$ K. The upper bound $T_c = 4$ K for the critical temperature for super-conductivity in molecular crystals is reported in [D28]. This would correspond to $T(157) = 240$ K measured in the case of frog. The predicted lowering of the resistance at this critical temperature for nerve conduction might be testable.

2. The observation that DNA attached between carbon and rhenium electrodes becomes super-conducting below the critical temperature of about 1 K for rhenium [I11] allows the possibility that DNA becomes super-conducting already at about $T_c(163) \simeq 4-5$ K but that the rhenium acts as the weak link in the super-conducting circuit.

3. Cell membrane thickness L might vary and the natural guess is that the critical temperature is inversely proportional to $1/L^2$. If this is the case, the ratio of cell membrane thicknesses for frog and rabbit should be

$$\frac{L(frog)}{L(rabbit)} = \sqrt{\frac{T(rabbit)}{T(frog)}} = \sqrt{5/4} = 1.12 \tag{4.10}$$

   for $T(rabbit) = 300$ K and $T(frog) = 240$ K.

4. A further prediction following from the fractal model for the conductance (Eq. 4.7) is that also the $k = 157 \to 163$ at about 4-5 K involves a 10-fold reduction of resistance. Also this prediction might be testable for nerves.

4.4.3 What happens in saltation?

An interesting question is what happens in the saltation over the myelin sheathed portions of the nerve. According to the TGD based model of nerve [K37] [K38], the ME ("massless extremal", "topological light ray" moving with effective velocity equal to the conduction velocity of nerve pulse acts as a bridge between cell membrane ($k = 151$) and cell exterior ($k = 169$) space-time sheets and in this manner allows the leakage of ions from cell interior to exterior and vice versa inducing the physiological effects of nerve pulse. ME could propagate along the myelin sheath rather than along the axon inside. Therefore nerve pulse would not be generated. The following picture about saltation suggests itself.

1. The transformation of the nerve pulse to an electronic $k = 151$ or $k = 169$ supra current propagating rapidly through the myelin sheathed portion would make possible a rapid signal transmission without physiological effects. Inside myelin sheathed portions of the axon the leakage to $k = 169$ space-time sheets would be impossible by the mechanism described above irrespective of the value of the critical temperature.

2. Nerve pulse conduction involves also communication and interaction between different space-time sheets and therefore necessitates the leakage of electronic Cooper pairs from $k = 151$ cell membrane space-time sheet. Therefore the critical temperature must be below the range of the physiological temperatures. Endotherms have an evolutionary advantage since the higher critical temperature implies that the dissipative effects associated with the nerve pulse conduction are weaker.

   Whether electronic supra current in the myelin sheathed portions of the axon propagates along $k = 151$ or $k = 169$ space-time sheet or along both plus possibly along some other space-time sheets, remains unclear. Note that the critical temperature in myelin sheathed regions could be higher than the physiological temperature. The endogenous magnetic field $B = .2$ Gauss suggested by the work of Blackman and others corresponds to a flux tube radius $L = sqrt5/2 \times L_e(169) \simeq 1.58L_e(169) = 17.7L(169) \sim L(177) = 2^(5)L(127)$.

It is interesting to notice that Evan Harris [J9] [J9] has developed a quantitative theory in which the tunnelling of electrons through the synaptic contact is the basic step of synaptic transfer. The theory applies also to ephapses in which electric transfer of the nerve pulse takes place. Theory explains the differences between ephapses and synapses and also the morphology of synapses and ephapses finds natural explanation. This kind of tunnelling might be induced by the formation of 151-169 ME contacts at presynaptic cell and 169-151 ME contacts at the postsynaptic cell.

5 Quantum Model For The Direct Currents Of Becker

Robert Becker [J7] proposed on basis of his experimental work that living matter behaves as a semiconductor in a wide range of length scales ranging from brain scale to the scale of entire body. Direct currents flowing only in preferred direction would be essential for the functioning of living manner in this framework.

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

TGD inspired model for nerve pulse assumes that ionic currents through the cell membrane are quantal currents. If they are Josephson currents, the situation is automatically stationary and dissipation is small as various anomalies suggest. One can criticize this assumption since the Compton length of ions for the ordinary value of Planck constant is so small that magnetic flux tubes carrying the current through the membrane look rather long in this length scale. Therefore either Planck constant should be rather large or one should have a non-ohmic quantum counterpart of a direct current in the case of ions and perhaps also protons in the case of neuronal membrane: electronic and perhaps also protonic currents could be still Josephson currents. This would conform with the low dissipation rate.

In the following the results related to laser induced healing, acupuncture, and DC currents are discussed first. The obvious question is whether these direct currents are actually supracurrents

and whether they could be universal in living matter. A TGD inspired model for quantal direct currents is proposed and its possible implications for the model of nerve pulse are discussed.

Whether the model for quantum direct currents is consistent with the proposed vacuum extremal property of the cell membrane remains an open question but both options explain the special role of Ca^{++} currents and current of Na^{+} Cooper pairs in the generation of nerve pulse as in would take place in TGD Universe. In fact, it is not clear what one exactly means with the vacuum extremal property of cell membrane. Many-sheeted space-time (see **Fig.** `http://tgdtheory.fi/appfigures/manysheeted.jpg` or **Fig.** 9 in the appendix of this book) allows to consider space-time sheets which can be both almost vacuum extremals and far from vacuum extremals. Also space-time sheets for which Planck constant is so large that both electronic and protonic Josephson currents become possible. Various pumps and channels could actually correspond to magnetic flux tubes along which various ionic supra currents or even Josephson currents can flow. The condition that both electronic and protonic supra currents are possible in same length scale leads to the hierarchy of Planck constants coming approximately as powers of $m_p/m_e \simeq 2^{11}$ proposed originally as a general truth. Radiation at Josephson frequency serves as a signature for Josephson currents.

In the following a TGD inspired quantum model for the direct currents of Becker as direct quantum currents is developed and shown to be consistent with what is known about nerve pulse generation.

5.1 Connection Between Laser Induced Healing, Acupuncture, And Association Of DC Currents With The Healing Of Wounds

The findings of Robert Becker (the book "The Body Electric: Electromagnetism and the Foundation of Life" by Becker and Selden, which can be found from web (see `http://tinyurl.com/y8rbgebw`) [J7], meant a breakthrough in the development of bioelectromagnetics. One aspect of bioelectromagnetic phenomena was the discovery of Becker that DC currents and voltages play a pivotal role in various regeneration processes. Why this is the case is still poorly understood and Becker's book is a treasure trove for anyone ready to challenge existing dogmas. The general vision guiding Becker can be summarized by a citation from the introduction of the book.

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

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

5.1.1 Observations relating to CNS

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

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

and these fields are probably closely related by the many-sheeted variants of Gauss's and Faraday's laws implying that voltages along two different space-time sheets in contact at two points are the same in a static situation.

2. A longitudinal potential along front to back in the brain with the frontal lobes in negative potential with respect to occipital lobes and with a magnitude of few mV was discovered. The strength of the electric field correlates with the level of consciousness. As the potential becomes weaker and changes sign, consciousness is lost. Libet and Gerard observed traveling waves of potentials across the cortical layers (with speeds of about 6 m/s: TGD inspired model of nerve pulse predicts this kind of waves [K37]). Propagating potentials were also discovered in glial cells. The interpretation was in terms of electrical currents.

3. It was found that brain injury generated positive polarization so that the neurons ceased to function in an area much larger than the area of injury. Negative shifts of neuronal potentials were associated with incoming sensory stimuli and motor activity whereas sleep was associated with a positive shift. Very small voltages and currents could modulate the firing of neurons without affecting the resting potential. The "generating" potentials in sensory receptors inducing nerve pulse were found to be graded and non-propagating and the sign of the generating potential correlated with sensory input (say increase/reduction of pressure). Standard wisdom about cell membrane has difficulties in explaining these findings.

4. The natural hypothesis was that these electric fields are accompanied by DC currents. There are several experimental demonstrations for this. For instance, the deflection of assumed DC currents by an external magnetic field (Hall effect) was shown to lead to a loss of consciousness.

5.1.2 Observations relating to regeneration

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

1. An interesting series of experiments on Planaria, a species of simple flatworm with a primitive nervous system and simple head-to-tail axis of organization, was carried out. Electrical measurements indicated a simple head-tail dipole field. The animal had remarkable regenerative powers; it could be cut transversely into a number of segments, all of which would regenerate a new total organism. The original head-tail axis was preserved in each regenerate, with that portion nearest the original head end becoming the head of the new organism. The hypothesis was that the original head-tail electrical vector persisted in the cut segments and provided the morphological information for the regenerate. The prediction was that the reversal of the electrical gradient by exposing the cut surface to an external current source of proper orientation should produce some reversal of the head-tail gradient in the regenerate. While performing the experiment it was found found that as the current levels were increased the first response was to form a head at each end of the regenerating segment. With still further increases in the current the expected reversal of the head-tail gradient did occur, indicating that the electrical gradient which naturally existed in these animals was capable of transmitting morphological information.

2. Tissue regeneration occurs only if some minimum amount of neural tissue is present suggesting that CNS plays a role in the process although the usual neural activity is absent. The repeated needling of the stump had positive effect on regeneration and the DC current was found to be proportional to innervation. Hence needling seems to stimulate innervation or at least inducing formation of DC currents. Something like this might occur also in the case of acupuncture.

3. Regeneration involves de-differentiation of cells to form a blastema from which the regenerated tissue is formed. Quite early it was learned that carcinogens induce de-differentiation of cells because of their steric properties and by making electron transfer possible and that denervation induces tumor formation. From these findings Becker concluded that the formation of blastema could be a relatively simple process analogous to tumor growth whereas the regeneration proper is a complex self-organization process during which the control by signals from CNS are necessary and possibly realized in terms of potential waves.

4. Regeneration is possible in salamanders but not in frogs. This motivated Becker and collaborators to compare these situations. In an amputated leg of both salamander and frog the original negative potential of approximately -1 mV was raised first to a positive value of about +10 mV. In the frog it returned smoothly to its original value without regeneration. In the salamander it returned over a period of three days to the original base line and then went to a much higher negative value around -20 mV (resting potential is around -70 mV) followed by a return to the original value once regeneration had occurred. Thus the large negative potential is necessary for the regeneration and responsible for the formation of blastema. Furthermore, artificial electron current also induced regeneration also in the case of the frog, even in the denervated situation. Thus the flow of electrons to the stump seems to be necessary for the formation of blastema and the difference between salamander and frog is that frog is not able to provide the needed electronic current although positive potential is present.

5. It was also learned that a so called neuroepidermal junction (NEJ) formed in the healing process of salamander stump was responsible for the regeneration in the presence of denervation. The conclusion was that the DC voltage and electronic current relevant for regeneration could be assigned the interface between CNS and tissue rather than to the entire nerve and the regeneration seemed to be a local process, perhaps a feed of metabolic energy driving self-organization. Furthermore, NEJ seemed to make possible the flow of electrons from CNS to the stump.

6. The red blood cells of animals other than mammals are complete and thus possess nuclei. Becker and collaborators observed that red blood cells also dedifferentiated to form blastemas. Being normally in a quiescent state, they are ideal for studying de-differentiation. It was found that the electric current acted as a trigger at the level of cell membrane inducing de-differentiation reflected as an increased amount of mRNA serving as marker of gene expression. Also pulsed magnetic field was found to trigger the de-differentiation, perhaps via induced electric field. By the way, the role of the cell membrane fits nicely with the TGD inspired view about DNA-cell membrane system as topological quantum computer with magnetic flux tubes that are assumed to connect DNA and cell membrane and serve as braid strands in TGD inspired model of DNA as topological quantum computer [K1].

7. The experiments of Becker and collaborators support the identification of the charge carriers of DC currents responsible for the formation of the stump's large negative potential as electrons. The test was based on the different temperature dependence of electronic and protonic conductivities. Electronic conductivity increases with temperature and protonic conductivity decreases and an increase was observed.

5.1.3 Gene activation by electrostatic fields?

The basic question concerns the method of activation. The discovery of chemists Guido Ebner and Guido Schuerch [J3] raises the hope that these ideas might be more than over-active imagination and their work also provides a concrete proposal for the activation mechanism. Ebner and Schuerch studied the effect of electrostatic fields on the growth and morphogenesis of various organisms. Germ, seeds, or eggs were placed between conducting plates creating an electric field in the range.5-2 kV/m: note that the Earth's electric field is in the range $.1 - 4$ kV/m and of the same order of magnitude.

The outcome was rather surprising and in the year 1989 their employer Ciba Geigy (now Novartis) applied for a patent "Method of enhanced fish breeding" [J3] for what is called Ciba

Geigy effect. The researchers describe how fishes (trouts) develop and grow much better, if their eggs have been conditioned in an electrostatic field. The researchers also reporedt [J3] that the morphology of the fishes was altered to what seems to represent an ancient evolutionary form: this was not mentioned in the patent.

The chemists founded their own Institute of Pharmaceutical Research near Basel, where Guido Ebner applied for another very detailed patent, which was never granted. In the patent he describes the effect of electrostatic fields on several life forms (cress, wheat, corn, fern, micro-organisms, bacteria) in their early stage of development. A clear change in the morphogenesis was observed. For instance, in one example fern had all sort of leaves in single plant apparently providing a series of snapshots about the evolution of the plant. The evolutionary age of the first leaf appeared to be about 300 million years whereas the last grown-up leaf looked close to its recent form.

If one takes these finding seriously, one must consider the possibility that the exposure to an electrostatic field can activate passive genes and change the gene expression so that older morphologies are expressed. The activation of not yet existing morphologies is probably more difficult since strong consistency conditions must be satisfied (activation of program requires activation of a proper hardware). This would suggest that genome is a kind of archive also containing also older genomes even potential genomes or that topological quantum computer programs [K1] determine the morphology to a certain extent and that external conditions such as electric fields determine the self-organization patterns characterizing these programs.

It is known that the developing embryo has an electric field along the head-tail axis and that this field plays an important role in the control of growth. These fields are much weaker than the fields used in the experiment. p-Adic length scale hierarchy however predicts an entire hierarchy of electric fields and living matter is indeed known to be full of electret structures. The strength of the electric field in some p-adic length scale related to DNA might somehow serve as the selector of the evolutionary age. The recapitulation of phylogeny during ontogeny could mean a gradual shift of the activated part of both genome and "memone" (as as menetic analog of genome: for a proposal of memetic code see [K18]), perhaps assignable to topological quantum computer programs realized as braidings, and be controlled by the gradually evolving electric field strength.

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

5.1.4 A TGD based model for the situation

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

The first series questions, observations, and ideas relates to the connection of DC currents with metabolism and ordinary biochemistry. The hierarchy of Planck constant is expected to be involved somehow.

1. How the DC currents relate to metabolism and ordinary biochemistry? For what purpose they are needed? The crucial point is that the energy of order 1 meV gained by electron in the electric field is much below the metabolic energy quantum and also thermal energy so that the interpretation in terms of metabolic energy quantum does not look promising. This forces to consider the possibility that the basic role of electric field is to drive electrons to where they are needed, say wounded part of tissue in positive potential and thus attrracting electrons. Electrons are indeed needed by the electron transport cycle appearing in both photosynthesis and cell respiration since the transport cycle induces leakage of electrons due to the formation of ROS (reactive oxygen species) such as O_2^-. The purpose of electronic Becker currents would be therefore the re-establishment of metabolism.

   The change of the sign of the Becker potential to positive induce a loss of electrons and reduced metabolism. This could explain why consciousness is lost when the sign of Becker

potential is changed or electrons are deviated by Hall effect. Wound damages the connections of the tissue to the organism and the transfer of electrons compensating for leaked electrons is prevented since Becker potential changes sign. The regeneration induced by an artificial Becker potential of correct sign would induce healing by re-establishing the electron feed.

The crucial question concerns the role of electrons. It seems that in all situations electron flow to the damaged tissue induces healing. Why electrons generating negative potential should help in healing? The first input is TGD model [K32] [L10] for the findings of Pollack [L10] involves the connection of dark matter hierarchy $h_{eff} = n \times h$ with negentropic entanglement characterized by density matrix reducing to $n \times n$ unit matrix for entanglement matrix proportional to a unitary matrix. In infinite-dimensional case the divisor is infinite unless one uses von Neumann's hyperfinite factor of type II_1 for which the normalization factor can be taken to be unity: in the case of quantum groups this corresponds to using quantum trace instead of the ordinary one. A further input is the observation that the gravitational Planck constant h_{gr} explaining planetary Bohr quantization rules can be equal to h_{eff} in living matter for microscopic systems like elementary particles, atoms, and ions, even molecules [K40, K35].

1. Pollack's findings about fourth phase of water formed when external energy feed induces formation of negatively charged exclusion zones of water obeying stoichiometry $H_{1.5}O$ with 1/4: th of protons going to the complement of exclusion zone. Something similar might happen also now.

2. In TGD framework this process is explained as a formation dark phase of protons at the magnetic flux tubes associated with the exclusion zone with dark protons realizing genetic code so that one obtains what might be regarded as primitive primordial life form.

3. There is evidence for a huge anomalous gravimagnetic Thomson field in rotating super conductors. Thomson field is proportional to square of Planck constant h_{eff} and TGD explanation is that large h_{gr} phase is formed at gravitational flux tubes. The assumption $h_{gr} = h_{eff}$ in elementary particle and atomic scales is possible and is consistent with the hypothesis that bio-photons in visible and UV energy range correspond to decay products of dark EEG photons.

4. $\hbar_{gr}$ can be generalized to $\hbar_{em} = -Z_1 Z_2 e^2/v_0$: v_0 would be typical rotational velocity in a system with opposite charges Z_1 and Z_2. Exclusion zone would be good example. For ATP v_0 would be rotational velocity of ATP. For exclusion zone v_0 could be rotational velocity of Cooper pairs in magnetic field associated with flux tubes or walls or rotational velocity of magnetic body. $Z_2 = -Z_1$ is natural assumption by charge neutrality.

5. In this framework the feed of electrons would increase the value of h_{eff} by increasing the negative charge associated with the analog of exclusion zone accompanying the wound and induce also a flow of dark protons to the magnetic flux tubes associated with the magnetic body of the analog of exclusion zone.

6. The DC currents would be needed because the damage of the tissue means that the $\hbar_{eff} = \hbar_{em} = Z^2 e^2/v_0$ is reduced for a pair formed by damaged system and its complement. Healing would be essentially attempt to increase h_{eff} to its original value. The parameter Z^2 is reduced and must be increased to its original value and perhaps even to a higher value since the larger ger the value of h_{eff} is, the richer the negentropic resources of system are. The transfer of electrons to the system analogous to exclusion zone induces transfer of dark protons to the magnetic flux quanta of the magnetic body of the system. Recall that dark proton strings at flux tubes could be analogs of dark nuclei and that the model for dark nucleons allows to identify nucleon states as counterparts of DNA, RNA, amino-acids and even tRNA. This leads to a model of prebiotic lifeforms [K19].

7. ATP synthase transforming ADP to ATP involves rotating shaft and one can ask whether the velocity parameter v_0 appearing in the expression for $\hbar_{em}$ equals to the rotation speed of the shaft. This predicts that the value of $\hbar_{em}$ to be same order as $\hbar_{eff}$ and $\hbar_{gr}$ for Earth-electron system assuming that v_0 corresponds to the rotation velocity at the surface of Earth. The

assumption $h_{eff} = h_{gr} = h_{em}$ makes it possible for the gravitational and em flux tubes to reconnect.

8. The original guess was that electrons to provide energy giving rise to the formation of ATP in cell respiration and photosynthesis. Electrons themselves receive their energy either from the oxidation of molecules or from solar photons. This model is consistent with the model above since electron transport chain is crucial for cell transpiration and needs both electrons and dark protons located at the dark flux tubes associated with the exclusion zones. Dark protons would flow through the ATP synthase attached to mitochodrial membrane and liberate dark cyclotron energy if the value of the magnetic fields associated with the flux tube is different for the interior and exterior portions of the flux tube [K14, K31].

The experimental support for the role of bio-photons in living matter is accumulating and a natural question concerns their role in metabolism. In TGD framework dark photons with large value of $\hbar_{eff}$ with energy of visible photon can transform to ordinary photons of same energy with some - presumably rather small - probability, and would be interpreted as bio-photons. Could dark photons take the role of solar photons and provide in some situations energy to the electrons in the electron transport cycle? This would mean a non-conventional non-local mechanism of metabolism. The effects of laser light on tissue suggest that laser light indeed takes the role of solar light and feed energy to the electron transport cycle transforming it to the energy of high energy phosphate bond of ATP. A more detailed TGD inspired view about what might happen is discussed in [K21].

One can consider also the possibility that quantum credit card mechanism (remote metabolism) could be at work in some the situations when chemical metabolic energy sources are absent. Damaged tissue might define this kind of exceptional situation. This brings in mind the strange ability of plants suffering under-nutrition to attract insects responsible for their pollination observed by Callahan, who has also reported that plants and insects communicate using infrared light which according to his findings serves as a sensor input in insect olfaction [I3]: also in this case quantum credit card mechanism building magnetic flux tube bridges guiding the insects to the plant might be at work. The electrons which have gained 1 meV energy during travel along pairs formed by MEs and parallel magnetic flux tubes (meridians), could send negative energy dark photons with energy of order -.5 eV to gain same positive energy allowing to get over the semiconductor junction after they have arrived to the damaged tissue. These negative energy photons would be absorbed by a metabolic energy store (ATP in mitochondria transforming to ADP) in the healthy part of the organism.

$h_{eff} = h_{em}$ implies that the spectrum of bio-photons originating from dark cyclotron photons is universal having no dependence on ion mass and in visible and UV range, which is also the range for molecular excitation energies. Dark cyclotron photons decaying to bio-photons would therefore allow magnetic body to control biochemistry by resonant absorption inducing transitions of molecules.

The original model for the charging of the metabolic batteries and for effective semi-conductor junction assumed that the electrons of supra current are transferred to smaller space-time sheets.

1. For ground state electrons this requires energy which is at least the difference of zero point kinetic energies of electron at the two space-time sheets. This energy should be of the order of fundamental metabolic energy quantum of about.5 eV.

   For Cooper pairs of electrons the sheet should correspond to p-adic length scale of order $L_e(k_e = 149) = 10$ nm, the thickness of lipid layer of cell membrane. For single proton corresponding scale would be $L_e(k_p = 139) \simeq 2^{-12} L_e(151)$ from $m_p/2m_e \simeq 2^{10}$ and $E_{0,p}/E_{0,2e} = (2m_e/m_p) \times (L_e(k_e)/L_e(k_p))^2 = (2m_e/m_p) \times 2^{k_e - k_p} \sim 1$.

   This suggests that electron Cooper pair is kicked to a smaller space-time sheet assignable to a mitochondrial lipid layer having $k_e = 149$. The larger space-time sheet could be that of cell membrane with $k = 151$. For protons the zero point kinetic energies at these space-time sheets are by a factor $2m_e/m_p$ lower and of the order of .5 meV. This happens to be of the same order of magnitude as the energy gained by proton or electron in the Becker potential. May be this is not an accident.

   There is also a second intriguing quantitative co-incidence. In the absence of an action potential, acetylcholine vesicles spontaneously leak into the synaptic junction and cause very

small de-polarizations in the postsynaptic membrane known as miniature end plate potentials (see `http://tinyurl.com/y98zhxzh`) (mEPSP) of magnitude .5 mV. These potentials are too small to generate action potential but together they can sum up to the needed action potential. Maybe the interpretation in terms of proton kicked to lipid layer space-time sheet might make sense.

2. The re-charging mechanism should relate directly to ADP→ ATP process occurring during electronic transport cycle in mitochondrial membrane. The connection with metabolism forces to ask how the formation of high energy phosphate bond in the addition of phosphate to ADP relates to the transfer of electrons to smaller space-time sheet. Somehow the energy of electrons must go to the formation of this bond: perhaps the dropping of electron back to larger space-time sheet transfers the energy to the high energy phosphate bond.

   In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

3. The transfer of particles between space-time sheets with different p-adic length scales is not the only one that one can consider, and recently a more elegant mechanism has emerged [K21]. If the particles are free, a phase transition in which the p-adic prime of the space-time sheet containing particles decreases adiabatically increases the scale of kinetic energy but leaves particle quantum numbers unchanged. If the same happens for charge particles at magnetic flux tubes, similar increase of cyclotron energy scale takes place since magnetic field strength increase to conserve magnetic flux. The predictions are in good approximation the same as for the original model. If the phase transition reducing p-adic length scale is accompanied by a compensating increase of Planck constant, the size scale of space-time sheet remains unaffected but metabolic batteries are loaded. The reversal of this phase transition liberates metabolic energy. What is important that metabolic energy and negentropic entanglement (measured in terms of the value of Planck constant) are closely correlated for this mechanism. The loading/liberation of energy is also a quantum coherent process.

4. Acupuncture and the application of DC current are known to induce the generation of endorphins. Do endorphins contribute to well-being by reducing the pain? In TGD framework the deeper level interpretation of metabolism is as a provider of negentropic entanglement in turn giving rise to well-being. Are endorphins kind of negentropy packets or just conscious signals about the improved situation?

Second series of questions, observations, and ideas relates to the meridians, acu points, and "chi".

1. A permanent potential difference of same sign between head and tail could mean an accumulation of positive and negative charges to the ends of the of the system if only electron currents are present. If both electron and proton currents with opposite directions are present, there is no accumulation of charge but there is an accumulation of protons and electrons. Probably there exists a pumping mechanism forcing the electrons (and possibly also protons) to move against the potential gradient from the tail back to the head. This however requires metabolic energy and the simplest source of this energy would be just the energy of electrons otherwise used to generate ATP. If so, the leakage would not be an unavoidable dissipative effect but a way to avoid charge accumulation.

   If the pumping mechanism is not at work, this situation cannot continue for ever and the sign of the potential difference must eventually change and induce loss of consciousness. The simplest possibility is that the potential difference changes sign rhythmically. A natural question is whether the sleep-awake rhythm is unavoidable and corresponds to the oscillatory behavior of the head-to-tail voltage.

"Chi" would correspond electrons or their Cooper pairs in this picture. Abnormal chi flow (reduced flow, flow in wrong direction, accumulation of chi) would cause various problems including also insomnia in which too much electron charge tends to accumulate.

3. What is the nature of acupuncture meridians, what kind of currents flow along them, and why are they not directly observed? The most natural identification in TGD Universe would be in terms of magnetic flux tubes accompanied by parallel massless extremals (MEs) making possible also the propagation of dark photons used for control purposes and perhaps even in metabolism as already discussed. Dark currents along pairs of MEs and magnetic flux tubes are ideal for the transfoer of particles and energy.

   If the length of the superconducting "wire" is long in the scale defined by the appropriate quantum scale proportional to $\hbar$, the classical picture makes sense and charge carriers can be said to accelerate and gain energy ZeV. For large values of $\hbar_{eff}$ an oscillating Josephson current would be in question. Since Becker currents are associated with CNS, it would be natural to associate the meridians with neural pathways although this assignment is not necessary. Magnetic flux tube system defined kind of magnetic circulation which could serve as a template for the neural pathways. The transfer of energy with minimal dissipation would explain why a semiconductor like property is needed and why acupuncture points have a high conductivity value.

4. What about acu-points? Acu points are known to be in negative potential normally. This suggests that the density of electrons or their Cooper pairs at them is higher than elsewhere in the meridian. Could they server as kind of electron stores providing electrons to their environment to compensate for losses caused by ROS. This would make possible higher metabolic activity in presence of nutrient molecules since the rate for the electron transform cycle should be proportional to the density of energizable electrons, "chi".

   When the potential of the acu-point is reduced or become positive, under-nutrition follows. This should relate to various symptoms like pain at acupuncture points. Acupuncture needle as an electronic conductor would develop a charge distribution with a concentration of electrons to the acu-point, and would re-establish the metabolic activity. Pain would be signature of lack of negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) and positive/negative coloring of emotions and sensations would quite generally correlate with the amount of negentropic entanglement.

5. Nanna Goldman *et al* have provided empirical evidence (see `http://tinyurl.com/4to42pc`) [I10] for the expectation that the healing effect of the acupuncture involves metabolism (see the popular article in Sciencedaily (see `http://tinyurl.com/3734uub`) [I4]).

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

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

How can understand the semiconducting character of Becker's DC currents?

1. Becker assigns to the system involved with DC currents an effective semiconductor property. Could the effective semiconductor property be due the fact that the transfer of charge carriers to a smaller space-time sheet by first accelerating them in electric field is analogous to the transfer of electrons between conduction bands in semiconductor junction? If so, semiconductor property would be a direct signature of the realization of the metabolic energy quanta as zero point kinetic energies. For metabolic energy quantum of order .5 eV this however makes sense only if the electrons transferred to the smaller space-time sheet have energy slightly below the minimum energy for the transfer to the smaller space-time sheet in absence of the Becker potential. The situation would be critical and 1 mV voltage could serve as a kind of control knob.

   One can imagine the analog of this mechanism also when the external energy feed corresponds to a phase transition reducing p-adic length scale and increasing Planck constant so that the size of the space-time sheet remains unaffected. Again 1 mV voltage would have the role of control knob.

2. Supra currents flowing along magnetic flux tubes would make possible dissipation-free loading of metabolic energy batteries. This even when oscillating Josephson currents are in question since the transformation to ohmic currents in semiconductor junction makes possible energy transfer only during second half of oscillation period. Could this be a universal mechanism applying to various stages of the regeneration process? In quantal situation the metabolic energy quanta have very precise values as indeed required.

3. The findings of Becker provide support for electronic DC currents. The Cooper pairs of electrons are indeed the best candidates for the carriers of supra current by their small mass. In the minimal situation the currents defined by leaked electrons moving against potential gradient (utilising the energy used otherwise to generate ATP) could compensate the Becker currents and give rise to closed current loops without charge accumulation. If the electronic DC currents observed by Becker are much stronger than needed to compensate for the local electron leakage, a larger metabolically driven return current is needed to guarantee local charge neutrality. These currents seem to be assignable to CNS: maybe the two electron currents could be associated with sensory and motor pathways. An interesting question whether sympathetic-parasympathetic dichotomy also relates to electron currents in opposite directions.

4. Could also dark protonic and even ionic DC currents be present and running along their own flux tubes and perhaps defining cyclotron Bose-Einstein condensates? How large the scale of flux tubes can be: could it be much larger than that of biological body (by simple argument magnetic body should have layers with even size scale of Earth). What is the possible connection with cell respiration? When single ATP is generated, three protons are are pumped through the mitochondrial membrane utilising the energy liberated in electron transport cycle. This does not however require protonic currents in longer scales.

5. In regeneration process NEJs are formed. They could consist of pairs of MEs and magnetic flux tube mediating the electronic DC current during blastema generation and regeneration proper during which also control signals from CNS would be present. Since NEJs seems to resemble cell membranes in some respects, the ideas inspired by the model of cell membrane and DNA as TQC can be used. The model for nerve pulse and the model for DNA as topological quantum computer suggest that dark ionic currents flowing along magnetic flux tubes characterised by a large value of the effective Planck constant are involved with both meridians and NEJs. Magnetic flux tubes can act as DC current wires or Josephson junctions generating oscillatory supra currents of ions and electrons. Also for large values of the effective Planck constant meridians look short in the relevant dark length scale and could act as Josephson junctions carrying oscillatory Josephson currents.

One can raise also questions about the relationship between DC currents and de-differentiation.

1. Could cell de-differentiation be caused by the presence of Becker's DC current? Also acupuncture is known to induce de-differentiation. Could the mere ability to charge metabolic energy

batteries provided by electron feed induce de-differentiation, which manifests as an increased genetic expression? Can one see differentiation as an eliminative process forced by the reduction of the electron feed and inducing a selective reduction of gene expression? If this were the case, de-differentiation could be induced by a feed of surplus electrons to the system using either external electron current or additional electric field. Local electron density would correlate negatively with the degree of differentiation.

2. In this framework it might be possible to understand the claimed effects of external electric fields on the development of plants and fishes. In this case rejuvenation means return to the earlier evolutionary stages. Maybe ontogeny-recapitulates-phylogeny principle might allow to understand this if genome in some sense contains archive about earlier stages of evolution. This archive might be virtual and realised by an epigenetic mechanism selecting different patterns of gene expression using the same genome.

   If this is the case, the density of electrons or their Cooper pairs - "chi" - possessed by the cell would serve as a measure for the biological age of the cell and the meridian system feeding "chi" would serve as a rejuvenating agent with respect to gene expression. The average density of dark electrons would serve as a measure for the age of cell: the larger the density the higher the metabolic activity and the lower the biological age.

5.2 Quantum Model For Effective Semiconductor Property

Becker [J7] summarizes his findings by stating that living matter is an effective semiconductor. There are pairs of structures in positive and negative potential in various scales and the current between the plates of this effective capacitor flows when above some minimum potential difference. The current flows from positive to negative pole and could be an electron current. Also proton current in the opposite direction can be considered but the electron current is experimentally favored. For instance consciousness is lost when a magnetic field is used to deflect the current.

In TGD framework natural carriers of these currents would be magnetic flux tubes also carrying electric fields. A very simple deformation of the embedding of a constant longitudinal magnetic field also gives longitudinal electric field. With a slight generalization one obtains helical electric and magnetic fields. A crucial difference is that these currents would be quantal rather than ohmic currents even in the length scale of the biological body and even longer scales assignable to the magnetic body.

The following argument allows us to understand the physical situation.

1. A precise everyday analogy is vertical motion in the gravitational field of the Earth between surface and some target at given height h. If the kinetic energy is high enough, the particle reaches the target. If not, the particle falls back. In the quantum case one expects that the latter situation corresponds to a very small probability amplitude at the target (tunnelling to classically forbidden kinematic region).

2. Now the electric field replaces the gravitational field. Suppose that the classical electric force experienced by the particle is towards the capacitor plate taking the role of the surface of Earth. Below critical field strength the charged particle cannot reach the target classically and quantum mechanically this occurs only by tunnelling with vanishingly small probability.

3. Particles with opposite value of charge experience a force which accelerates them and classically they certainly reach the second plate. What happens in a quantum situation? It seems that this situation is essentially identical with the first one: one has linear potential in finite interval and wave functions are localized in this range. One can equivalently regard these states as localized near the second capacitor plate.

4. A good analogy is provided by atoms: classically the electron would end down at the nucleus but quantization prevents this. One can imagine also now stationary solutions for which the electric currents for individual charges vanish at the plates although classically there would be a current in another direction. Also quantum mechanically non-vanishing conserved current is possible: all depends on boundary conditions.

5.2.1 Basic model

Consider now the situation at more quantitative level.

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

$$i\partial_t \Psi_k \quad = \quad (-\frac{\hbar^2}{2m_k}\partial_z^2 + q_k E z)\Psi_k \quad . \tag{5.1}$$

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

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

$$\sigma \quad = \quad E = \sum \sigma_i = \sum_i q_i \overline{\Psi}_i \Psi_i \quad . \tag{5.2}$$

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

$$E_{tot} \quad = \quad E + E_0 \quad . \tag{5.3}$$

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

3. The electric currents are given by

$$j_k \quad = \quad \frac{i\hbar q_k}{2m_k}\overline{\Psi}_k \partial_z^{\leftrightarrow} \Psi_k \quad . \tag{5.4}$$

   In stationary situation the net current must vanish:

$$\sum_k j_k \quad = \quad 0 \quad . \tag{5.5}$$

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

$$j_k \quad = \quad 0 \quad . \tag{5.6}$$

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

5.2.2 Explicit form of Schrödinger equation

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

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

$$\Psi = R(aexp(iU) + bexp(-iU))exp(-iE_n t) \tag{5.7}$$

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

2. The Schrödinger equation reduces with the change of variable

$$\begin{aligned} z &\rightarrow \frac{(z-z_0)}{z_1} \equiv x \ , \\ z_0 &= \frac{E_n}{qE} \ , \ z_1 = (\frac{\hbar^2}{2mqE})^{1/3} \ . \end{aligned} \tag{5.8}$$

   to

$$(\partial_x^2 + x)\Psi = 0 \ . \tag{5.9}$$

   The range $[0, z_0]$ for z is mapped to the range $[-z_0/z_1, 0]$. z_0/z_1 has positive sign as is easy to verify. The value range of x is therefore negative irrespective of the sign of qE. This is the differential equation for Airy functions (see `http://tinyurl.com/6b8yh7`) [**?**]. Airy functions are encountered in WKB approximation obtained by linearing the potential function: $V(x) = ax + b + O(x^2)$.

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

3. Using the polar representation $\Psi = Rexp(iU)$ Schrödinger equation reduces to two equations

$$\begin{aligned} \left[(\partial_x^2 - U_x^2 + x)R\right] cos(U) &+ \left[U_{xx} + 2\partial_x R \partial_x U\right] sin(U) = 0 \ , \\ \left[(\partial_x^2 - U_x^2 + x)R\right] sin(U) &- \left[U_{xx} - 2\partial_x R \partial_x U\right] cos(U) = 0 \ . \end{aligned} \tag{5.10}$$

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

$$j = \frac{\hbar}{2m}\frac{U_x}{z_1}R^2 \ , \ z_1 = (\frac{\hbar}{2mqE})^{1/3} \ . \tag{5.11}$$

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

5.2.3 Semiclassical treatment

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

$$\Psi = R_0 exp\left(\frac{i}{\hbar}\int_0^z \sqrt{2m}\sqrt{E-qEz}dz\right) = R_0 exp\left(i\int_0^x x^{1/2}dx\right) \quad . \tag{5.12}$$

The plate at which the initial values are given can be chosen so that the electric force is analogous to gravitation at the surface of Earth. This requires only to replace the coordinate z with a new one, vanishing at the plate in question - and gives to the energies a positive shift $E_0 = qE_0h$.

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

$$\frac{\oint p_z dz}{\hbar} = \frac{2}{\hbar}\int_0^h p_z dz = n \quad . \tag{5.13}$$

   This gives

$$\frac{\oint p_z dz}{\hbar} = \frac{2\sqrt{2m}}{\hbar}\int_0^h \sqrt{E_n - qEz}dz = 2\int_0^{x_0} x^{1/2} = \frac{4}{3}x_0^{3/2} = n \quad . \tag{5.14}$$

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

2. One obtains

$$E_n = \frac{1}{2}(\frac{nqE\hbar^2}{r\sqrt{m}})^{2/3} \quad , \quad r = \int_0^1 (1-u)^{1/2}du = \frac{2}{3} \quad . \tag{5.15}$$

   The value of z_{max} is

$$z_{max} = \frac{E_n}{qE} = \frac{n^{2/3}}{2r^{2/3}}(\frac{\hbar^2}{qEm})^{1/3} \quad . \tag{5.16}$$

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

5.2.4 Possible quantum biological applications

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

1. The original situation would be stationary with no currents flowing. The application of an external electric field in the correct direction would reduce the voltage below the critical value and currents would start to flow. This is consistent with Becker's findings if there is a background electric field E_0 with direction opposite to that of the applied field has a direction opposite to E_0 so that the field strength experienced by charged particles is reduced and it is easier for them to reach the second plate.

2. Becker's DC currents appear in several scales. They are assigned with the pairs formed by CNS and perineural tissue (this includes also glia cells) and by frontal and occipital lobes. Acupuncture could involve the generation of a DC supra current. The mechanism would be essential in the healing. Also the mechanism generating qualia could involve generation of supra currents and dielectric breakdown for them. The role of the magnetic flux tubes in TGD inspired biology suggests that the mechanism could be universal. If this were the case one might even speak about a Golden Road to the understanding of living matter at the basic level.

Even the generation of nerve pulse [K37] might be understood in terms of this mechanism. One can argue that neurons have a higher evolutionary level than the system pairs to which only electron currents or electron and proton currents can be assigned. This is because the value of the effective Planck constant is higher for the magnetic flux tubes carrying the quantal ionic currents.

1. For Bose-Einstein condensate the simplest choice is $n = 1$ at both plates. The energy eigenvalues would naturally differ by the shift $E_0 = qE_0h$ at the two plates for a given particle type. Under these assumptions the current can flow appreciably only if the voltage is below the minimum value. This is certainly a surprising conclusion but brings in mind what happens in the case of neuronal membrane. Indeed, hyper-polarization has a stabilizing - something difficult to understand classically but natural quantum mechanically.

2. The reduction of membrane potential slightly below the resting potential generates nerve pulse. Also a phase transition increasing the value of the effective Planck constant might give rise to quantal direct currents and generate flow of ionic currents giving rise to nerve pulse. Stationary solutions are located near either capacitor plate. What comes to mind is that the nerve pulse involves a temporary change of the capacitor plate with this property.

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

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

   (a) Nerve pulses canbe generated by voltage gated channels for potassium and calcium. Voltage gated channels would correspond to magnetic flux tubes carrying electric field. For voltage gated channels Na^+ ions with atomic weight $A = 23$ and nuclear charge $Z = 11$ start to flow first, then K^+ ions with atomic weight $A = 39$ and $Z = 19$ follow. This conforms with the prediction that the lightest ions flow first. The nerve pulse duration is of the order of 1 millisecond at the most.

   (b) Nerve pulses can be also generated by voltage gated Ca^{+2} channels. In this case the duration can be 100 ms and even longer. Ca has $A = 40$ and $Z = 20$. The proper parameter is $x = r^2/qA$, $r = \hbar/\hbar_0$. One has

$$\frac{x(Ca^{++})}{x(Na^+)} = (\frac{r(Ca^{++})}{r(Na^+)})^2 \times \frac{23}{2 \times 40} \quad . \tag{5.17}$$

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

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

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

   Ca^{++} and Na^+ pair would be in very similar position for a given value of Planck constant. This is a highly satisfactory prediction. Another manner to circumvent the problem is more science fictive and assumes that the Na^+ ions are exotic nuclei behaving chemically as Na^+ but having one charged color bond between nucleons [L2].

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

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

5.2.5 The effects of ELF em fields on vertebrate brain

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

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

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

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

potential of about 6×10^6 V/m. This is of course only a rough order of magnitude estimate since perturbations of these field are in order.

Fractality motivates some guess for voltage and electric field.

1. The voltage along the flux tube could be invariant under the scaling of Planck constant. The interpretation could be that the charges at the ends of the linear structure generate an electric flux running along the structure do not depend on the length L of the structure so that the electric field along linear structure behaves as $1/L \propto 1/h_{eff}$ as a function of the length scale $L \propto h_{eff}$ so that voltage between the ends does not depend on the length of the structure. This would give rise to a universal amplitude window for voltage rather than potential. The cell membrane electric field of 6×10^6 V/m would correspond to the field 6 mV/m. This kind of voltages could be associated with Becker's DC currents and the order of magnitude would be around few mV.

   Note that if the electric flux is like that between point charges, the scaling law $E \propto 1/h_{eff}^2$ holds true.

2. There could be also a constant electric field along microtubular structures due to polarization - most naturally tubulin polarization. This field strength serves as a candidate for a universal amplitude window for electric field.

   The idea that the direct currents of Becker run between lipid layers of cell does not conform with the hypothesis about generalized Josephson currents between them. There are electric fields along microtubules and one could wonder whether the DC voltages of Becker could relate to the voltages between the ends of linear structures formed by axonal and dendritic microtubules connected to each other by MAPs - single MT can have a length up to about 1 cm. The longitudinal electric field due to the dipole moments of tubulins and confined to tubulin structure does not depend on its length L, and the electric field of 1 mV/m would correspond 10^3 V/μm, which is by order of magnitude larger than the constant longitudinal dipole electric field of order 10^2 eV/μm generated by tubulin dipoles estimated to have strength 337 Debye in [I15] (note that MT has radius of $R = 25$ nm, thickness of $\Delta R = 4$ nm and length of $d = 8$ nm and the volume of MT fragment defined by 13 parallel tubulins is given by $V = 13 \times 2\pi R^2 \Delta R$ and that electric is $E = p/V$). If Becker's direct currents correspond to electric fields due to the charge difference between the ends of tubulins, one can consider the possibility that Becker's longitudinal electric fields have micro.tubular origin.

3. Electric field in the range $E = 1 - 10$ V/m assignable to EEG would correspond to field of $(1 - 10) \times 10^3$ V/μm and seems to be too large to be assigned with microscopic structures. DNA is a possible candidate since the smaller thickness of DNA would increase the dipole moment density by a factor of order 10^3 from that for MTs. The electric field of 10^{-7} eV/m seems to be associated with much larger structure than organism.

5.2.6 Effects of 50 Hz magnetic fields on living matter

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

There are also other experiments have demonstrated that oscillating electromagnetic fields have effects on living matter. In particle oscillatory magnetic fields with frequency of 50 Hz and with field strengths typically in the range.1-1 mT are used: these effects are summartized in [J15]. Even fields of order.14 Tesla are used.

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

1. For 50 Hz oscillation frequency the wave length λ is 6000 km to be compared with the radius of Earth which is 6371 km. If one takes seriously the notion of magnetic body this need not be an accident. I do not know how essential it is to have just 50 Hz frequency. The magnetic field is nearby oscillating dipole field (see `http://tinyurl.com/36c4pfg`) up to distances of order λ and radiation field at much longer distances. Therefore the field in question is in good approximation nearby field as fart as biological body is considered. For magnetic body the radiation field could dominate

2. For the endogenous magnetic field $B_{end} = .2$ Gauss cyclotron frequencies of ions are in EEG range: Ca^{++} cyclotron frequency is 15 Hz. The scaling up to r=.1-1 mT means scaling of cyclotron frequencies by a factor $5 - 50$. For Ca^{++} this would give frequency range 75-750 Hz. For K^+ and Cl^+ ions the frequency range would be about 35-375 Hz.

3. The magnetic length $r = \sqrt{2/eB}$ characterizing flux tube thickness for flux quantization with minimum value of flux is for $B = .05$ mTesla equal to 5 μm. For the fields in the range .1-1 mTesla it is in the range 3.5 μm- 1.1 μm. 2.5 μm corresponds to p-adic length scales $L_e(k)$ associated with Gaussian Mersenne $M_{G,k} = (1+i)^k - 1$, $k = 167$, and Gaussian Mersenne correspondng to $k = 163$ would correspond to p-adic length scale .36 μm. .14 Tesla corresponds to magnetic length of 9.4 nm rather near to cell membrane thickness of 10 nm which corresponds to p-adic length cale $L_e(151)$ assignable to Gaussian Mersenne $M_{G,151}$.

5.2.7 The effects of polarized light on living matter

Polarized light is known to have effects on living matter [J15]. For instance, Peter Gariaev has found that the polarized light generated by living matter sample irradiated by polarized laser light has effects on distant organism and there are even indications that genetic code might be realized in terms of radiation patterns [K45]. The quantum model for Becker currents suggest that these effects result as a modification of the voltage between the ends of magnetic flux tubes If the flux tubes are near criticality for the generation of quantal DC currents, polarized light could be utilized both communication and control purposes wheres the acceleration in the electric fields along flux tubes would serve as a provider of metabolic energy allowing to load metabolic batteries. This process could be initiated by an electromagnetic signal inducing generation of quantal currents. The same basic mechanism could be at work also in DNA transcription, replication and other similar processes.

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

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

It is known that the energy of radiation can be transformed to metabolic energy. For instance, IR light for which photons have energies of order metabolic quantum has biological effects [I25]. The mechanism could be following. Suppose that the electric field of IR photon is parallel to the flux tube which carries an electric field and is near criticality for the generation of quantal DC currents. If the direction of polarization is correct, the additional contribution to electric field induces direct current and acceleration of electrons and protons and their transfer to smaller space-time sheets and therefore loading of metabolic batteries. This could also make generation of ATP possible.

Suppose that one takes seriously the model for remote replication of DNA [K45] involving flux tubes connecting identical DNA nucleotides and that the radiation propagating along them induces quantal currents along the receiving DNA inducing replication and perhaps even transcription. The direction of polarization for the emitted radiation should be parallel to the DNA strand locally and during its travel to the target the polarization should remain orthogonal to the flux tube so that one would have what might be called polarization window. Parallel translation of the polarization vector in the induced metric suggests itself.

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

The basic prediction of the interaction mechanism is that the effects of em field with a given frequency occur only at the second half period when the direction of electric field is "correct". This prediction might be testable. In fact, there is evidence for this interaction mechanism in the

case of theta waves of EEG. The memory storage occurs only at the second half of the theta wave This is discussed from different point of view in [K1].

The place coding by phase shifts was discovered by O'Reefe and Recce [J14]. In [J17, J16]. Y. Yamaguchi describes the vision in which memory formation by so called theta phase coding is essential for the emergence of intelligence. It is known that hippocampal pyramidal cells have "place property" being activated at specific "place field" position defined by an environment consisting of recognizable objects serving as landmarks. The temporal change of the percept is accompanied by a sequence of place unit activities. The theta cells exhibit change in firing phase distributions relative to the theta rhythm and the relative phase with respect to theta phase gradually increases as the rat traverses the place field. In a cell population the temporal sequence is transformed into a phase shift sequence of firing spikes of individual cells within each theta cycle.

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

One can say that neurons in ensemble provide a representation for the external world and the location of the rodent in the external world is represented as a firing of a neuron in this landscape. Besides this also temporal scaling down by a factor about ten is carried out so that actual event is represented as much shorter copies of it. Obviously this represents temporal fractality.

This scaling down - story telling - seems to be a fundamental aspect of memory. Our memories can even abstract the entire life history to a handful of important events represented as a story lasting only few seconds. This scaling down is thought to be important not only for the representation of the contextual information but also for the memory storage in the hippocampus. Hierarchy of Planck constants and phase transitions changing Planck constant make this story building possible.

The finding of Yamaguchi and collaborators relevant in the recent context is that the gradual phase shift occurs at half theta cycle whereas firings at the other half cycle show no correlation [J17]. The proposed model for the interaction of theta waves with flux tubes could explain this naturally. The relevant neural sub-system would be critical to the generation of quantal DC current only when the direction electric field of synchronizing theta wave generated by magnetic body is correct. Hence synchronous neural activity would be induced only at second half cycle of theta wave and firing would be random during the other half cycle.

5.3 A Model For Remote Gene Expression Based On Becker Currents

If one accepts the notion of magnetic body as intentional agent, the basic challenge is to understand how magnetic body realizes its intents as remote mental interactions on biological body. This model must of course apply also to the more conventional remote mental interactions such as remote realization of intent.

The hypothesis is that electromagnetic and possibly also other massless classical fields assignable to so called massless extremals are in a key role. Also cyclotron frequencies characterizing magnetic bodies play a key role. The vision is that magnetic flux sheets traverse many-sheeted DNA in various scales giving rise to a hierarchy of genomes and coherent gene expression in scales of cell, organelles, organism, and even population, and species. Hierarchy of Planck constants is in an essential role in realizing this hierarchy in terms of photons with energies above the thermal energy at physiological temperature and having spectrum of wavelengths coming as multiples $\lambda = n\lambda_0$, $n = \hbar/\hbar_0$.

The findings of Benveniste and followers relating to water memory and homeopathy, the recent work of group led by HIV Nobelist Luc Montagnier coupling the findings with genetics and suggesting a new nanoscale realization of genetic code [L3]), the work of the group of Popp with bio-photons identified as decay produces of large $\hbar$ photons with visible energies (in particular dark EEG photons), and the work of Peter Gariaev and collaborators supporting remote gene expression and replication discussed [K45] suggest that electromagnetic radiation is indeed involved. In the case of water memory and homeopathy the spectrum of cyclotron frequencies for the chemical

invader characterizes it and induces immune response trying to eliminate it. I have also proposed a model for how genes coding for proteins eliminating the invader could be generated almost automatically: the model is based on the predicted realization of vertebrate genetic code in terms of dark proton states [K19]. DNA would like an animal which sniffs the invaders magnetic body and automatically reacts to the smell.

The discussions with Lian Sidorov and people who have realized that new era is beginning in biology have served as a driving force in the attempts to formulate in more detail TGD inspired view about how remote mental interactions - which are basic element of the model in TGD framework - might be realized. As a matter fact, I have added to my homepage a new book summarizing briefly the recent view about quantum TGD and its applications to quantum consciousness, quantum biology, to quantum neuroscience, and to remote mental interactions with some proposals for possible tests [K41]).

To start with, suppose that in the case of biological target realization of intent in the simplest situation reduces to expression of genes. This is of course a strong limitation to the type of remote mental interactions. The challenge is to develop a model for remote realization of genetic activities like replication, and transcription. For some time ago I proposed a model with Peter Gariaev [K45] but it was still too clumsy since it required too much of information transfer between the genomes of sender and receiver. Much simpler model involving only sending of simple commands initiating genetic programs suggests itself. The following proposal tries to achieve this and involves three basic ideas.

1. The idea of password and addressing is familiar from ordinary computers. Collection of frequencies as password/address allows to reach tuned targets without specific targeting of the command. This is a dramatic improvement to the previous model.

2. Password and fractal addressing realized in terms of frequencies coupling resonantly (already in the original model: I did not however realize the implications of resonant coupling!) and the hierarchy of Planck constants to realize the hierarchical addressing. I have discussed analogous addressing based on information molecules and their receptors at the biochemical level to realize magnetic flux tube connections between sender and target inside organism (hormonal action would be very analogous to what I am proposing here).

3. Becker's DC currents as supra currents flowing along DNA and activated optimally when the incoming laser light has polarization parallel to DNA's local direction, activation of super currents would mean activation of the gene. This is second new element to the original model.

In the following I discuss this with more details.

5.3.1 The analogy with ordinary computer

Consider first the analog of remote mental interactions for ordinary computer. Computer sends a password to the other computer and after that it can use it to run programs of the other computer. Whisling to a dog is another example: extremely simple command activates arbitrary complex programs.

In the recent case electromagnetic radiation with a given frequency coupling resonantly like radio signal to a tuned radio receiver would be the simplest command activating the target. There would no need to specify the direction or distance of the target precisely since essentially mass communications would be in question: intent would be enough. Password could consist of several frequencies which must be received simultaneously by the target before it would activate and tunes to receive more frequencies representing simple commands - perhaps acting on the intronic portion of DNA and activating the genome to remote gene expression or something else such as activating DNAs of other cells by sending similar em addresses!

I have discussed topological quantum computer programs (see `http://tinyurl.com/y84g3tk7`) based on braiding could look like in this framework [L5]. Also here addressing but now realized as information molecule-receptor pair would play a key role.

5.3.2 Hierarchy of Planck constants and hierarchical addressing

Fractal hierarchy of frequencies (in Peter's experiment laser light induced generation of radiation at frequencies down to about 10 kHz) would allow to transform passwording to addressing. Very naïvely, the longest wavelengths: about 10^4 meters would reach the tuned receivers in nearly the same phase in a region of this size. One would have some subregions in tune. The shorter wavelengths would allow to pinpoint the tuned receivers inside each of these subregions and so on. This would be fractal addressing with most significant bits correspond to the longest wavelengths. Only those receivers which would be tuned to all frequencies would start to express the gene in the case of AND logic. Of course, also other Boolean functions of tuned-not tuned bits can be considered.

A good guess is that all photons correspond to the same energy of visible photon and only Planck constant varies. For ordinary value of Planck constant one would have a photon with wavelength of order size scale of single cell, and the frequencies in this range would select single gene in the genome ofa particular kind of cell, say neuron within particular region of brain.

In Peter Gariaev's experiment involving 2 eV incoming red laser light the outgoing photons would have same energy but larger Planck constant so that also wavelengths would be longer and range down to at least 3×10^4 meters corresponding to radiofrequency scale of 10 kHz. What is interesting that 2 eV is 4 times the nominal value of the metabolic energy quantum of.5 eV identifiable as zero point kinetic energy of electron or proton for the p-adic length scale $L_e(151)$ corresponding to cell membrane thickness and Gaussian Mersenne $M_{151} = (1+i)^{151} - 1$. Could it be that 2 eV could be preferred photon energy or is its use simply due to the unavailability of continuous frequency spectrum for laser light. And why the laser light induces the generation of the command inducing remote gene expression?

This picture conforms with Peter's experiment and with the reports of Benveniste and followers about the possibility of representing homeopathic remedy using very low frequency spectrum - presumably cyclotron frequencies - assignable to remedy. These frequencies would be addresses for genes activating genes transcribing building bricks of biomolecules of immune response eliminating the substance from the organism. The proposal could be seen as a generalization of Benveniste's observation and realization of wave DNA proposal.

5.3.3 DNA supra currents and activation of genes by Becker mechanism

The third bulding brick of the model would be quantum model for Becker currents (see `http://tinyurl.com/ybnjk9bq`) [L6] as supra currents or quantal DC currents: also this element is new. Assume - in accordance with the general vision - that these supra currents can flow also along the strands of many-sheeted DNA (flux sheets associated with the strand, entire hierarchy labelled by the values of $\hbar$). Assume also that the interaction of polarized photons addressing for genes with DNA is such that the electric fields of DNA flux tube and "massless extremal" representing laser beam superpose and charges (electrons) experience the superposition of field already present and the field of ME. If the net electric field is near criticality originally (think as analog neuronal membrane) and becomes over-critical, quantal Becker current starts to flow and the machinery responsible for gene activation is activated.

This means also the activation of metabolic machinery since the acceleration of electrons in the electric field gives them energy making possible a transfer to smaller space-time sheets where they form Cooper pair like states with negentropic entanglement. Metabolic energy corresponds to zero point kinetic energy and negentropic entanglement is relevant from the point of view of consciousness: in the case of healing understood as a regeneration of negentropic resources this aspect is especially important. This mechanism generates high energy phosphate bonds in ATP and the decay ATP $\rightarrow$ ADP liberates the metabolic energy and destroys the negentropic entanglement possibly associated with ATP so that the second law in generalized form (see `http://tinyurl.com/yakmqhz6`) [L4] allowing local generation of genuine negentropy (but assigned to information carried by entanglement defining a quantum rule) wins after all.

It could also happen that the decay of ATP generates dark photon or photons absorbed by cyclotron condensate at magnetic flux tube. The excited state is non-local single particle excitation and involves very simple negentropic entanglement between the particles of the condensate. In this case the negentropy of ATP would be transformed to the negentropy of the magnetic flux tube

or even several of them if large value of Planck constant is associated with the photon. This mechanism could allow the generation of negentropic entanglement associated with attention. The storage of metabolic energy in photosynthesis could involve similar excitation of cyclotron state at the first step. The most plausible candidate is cyclotron condensate for electron Cooper pairs. Also electrons filling state up to some Fermi energy could be in question. In this case the excitations would be excitation in longitudinal degrees of freedom of the flux tube generating current.

6 Could Cell Membrane Correspond To Almost Vacuum Extremal?

The question whether cell membrane or even cell could correspond almost vacuum extremal of Kähler action (in some cases) was the question which led to the realization that the frequencies of peak sensitivity for photoreceptors correspond to the Josephson frequencies of biologically important ions if one accepts that the value of the Weinberg angle equals to $sin^2(\theta_W) = .0295$ instead of the value .23 in the normal phase, in which the classical electromagnetic field is proportional to the induced Kähler form of CP_2 in a good approximation. Another implication made possible by the large value of Planck constant is the identification of Josephson photons as the counterparts of bio-photons one one hand and those of EEG photons on the other hand. These observation in turn led to a detailed model of sensory qualia and of sensory receptor. Therefore the core of this argument deserves to be represented also here although it has been discussed in [K37].

6.1 Cell Membrane As Almost Vacuum Extremal

Although the fundamental role of vacuum extremals for quantum criticality and life has been obvious from the beginning, it took a long time to realize how one could model living cell as this kind of system.

1. Classical electric fields are in a fundamental role in biochemistry and living biosystems are typically electrets containing regions of spontaneous electric polarization. Fröhlich [I19] proposed that oriented electric dipoles form macroscopic quantum systems with polarization density serving as a macroscopic order parameter. Several theories of consciousness share this hypothesis. Experimentally this hypothesis has not been verified.

2. TGD suggests much more profound role for the unique di-electric properties of the biosystems. The presence of strong electric dipole fields is a necessary prerequisite for cognition and life and could even force the emergence of life. Strong electric fields imply also the presence of the charged wormhole BE condensates: the surface density of the charged wormholes on the boundary is essentially equal to the normal component of the electric field so that wormholes are in some sense "square root" of the dipole condensate of Fröhlich! Wormholes make also possible pure vacuum polarization type dipole fields: in this case the magnitudes of the em field at the two space-time sheets involved are same whereas the directions of the fields are opposite. The splitting of wormhole contacts creates fermion pairs which might be interpreted as cognitive fermion pairs. Also microtubules carry strong longitudinal electric fields. This formulation emerged much before the identification of ordinary gauge bosons and their superpartners as wormhole contacts.

Cell membrane is the basic example about electret and one of the basic mysteries of cell biology is the resting potential of the living cell. Living cell membranes carry huge electric fields: something like 10^7 Volts per meter. For neuron resting potential corresponds to about.07 eV energy gained when unit charge travels through the membrane potential. In TGD framework it is not at all clear whether the presence of strong electromagnetic field necessitates the presence of strong Kähler field. The extremely strong electric field associated with the cell membrane is not easily understood in Maxwell's theory and almost vacuum extremal property could change the situation completely in TGD framework.

1. The configuration could be a small deformation of vacuum extremal so that the system would be highly critical as one indeed expects on basis of the general visiona about living matter

as a quantum critical system. For vacuum extremals classical em and Z^0 fields would be proportional to each other. The second half of Maxwell's equations is not in general satisfied in TGD Universe and one cannot exclude the presence of vacuum charge densities in which case elementary particles as the sources of the field would not be necessarily. If one assumes that this is the case approximately, the presence of Z^0 charges creating the classical Z^0 fields is implied. Neutrinos are the most candidates for the carrier of Z^0 charge. Also nuclei could feed their weak gauge fluxes to almost non-vacuum extremals but not atomic electrons since this would lead to dramatic deviations from atomic physics. This would mean that weak bosons would be light in this phase and also Weinberg angle could have a non-standard value.

2. There are also space-time surfaces for CP_2 projection belongs to homologically non-trivial geodesic sphere. In this case classical Z^0 field can vanish [L1], [L1] and the vision has been that it is sensible to speak about two basic configurations.

   (a) Almost vacuum extremals (homologically trivial geodesic sphere).

   (b) Small deformations of non-vacuum extremals for which the gauge field has pure gauge Z^0 component (homologically non-trivial geodesic sphere).

   The latter space-time surfaces are excellent candidates for configurations identifiable as TGD counterparts of standard electroweak physics. Note however that the charged part of electroweak fields is present for them.

3. To see whether the latter configurations are really possible one must understand how the gauge fields are affected in the color rotation.

   (a) The action of color rotations in the holonomy algebra of CP_2 is non-trivial and corresponds to the action in $U(2)$ sub-group of $SU(3)$ mapped to $SU(2)_L \times U(1)$. Since the induced color gauge field is proportional to Kähler form, the holonomy is necessary Abelian so that also the representation of color rotations as a sub-group of electro-weak group must correspond to a local $U(1)$ sub-group local with respect to CP_2 point.

   (b) Kähler form remains certainly invariant under color group and the right handed part of Z^0 field reducing to $U(1)_R$ sub-algebra should experience a mere Abelian gauge transformation. Also the left handed part of weak fields should experience a local $U(1)_L$ gauge rotation acting on the neutral left handed part of Z^0 in the same manner as it acts on the right handed part. This is true if the $U(1)_L$ sub-group does not depend on point of CP_2 and corresponds to Z^0 charge. If only Z^0 part of the induced gauge field is non-vanishing as it can be for vacuum extremals then color rotations cannot change the situation. If Z^0 part vanishes and non-vacuum extremal is in question, then color rotation rotation of W components mixing them but acts as a pure $U(1)$ gauge transformation on the left handed component.

   (c) It might not be without importance that for any partonic 2-surface induced electroweak gauge fields have always U(1) holonomy, which could allow to define what neutral part of induced electroweak gauge field means locally. This does not however hold true for the 4-D tangent space distribution. In any case, the cautious conclusion is that there are two phases corresponding to nearly vacuum extremals and small deformations of extremals corresponding to homologically non-trivial geodesic spheres for which the neutral part of the classical electro-weak gauge field reduces to photon field.

4. The unavoidable presence of long range Z^0 fields would explain large parity breaking in living matter, and the fact that neutrino Compton length is of the order of cell size would suggest the possibility that within neutrino Compton electro-weak gauge fields or even longer scales could behave like massless fields. The explanation would be in terms of the different ground state characterized also by a different value of Weinberg angle. For instance, of the p-adic temperature of weak bosons corresponds to $T_p = 1/2$, the mass scale would be multiplied by a factor $\sqrt{M_{89}}$ and Compton lengths of weak bosons would be around 10^{-4} meters corresponding to the size scale of a large neuron. If the value of Planck constant is also large then the Compton length increases to astrophysical scale.

5. From the equations for classical induced gauge fields in terms of Kähler form and classical Z^0 field [L1] , [L1]

$$\gamma = 3J - \frac{p}{2}Z^0 \quad , \quad Q_Z = I_L^3 - pQ_{em} \quad , \quad p = sin^2(\theta_W) \tag{6.1}$$

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

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

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

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

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

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

From $f_e \simeq .57\times$ MHz and $p = sin^2(\theta_W) = .23$ one obtains $E_\nu = 1.7 \times 10^{-2}$ eV, which is roughly one third to the Josephson frequency of electron assignable to cell membrane. Could Josephson frequency of cell membrane excite neutrino cyclotron transitions?

2. The model for photoreceptors to be discussed below forces to conlude that the value of Weinberg angle in the phase near vacuum extremal must be $p = .0295$ if one wants to reproduces the peak energies of photoreceptors as Josephson frequencies of basic biological ions. This would predict $E_\nu = .41$ eV, which is rather near to the metabolic energy quantum. The non-relativistic formula however fails in this case and one must use the relativistic formula giving

$$E = \sqrt{g_Z Q_Z B_Z 2\pi} \simeq .48 \ \ eV$$

giving the metabolic energy quantum. Does this mean that Z^0 cyclotron frequency for neutrino is related to the transfer of metabolic energy using Z^0 MEs in the phase near vacuum extremals.

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

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

Here n refers to the cyclotron harmonic.

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

6.1.2 Ionic Josephson frequencies defined by the resting potential for nearly vacuum extremals

If cell membrane corresponds to an almost vacuum extremal, the membrane potential potential is replaced with an effective resting potential containing also the Z^0 contribution proportional to the ordinary resting potential. The surprising outcome is that one could understand the preferred frequencies for photo-receptors [J4] as Josephson frequencies for biologically important ions. Furthermore, most Josephson energies are in visible and UV range and the interpretation in terms of bio-photons is suggestive. If the value of Planck constant is large enough Josephson frequencies are in EEG frequency range so that bio-photons and EEG photons could be both related to Josephson photons with large $\hbar$.

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

2. For exact vacuum extremals elementary fermions couple only via left-handed isospin to the classical Z^0 field whereas the coupling to classical em field vanishes. Both K_+, Na_+, and Cl_- $A - Z = Z + 1$ so that by p-n pairing inside nucleus they have the weak isospin of neuron (opposite to that of neutrino) whereas Ca_{++} nucleus has a vanishing weak isospin. This might relate to the very special role of Ca_{++} ions in biology. For instance, Ca_{++} defines an action potential lasting a time of order.1 seconds whereas Na_+ defines a pulse lasting for about 1 millisecond [J1]. These time scales might relate to the time scales of CDs associated with quarks and electron.

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

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

Table 1: Values of the Josephson energy of cell membrane for some values of the membrane voltage for $p = .23$. The value $V = -40$ mV corresponds to the resting potential for photoreceptors and $V = -70$ mV to the resting state of a typical neuron.

$$\begin{aligned}(\frac{Z-N}{4} - pZ)Z^0 + q_{em}\gamma &= Q_{eff}\gamma \ , \\ Q_{eff} &= -\frac{Z-N}{2p} + 2Z + q_{em} \ . \end{aligned} \tag{6.2}$$

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

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6.2 Are Photoreceptors Nearly Vacuum Extremals?

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

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

From **Table 1** it is clear that the energies of Josephson photons are in visible range for reasonable values of membrane voltages, which raises the question whether Josephson currents of nuclei in the classical em and Z^0 fields of the cell membrane could relate to vision.

Consider first the construction of the model.

1. Na^+ and Ca^{++} currents are known to present during the activation of the photoreceptors. Na^+ current defines the so called dark current [J4] reducing the membrane resting potential below its normal value and might relate to the sensation of darkness as eyes are closed. Hodgkin-Huxley model predicts that also K^+ current is present. Therefore the Josephson energies of these three ion currents are the most plausible correlates for the three colors.

2. One ends up with the model in the following manner. For Ca^{++} the Josephson frequency does not depend on p and requiring that this energy corresponds to the energy 2.32 eV of

maximal sensitivity for cones sensitive to green light fixes the value of the membrane potential during hyper-polarization to $V = .055$ V, which is quite reasonable value. The value of the Weinberg angle parameter can be fixed from the condition that other peak energies are reproduced optimally. The result of $p = .0295$.

The predictions of the model come as follows summarized also by the **Table 2**.

1. The resting potential for photoreceptors is $V = -40$ mV [J5]. In this case all Josephson energies are below the range of visible frequencies for $p = .23$. Also for maximal hyper-polarization Na^+ Josephson energy is below the visible range for this value of Weinberg angle.

2. For $V = -40$ mV and $p = .0295$ required by the model the energies of Cl^- and K^+ Josephson photons correspond to red light. 2 eV for Cl^- corresponds to a basic metabolic quantum. For Na^+ and Ca^{++} the wave length is below the visible range. Na^+ Josephson energy is below visible range. This conforms with the interpretation of Na^+ current as a counterpart for the sensation of darkness.

3. For $V = -55$ mV - the threshold for the nerve pulse generation- and for $p = .0295$ the Josephson energies of Na^+, Ca^{++}, and K^+ a correspond to the peak energies for cones sensitive to red, green, and blue respectively. Also Cl^- is in the blue region. Ca^{++} Josephson energy can be identified as the peak energy for rods. The increase of the hyper-polarization to $V = -59$ mV reproduces the energy of the maximal wave length response exactly. A possible interpretation is that around the criticality for the generation of the action potential ($V \simeq -55$ mV) the qualia would be generated most intensely since the Josephson currents would be strongest and induce Josephson radiation inducing the quale in other neurons of the visual pathway at the verge for the generation of action potential. This supports the earlier idea that visual pathways defines a neural window. Josephson radiation could be interpreted as giving rise to bio-photons (energy scale is correct) and to EEG photons (for large enough values of $\hbar$ the frequency scales is that of EEG).

4. In a very bright illumination the hyper-polarization is $V = -65$ mV [J5], which the normal value of resting potential. For this voltage Josephson energies are predicted to be in UV region except in case of Ca^{++}. This would suggests that only the quale "white" is generated at the level of sensory receptor: very intense light is indeed experienced as white.

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

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

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

2. For neurons the value of the resting potential is -70 mV. Na^+ and Ca^{++} Josephson energies 2.80 eV and 2.94 eV are in the visible range in this case and correspond to blue light. This does not mean that Ca^{++} Josephson currents are present and generate sensation of blue at neuronal level: the quale possibly generated should depend on sensory pathway. During the hyper-polarization period with -75 mV the situation is not considerably different.

3. The value of the resting potential is -95 mV for skeletal muscle cells. In this case Ca^{++} Josephson frequency corresponds to 4 eV metabolic energy quantum as **Table 1** shows.

4. For smooth muscle cells the value of resting potential is -50 mV. In this case Na^+ Josephson frequency corresponds to 2 eV metabolic energy quantum.

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

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

5. For astroglia the value of the resting potential is -80/-90 mV for astroglia. For -80 mV the resting potential for Cl^- corresponds to 4 eV metabolic energy quantum. This suggests that glial cells could also provide metabolic energy as Josephson radiation to neurons.

6. For all other neurons except photo-receptors and red blood cells Josephson photons are in visible and UV range and the natural interpretation would be as bio-photons. The bio-photons detected outside body could represent sensory leakage. An interesting question is whether the IR Josephson frequencies could make possible some kind of IR vision.

To sum up, the basic criticism against the model is that the value of Weinberg angle must be by a factor of 1/10 smaller than the standard model value, and at this moment it is difficult to say anything about its value for nearly vacuum extremals.

A possible cure could be that the voltage is not same for different ions. This is possible since at microscopic level the Josephson junctions correspond to transmembrane proteins acting as channels and pumps. The membrane potential through receptor protein is different for color receptors. For this option one would have the correspondences
$Na^+ \leftrightarrow$ 2.19 eV (R) and $eV = 86.8$ eV,
$Cl^- \leftrightarrow$ 2.32 eV (G) and $eV = 65.8$ eV,
$K^+ \leftrightarrow$ 2.49 eV (W) and $eV = 60.2$ eV,
$Ca^{++} \leftrightarrow$ 3.06 eV (B) and $eV = 67.3$ meV.
For Na^+ the value of the membrane potential is suspiciously large.

It is interesting to look what happens when the model is generalized so that Josephson energy includes the difference of cyclotron energies at the two sides of the cell membrane and Weinberg angle has its standard model value.

1. Consider first *near to vacuum extremals*. In the formula for cyclotron frequencies in the effective magnetic field the factor Z/A in the formula of is replaced with

$$\frac{\frac{N-Z}{2p} + 2Z + q_{em}}{A} \ ,$$

which is not far from unity so that the cyclotron frequency would be near to that for proton for all ions. Also neutral atoms would experience classical and magnetic Z^0 fields. Cyclotron

frequency would be almost particle independent so that cyclotron contribution gives an almost constant shift to the generalized Josephson energy. When the difference of cyclotron energies vanishes, the model reduces to that discussed above.

The weak independence of the cyclotron frequency on particle properties does not conform with the idea that EEG bands correspond to bosonic ions or Cooper pairs of fermionic ions.

2. For *far from vacuum extremals* the proportionality of cyclotron energy to h_{eff} and B_{end} allows easy reproduction the energies for which photon absorption is maximal if one allows the cyclotron energies to differ at the two sides of the membrane for sensory receptors.

A remark about decade later: The model just discussed neglects the fact that superconductivity requires that Cooper pairs of fermionic ions are present unless one assumes that the nuclei are bosonic counterparts of fermionic nuclei with same chemical properties - TGD inspired nuclear physics indeed predicts this kind of exotic nuclei [L2]. For Cooper pairs of Na^+, Cl^-, and K^+, $p = .23$ and $E_J = .04$ eV assignable to visual receptors the Josephson energies are doubled being $2.02, 2.80, 3.02$ eV. These energies could correspond to peak energies for visible photons. The assumption of ionic Cooper pairs is rather attractive since it would allow to avoid two questionable assumptions.

For electron the Josephson energy would be scaled by a factor $-1+1/2p$ to $E_J = 1.0859 \times eV_{rest}$ for $p = .2397$. For neutrino the energy would be given by $E_J = -0.0859 \times V_{rest}$: for $p = 1/4$ it would vanish by the vanishing of vectorial part of Z^0 charge. For proton the energy would be $E_J = (3 - 1/2p)V_{rest} = .914 \times V_{rest}$ and for neutron $E_J = V_{rest}/2p = 2.086 \times V_{rest}$.

6.3 Water Electric As Protocell

Ulla Matfolk sent to me some interesting material at the web page of Dr. Mae-Wan Ho which provides further insights into the model of cell. The articles are "Water electric" [D25] and "Making Fuel from Water" [D23]. The articles summarize an experimental discovery which could be called Pollack-Zheng effect [D29, D26]. Both articles relate closely to what might be called the holy grail of artificial photosynthesis. The unreasonable effectiveness of photosynthesis in the sense that the waste of energy during the process is extremely small, makes artificial photosynthesis an excellent candidate for the final solution of energy problems as far energy sources and minimization of wastes are considered. In the following I comment only the first paper in detail from TGD viewpoint.

How photosynthesis manages to be so effective is one of the mysteries of biology. TGD based view about metabolic energy involves two ideas.

1. TGD predicts a hierarchy of metabolic energy quanta [K5, K20]. The basic quanta come as $E(k) = 2^k E_0$, where k is positive or negative integer and $E_0 \simeq .5$ eV holds true. For instance, 2 eV metabolic energy quantum corresponding to red light corresponds to $k = 3$. This is actually oversimplification since there is a cascade of quanta $E(k, n) = (1 - 2 < sup > -n < /sup >)E(k)$ converging to $E(k)$ for each p-adic length scale. These energies correspond to energies liberated when electron or proton drops to a larger space-time sheet at the limit when second space-time becomes very large and the particle starts from rest and remains to rest: this is second idealization as also the particle in a box geometry. The idea is that these universal metabolic energy quanta preceded the metabolism based on chemical storage of energy and that the primary step in photosynthesis is kicking of proton or electron to a smaller space-time sheet.

2. Second idea relies on the hierarchy of Planck constants.

   (a) The rate of dissipation - that this the energy wasted per unit time - is inversely proportional to $\hbar$ in the first naïve guess and means that macroscopically quantum coherent dark matter dissipates very little. Could photon kick charged dark particles to smaller space-time sheet where they dissipate very little? Or could photosynthesis capture ordinary or dark photons of sunlight to some layer of the onion like structure formed by the magnetic body of the organism, where it kicks particles to smaller space-time sheets. This light could correspond to bio-photons liberated as the biological body of the organism dies.

(b) Could this storage of photons have preceded chemical storage of energy in living matter? And could this energy reserve explain some rather mysterious findings about the ability of some people to survive without ordinary metabolic energy feed (usually saints and this kind of people telling that light is enough for them to survive. Also animals are capable to these metabolic miracles [I7] : see the article "Researchers Seek to Demystify the Metabolic Magic of Sled Dogs" in Science. Of course, the storage of energy to that of dark matter or dark photons confined to the net defined by magnetic flux tubes could be the eventual manner to avoid energy waste and associated entropy growth inducing environmental problems. Hierarchy of Planck constants would allow the storage in arbitrary long length scales for given energy of photon so that even a community of organisms could have collective metabolic energy resources: maybe synergy has something to do with this.

The first article summarizing the Pollack-Zheng effect gives quantitative support for this picture. I have formatted the text as comments to the summary represented in the article of Mae-Wan Ho [D25].

6.3.1 Exclusion zones

The article summarizes the sequence of events initiated by the discovery of Gerald Pollack and his student Jian-ming Zheng [D29, D26]. As a matter fact, the fascinating findings described in detail by Gerald Pollack in his book were absolutely crucial for the recent TGD based view about quantum biology in which dark matter plays key role.

1. Pollack and his student discovered that suspensions of colloids and dissolved substances are excluded from a region extending some hundreds of micrometres from the surfaces of hydrophilic gels. An "exclusion zone" (EZ) of this magnitude conflicts the belief that interfacial water forming at liquid-solid, or liquid-air interfaces can be no more than a few layers of molecules thick. What's observed is a million layers or more! "Exclusion" means that the water suspension of micro-spheres moved away from the surface of gel with constant velocity and behaving like single structural unit.

   Comment: The sizes of cells vary up to hundreds of micrometers and cells are by definition structures which are isolated from the environment. Maybe EZs represent protocells or their precedessors. Pollack and coauthors have indeed proposed that their finding might relate to the origin of life [D26]. That the surface was that of gel might be important. In TGD based model of living matter gels have magnetic bodies and their presence might relate to the formation of the thick water layer in non-standard phase.

2. Similar exclusion zones were found next to any hydrophilic surface including surfaces coated with a monolayer of hydrophilic molecules, and around ion exchange resin beads. Electric charge appears to be important, as EZ failed to form around charge-exhausted resin beads. Although EZ can form in pure water, it is enhanced and stabilized by low concentrations of buffer (2 to 10 mM at pH 7).

   Comment: Hydrophily could correspond to the formation of magnetic flux tubes connecting the hydrophilic surface to water molecules as assumed in the model of protein folding and bio-catalysis [K3].

3. The EZ phase is very different from the bulk water. An unusually ordered crystalline phase where the molecules are less free to move is suggestive. The UV and visible absorption spectrum gave a single absorption peak at $\lambda \simeq 270$ nm in the UV region completely absent in the bulk phase. The infrared emission record showed that the EZ radiates very little compared with bulk water, as would be expected on account of the reduced mobility of water molecules. The magnetic resonance imaging mapping similarly gave a transverse relaxation time (T2) of 25.4 + 1 ms, which is shorter than the 27.1 + 0.4 ms recorded for the bulk water phase, again indicative of restricted motion.

   Comment: The reduced radiation might mean that part of photons are dark and bound inside magnetic flux tubes defining a structure responsible for the formation of gel like phases

inside cell and perhaps also inside EZ. The interpretation as bio-photons is suggestive. This phase of water could be precedessor of the water in cell interior since in the crystalline phase long bio polymers like DNA and amino-acid sequences would be stable against hydration.

4. EZ had a different electrical potential from the bulk phase, by as much as 100 200 mV, depending on the hydrophilic surface. With a negatively charged surface such as polyacrylic acid or Nafion (widely used as a proton exchange membrane), the potential is negative compared with the bulk water away from the EZ. Simultaneously, the hydrogen ion (proton, H^+) concentration is high just outside the EZ, decreasing in a gradient away from it. This indicates that the formation of the EZ is accompanied by a separation of positive and negative electrical charges, which led to the build up of electrical potential between the EZ and the bulk water. In effect, the water has become an electrical battery, and can provide electricity through an external circuit.

   Comment: Cell membrane is also a battery and the potential is around 50-80 mV to be compared with 100 200 mV, and the size scale of cell varies from 5 micrometer to hundreds of micrometers so that EZs could be involved with the formation of cell and cell membranes. The kicking of electrons or protons to smaller space-time sheet could be the mechanism inducing electric potential at a given space-time sheet. The formation of battery would mean that water could some day used to store very effectively the energy of solar radiation.

6.3.2 A connection with photosynthesis

Separating H^+ from e^- (electron) is the first step of photosynthesis in green plants which provides energy for most of the biosphere. In this case the energy comes from solar radiation. The separation of charges requires energy also in the case of EZ and the question is where this energy comes from in the case of EZ.

1. A clue came after having inadvertently left the experimental chamber with the EZ on the microscope overnight. Next morning, the EZ had shrunk considerably. But after turning on the microscope lamp, it began to immediately grow again, restoring itself within minutes to its former size. The energy for EZ formation comes from light, as in photosynthesis, but it can use the low energy part of the solar spectrum that photosynthesis cannot.

   Comment: Could one consider the possibility that photosynthesis involves unknown step and this step is just the kicking of electrons or protons to a smaller space-time sheet. This step would also induce the separation of charges and the generation of electric potential.

2. Although the entire spectrum of visible light appeared effective in making the EZ grow, the most effective part is in the infrared region, peaking at $\lambda \simeq 3100$ nm. A 10 minute exposure at that wavelength expanded the width of an EZ 3.7 times, and after an hour of exposure, the expansion was more than 6 times. After the light was turned off, the EZ remained constant for about 30 minutes before beginning to shrink, reaching halfway to its baseline level in about 15 minutes.

   Comment: $\lambda = 3100$ nm corresponds to.4 eV. The nominal value of the fundamental metabolic energy quantum is around $E_0 = .5$ eV and one has $E(k = 0, n = 3) = 0.4375$ eV for this value of E_0. Perhaps the photons indeed kick electrons or protons to a smaller space-time sheet.

   (a) In the case of protons the smaller space-time sheet would correspond to atomic space-time sheets characterized by $p \simeq 2^{137}$: the larger one would correspond to to $k = 141$.

   (b) For electrons the size of the smaller space-time sheet would be by a factor $m_p/m_e = 940/.5 = 1880 \simeq 2^{11}$ larger and would correspond to $k = 137 + 11 = 148$. This served as one motivation for the original $\hbar/\hbar_0 = 2^{11k}$ hypothesis for the preferred values of Planck constant. This is one half of the thickness of the lipid layer of cell membrane. The larger space-time sheet would correspond to cell membrane thickness $L(151) = 10$ nm and perhaps the dark space-time sheet serving as a template for the formation of the cell membrane! If $E = .4$ eV corresponds to electron, then proton would correspond to $E(0, 3) = .44$ eV giving for the metabolic energy quantum the value $E_0(p) = 0.5029$ eV in the case of proton and $E_0(e) = 0.4616$ eV in the case of electron.

3. When the UV and visible range was tested, a peak in the degree of EZ expansion was detected at $\lambda = 270$ nm in the UV region, corresponding to the characteristic absorption peak of EZ that was identified before. However, as the optical power used in the UV and visible region was 600 times that in the IR, the most profound effect was identified in the IR region, particularly at 3 100 nm.

   Comment: $\lambda = 270$ nm corresponds to the energy 4.5926 eV. E=4 eV is the nearest metabolic energy quantum. This energy does not correspond directly to any metabolic energy quantum assignable to.4 eV or.43 eV. One must be however cautious with conclusions since the model is very rough.

4. The mechanism of EZ formation is still unknown. But the two wavelengths that expand the EZ most effectively may offer some hint. The UV wavelength 270 nm is close to the 250 nm ($\simeq$ 5 eV) required to ionize water under standard state conditions and taking into account the hydration of the resulting ions. The 3 100 nm peak, on the other hand is close to the OH stretch of the ring hexamer identified as the most abundant species in infrared predissociation spectroscopy of large water clusters, and also in neon matrices by infrared spectroscopy. These results suggest that photoexcitation of ring hexamers and photoionisation followed by ejection of protons play synergistic roles in the assembly of the EZ phase. Pollack and colleagues believe that the infrared radiation, though normally insufficient to break OH bonds, can nevertheless work via resonance induced dissociation of large hydrogen-bonded networks.

   Comment: Ring hexamers bring in mind the crucial role of aromatic cycles in TGD inspired model of DNA as topological quantum computer which leads also to a model of ADP$\leftrightarrow$ ATP transition involving reconnection of magnetic flux tubes and having also information theoretic interpretation as a change of the topology of the braid structure defining topological quantum computer program [K1]. Magnetic flux tubes carrying dark electrons begin from these and can end up to other bio-molecules or water. Just a guess: could they end on ring hexamers?

6.3.3 Summary

The findings suggest additional details to the TGD based view about living matter.

1. The kicking of electrons or protons or both of them to a larger space-time sheet would be the first step in photosynthesis as I indeed suggested for years ago. The energy of 3100 nm photons indeed corresponds to that for the fundamental metabolic energy quantum. I have also proposed this process to be a fundamental step also in bio-catalysis: the temporary dropping of electron or proton of the catalyst molecule could provide the energy helping the reacting molecules to overcome the potential wall preventing the reaction from running. This metabolic coin could be returned to catalyst with high enough probability or the photons exchanged could be virtual.

   In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

2. The findings suggest also a mechanism for how solar radiation generates proto cells or their precedessors. The resulting phases of water have size extending to those for largest cells and the water could involve a gel like phase in which magnetic flux tubes containing dark matter could play a key role and eventually lead to quantum computer like behavior [K1]. The kicking of electrons (or protons) to smaller space-time sheet would induce ionization at given space-time sheet so that electric potential difference would result. The magnitude of the potential difference is of a correct order of magnitude. Cell membrane scale is present as a p-adic length scale for the space-time sheet of electrons before the kicking to the smaller space-time sheet and these space-time sheets could act as templates for the formation of cell membrane.

3. Interestingly, TGD based model of high T_c super conductivity predicts that both cell membrane length scale and size scale of cell are involved with the super-conductivity [K9]. Cell membrane acts as a Josephson junction in TGD based model of cell membrane, nerve pulse, and EEG.

7 Pollack's Findings About Fourth Phase Of Water And The Model Of Cell

The discovery of negatively charged exclusion zone formed in water bounded by gel phase has led Pollack to propose the notion of gel like fourth phase of water. In this article this notion is discussed in TGD framework. The proposal is that the fourth phase corresponds to negatively charged regions - exclusion zones - with size up to 100-200 microns generated when energy is fed into the water - say as radiation, in particular solar radiation. The stoichiometry of the exclusion zone is $H_{1.5}O$ and can be understood if every fourth proton is dark proton residing at the flux tubes of the magnetic body assignable to the exclusion zone and outside it.

This leads to a model for prebiotic cell as exclusion zone. Dark protons are proposed to form dark nuclei whose states can be grouped to groups corresponding to DNA, RNA, amino-acids, and tRNA and for which vertebrate genetic code is realized in a natural manner. The voltage associated with the system defines the analog of membrane potential, and serves as a source of metabolic energy as in the case of ordinary metabolism. The energy is liberated in a reverse phase transition in which dark protons transform to ordinary ones. Dark proton strings serve as analogs of basic biopolymers and one can imagine analog of bio-catalysis with enzymes replaced with their dark analogs. The recent discovery that metabolic cycles emerge spontaneously in absence of cell support this view.

One can find a biographical sketch [I2] (`http://tinyurl.com/ycqtuchp`) giving a list of publications containing items related to the notions of exclusion zone and fourth phase of water discussed in the talk.

7.1 Pollack's Findings

I list below some basic experimental findings about fourth gel like phase of water made in the laboratory led by Gerald Pollack [L10].

1. In water bounded by a gel a layer of thickness up to 100-200 microns is formed. All impurities in this layer are taken outside the layer. This motivates the term "exclusion zone". The layer consists of layers of molecular thickness and in these layers the stoichiometry is $H_{1.5}O$. The layer is negatively charged. The outside region carries compensating positive charge. This kind of blobs are formed in living matter. Also in the splitting of water producing Brown's gas negatively charged regions are reported to emerge [**?**, **?**].

2. The process requires energy and irradiation by visible light or thermal radiation generates the layer. Even the radiation on skin can induce the phase transition. For instance, the blood flow in narrow surface veins requires metabolic energy and irradiation forces the blood to flow.

3. The layer can serve as a battery: Pollack talks about a form of free energy deriving basically from solar radiation. The particles in the layer are taken to the outside region, and this makes possible disinfection and separation of salt from sea water. One can even understand how clouds are formed and mysteries related to the surface tension of water as being due the presence of the layer formed by $H_{1.5}O$.

4. In the splitting of water producing Brown's gas [**?**, **?**] having a natural identification as Pollack's fourth phase of water the needed energy can come from several alternative sources: cavitation, electric field, etc...

7.2 Dark Nuclei And Pollack's Findings

While listening the lecture of Pollack I realized that a model for dark water in term of dark proton sequences is enough to explain the properties of the exotic water according to experiments done in the laboratory of Pollack. There is no need to assume sequences of half-dark water molecules containing one dark proton each.

7.2.1 Model for the formation of exclusion zones

The data about formation of exclusion zones allows to construct a more detailed model for what might happen in the formation of exclusion zones.

1. The dark proton sequences with dark proton having size of order atomic nucleus would reside at the flux tubes of dark magnetic field which is dipole like field in the first approximation and defines the magnetic body of the negatively charged water blob. This explains the charge separation if the flux tubes have length considerably longer than the size scale of the blob which is given by size of small cell. In the model inspired by Moray B. King's lectures charge separation is poorly understood.

2. An interesting question is whether the magnetic body is created by the electronic currents or whether it consists of flux tubes carrying monopole flux: in the latter case no currents would be needed. This is obviously purely TGD based possibility and due to the topology of CP_2.

3. This means that in the model inspired by the lectures of Moray B. King discussed above, one just replaces the sequences of partially dark water molecules with sequences of dark protons at the magnetic body of the $H1.5O$ blob. The model for the proto-variants of photosynthesis and metabolism remain as such. Also now genetic code would be realized [K19, L2].

4. The transfer of impurities from the exclusion zone could be interpreted as a transfer of them to the magnetic flux tubes outside the exclusion zone as dark matter.

These primitive forms of photosynthesis and metabolism form could be key parts of their higher level chemical variants. Photosynthesis by irradiation would induce a phase transition generating dark magnetic flux tubes (or transforming ordinary flux tubes to dark ones) and the dark proton sequences at them. Metabolism would mean burning of the resulting blobs of dark water to ordinary water leading to the loss of charge separation. This process would be analogous to the catabolism of organic polymers liberating energy. Also organic polymers in living matter carry their metabolic energy as dark proton sequences: the layer could also prevent their hydration. That these molecules are typically negatively charged would conform with the idea that dark protons at magnetic flux tubes carry the metabolic energy.

The liberation of energy would involve increase of the p-adic prime characterizing the flux tubes and reduction of Planck constant so that the thickness of the flux tubes remains the same but the intensity of the magnetic field is reduced. The cyclotron energy of dark protons is liberated in coherent fashion and in good approximation the frequencies of the radiation corresponds to multiplies of cyclotron frequency: this prediction is consistent with that in the original model for the findings of Blackman and others [J8].

The phase transition generating dark magnetic flux tubes containing dark proton sequences would be the fundamental step transforming inanimate matter to living matter and the fundamental purpose of metabolism would be to make this possible.

7.2.2 Minimal metabolic energy consumption and the value of membrane potential

This picture raises a question relating to the possible problems with physiological temperature.

1. The Josephson radiation generated by cell membrane has photon energies coming as multiples of ZeV, where V is membrane potential about.06 V and $Z = 2$ is the charge of electron Cooper pair. This gives $E = .12$ eV.

2. There is a danger that thermal radiation masks Josephson radiation. The energy for photons at the maximum of the energy density of blackbody radiation as function of frequency is given as the maximum of function $x^3/(e^x - 1)$, $x = E/T$ given by $e^{-x} + x/3 - 1 = 0$. The maximum is given approximately by $x = 3$ and thus $E_{max} \simeq 3T$ (in units $c = 1, k_B = 1$). At physiological temperature $T = 310$ K (37 C) this gives .1 eV, which is slightly below Josephson energy: living matter seems to have minimized the value of Josephson energy - presumably to minimize metabolic costs. Note however that for the thermal energy density as function of *wavelength* the maximum is at $E \simeq 5T$ corresponding to 1.55 eV which is larger than Josephson energy. The situation is clearly critical.

3. One can ask whether also a local reduction of temperature around cell membrane in the fourth phase of water is needed.

   "Electric expansion" of water giving rise to charge separation and presumably creating fourth phase of water is reported to occur [**?**, **?**].

   (b) Could the electric expansion/phase transition to dark phase be adiabatic involving therefore no heat transfer between the expanding water and environment? If so, it would transform some thermal energy of expanding water to work and reduce its temperature. The formula for the adiabatic expansion of ideal gas with f degrees of freedom for particle ($f = 3$ if there are no other than translational degrees of freedom) is $(T/T_0) = (V/V_0)^{-\gamma}$, $\gamma = (f + 2)/f$. This gives some idea about how large reduction of temperature might be involved. If p-adic scaling for water volume by a power of two takes place, the reduction of temperature can be quite large and it does not look realistic.

   (c) The electric expansion of water need not however involve the increase of Planck constant for water volume. Only the Planck constant for flux tubes must increase and would allow the formation of dark proton sequences and the generation of cyclotron Bose-Einstein condensates or their dark analog in which fermions (electrons in particular) effectively behave as bosons (the anti-symmetrization of wave function would occur in dark degrees of freedom corresponding to multi-sheeted covering formed in the process).

7.3 Fourth Phase Of Water And Pre-Biotic Life In TGD Universe

7.3.1 Metabolism and fourth phase of water

If the fourth phase of water defines pre-biotic life form then the phase transition generating fourth phase of water and its reversal are expected to be fundamental elements of the ordinary metabolism, which would have developed from the pre-biotic metabolism. The following arguments conforms with this expectation.

1. Cell interiors, in particular the interior of the inner mitochondrial membrane are negatively charged as the regions formed in Pollack's experiments. Furthermore, the citric acid cycle, (`http://tinyurl.com/y8ubjgnc`), which forms the basic element of both photosynthesis (`http://tinyurl.com/yauwzkho`) and cellular respiration `http://tinyurl.com/ybeefxmb`, involves electron transport chain (`http://tinyurl.com/yat3m4vk`) in which electron loses gradually its energy via production of NADP and proton at given step. Protons are pumped to the other side of the membrane and generates proton gradient serving as metabolic energy storage just like battery. The interpretation for the electron transport chain in terms of Pollack's experiment would be in terms of generation of dark protons at the other side of the membrane.

2. When ATP is generated from ADP three protons per ATP flow back along the channel formed by the ATP synthase molecule (`http://tinyurl.com/yd5ndcyk`) (perhaps Josephson junction) and rotate the shaft of a "motor" acting as a catalyst generating three ATP molecules per turn by phosphorylating ADP. The TGD based interpretation is that dark protons are transformed back to ordinary ones and possible negentropic entanglement is lost.

3. ATP is generated also in glycolysis (`http://tinyurl.com/ybzgdgve`), which is ten-step process occurring in cytosol so that membrane like structure need not be involved. Glycolysis involves also generation of two NADH molecules and protons. An open question (to me) is whether the protons are transferred through an endoplasmic reticulum or from a region of ordered water (fourth phase of water) to its exterior so that it would contribute to potential gradient and could go to magnetic flux tubes as dark proton. This would be natural since glycolysis is realized for nearly all organisms and electron transport chain is preceded by glycolysis and uses as input the output of glycolysis (two pyruvate molecules (`http://tinyurl.com/y8v7aq9s`)).

4. Biopolymers - including DNA and ATP - are typically negatively charged. They could thus be surrounded by fourth phase of water and neutralizing protons would reside at the magnetic bodies. This kind of picture would conform with the idea that the fourth phase (as also magnetic body) is fractal like. In phosphorylation the metabolic energy stored to a potential difference is transferred to shorter length scales (from cell membrane scale to molecular scale).

In glycolysis (`http://tinyurl.com/ybzgdgve`) the net reaction $C_6H_{12}O_6+6O_2 \rightarrow 6CO_2(g)+6H_2O(l)+heat$ takes place. The Gibbs free energy change is $\Delta G = -2880$ kJ per mole of $C_6H_{12}O_6$ and is negative so that the process takes place spontaneously. Single glucose molecule is theoretized to produce $N = 38$ ATP molecules in optimal situation but there are various energy losses involved and the actual value is estimated to be 29-30. From $Joule = 6.84 \times 10^{18}$ eV and $mol = 6.02 \times 10^{23}$ and for $N = 38$ one would obtain the energy yield.86 eV per single ATP. The nominal value that I have used.5 eV. This is roughly 5 to 8 times higher than $E = ZeV, Z = 2$, which varies in the range.1-.16 eV so that the metabolic energy gain cannot be solely due to the electrostatic energy which would actually give only a small contribution.

In the thermodynamical approach to metabolism the additional contribution would be due to the difference of the chemical potential μ for cell exterior and interior, which is added to the membrane potential as effective potential energy. The discrepancy is however rather large and this forces the question the feasibility of the model. This forces to reconsider the model of osmosis in the light of Pollack's findings.

7.3.2 Pollack's findings in relation to osmosis and model for cell membrane and EEG

Osmosis (`http://tinyurl.com/yc5dbtzv`) has remained to me poorly understood phenomenon. Osmosis means that solvent molecules move through a semipermeable membrane to another side of the membrane if the concentration of solute is higher at that side. Solute can be water or more general liquid, supercritical liquid, and even gas.

Osmosis is not diffusion: it can occur also towards a higher concentration of water. Water molecules are not attracted by solute molecules. A force is required and the Wikipedia explanation is that solute molecules approaching pores from outside experience repulsion and gain momentum which is transferred to the water molecules.

The findings of Pollack inspire the question whether the formation of exclusion zone could relate to osmosis and be understood in terms of the fourth phase of water using genuine quantal description.

In the thermodynamical model for ionic concentrations one adds to the membrane resting potential a contribution from the difference of chemical potentials μ_i at the two sides of the membrane. Chemical potentials for the ions parametrize the properties of the cell membrane reducing basically to the properties of the channels and pumps (free diffusion and membrane potential do not entirely determine the outcome).

If the transfer of ions - now protons - through cell membrane is quantal process and through Josephson junctions defined by transmembrane proteins, then the thermodynamical model can at best be a phenomenological parameterization of the situation. One should find the quantum counterpart of thermodynamical description, and here the identification of quantum TGD as square root of thermodynamics in Zero Energy Ontology (ZEO) suggests itself. In this approach thermodynamical distributions are replaced by probability amplitudes at single particle level such that their moduli squared give Boltzmann weights.

1. Simplest Josephson junction model for cell membrane

The first guess is that quantum description is achieved by a generalization of the Josephson junction model allowing different values of Planck constant at magnetic flux tubes carrying dark matter.

1. Josephson junctions correspond microscopically to transmembrane proteins defining channels and pumps. In rougher description entire cell membrane is described as Josephson junction.

2. The magnetic field strength at flux tube can differ at the opposite side of the membrane and even the values of h_{eff} could in principle be different. The earlier modelling attempts suggest that $h_{eff}/h = n = 2^k A$, where A is the atomic weight of ion, is a starting assumption deserving testing. This would mean that each ion resides at its own flux tubes.

   The phase transitions changing the value of h_{eff} could induce ionic flows through cell membrane, say that occurring during nerve pulse since the energy difference defining the ratio of square roots of Boltzmann weights at the two sides of the membrane would change. Also the change of the local value of the magnetic field could do the same.

Consider first the simplest model taking into account only membrane potential.

1. The simplest model for Josephson junction defined by the transmembrane protein is as a two state system (Ψ_1, Ψ_2) obeying Schrödinger equation.

$$i\hbar_1 \frac{\partial \Psi_1}{\partial t} = ZeV\Psi_1 + k_1\Psi_2 \ ,$$

$$i\hbar_2 \frac{\partial \Psi_2}{\partial t} = k_2\Psi_2 \ .$$

   One can use the decomposition $\Psi_i = R_i exp(i\Phi(t)$ to express the equations in a more concrete form. The basic condition is that the total probability defined as sum of moduli squared equals to one: $R_1^2 + R_2^2 = 1$. This is guaranteed if the hermiticity condition $k_1/\hbar_1 = \overline{k_2}\hbar_2$ holds true. Equations reduce to those for an ordinary Josephson junction except that the frequency for the oscillating Josephson current is scaled down by $1/h_{eff}$.

2. One can solve for R_2 assuming $\Phi_1 = eVt/\hbar_{eff}$. This gives

$$R_2(t) = sin(\Phi_0) + \frac{k_1}{\hbar_1} sin(\frac{eVt}{\hbar_1}) \ .$$

   R_2 oscillates around $sin(\Phi_0)$ and the concentration difference is coded by $\Phi 0$ taking the role of chemical potential as a phenomenological parameter.

3. The counterparts of Boltzmann weights would be apart from a phase factor square roots of ordinary Boltzmann weights defined by the exponent of Coulomb energy:

$$R = sin(\phi_0) = exp(\frac{ZeV(t)}{2T}) \ .$$

   Temperature would appear as a parameter in single particle wave function and the interpretation would be that thermodynamical distribution is replaced by its square root in quantum theory. In ZEO density matrix is replaced by its hermitian square root multiplied by density matrix.

2. The counterpart of chemical potential in TGD description

This model is not as such physically realistic since the counterpart of chemical potential is lacking. The most straightforward generalization of the thermodynamical model is obtained by the addition of an ion dependent chemical potential term to the membrane potential: $ZeV \to ZeV + \mu_I$. This would however require a concrete physical interpretation.

1. The most obvious possibility is that also the chemical potential actually correspond to an interaction energy - most naturally the cyclotron energy $E_c = \hbar_{eff} ZeB_{end}/m$ of ion - in this case proton - at the magnetic flux tube. Cyclotron energy is proportional to h_{eff} and can be rather large as assumed in the model for the effects of ELF em fields on brain.

2. This model would predict the dependence of the effective chemical potential on the mass and charge of ion for a fixed value of on h_{eff} and B_{end}. The scales of ionic chemical potential and ion concentrations would also depend on value of h_{eff}.

3. The model would provide a different interpretation for the energy scale of bio-photons, which is in visible range rather than infrared as suggested by the value of membrane potential.

   The earlier proposal [K17] was that cell membrane can be in near vacuum extremal configuration in which classical Z^0 field contributes to the membrane potential and gives a large contribution for ions. The problematic aspect of the model was the necessity to assume Weinberg angle in this phase to have much smaller value than usually. This difficulty could be perhaps avoided by noticing that the membrane potentials can differ for color receptors so that the earlier assignment of specific ions to color receptors could make sense for ordinary value of Weingerg angle. Second problem is that for proton the Z^0 contribution is negligible in good approximation so that this model does not explain the high value of the metabolic energy currency.

4. The simplest model the communications to magnetic body rely on Josephson radiation whose fundamental frequency f_J is at resonance identical with the cyclotron frequency $f_c(MB)$ at particular part of the flux tube of the magnetic body: ($f_c(MB) = f_J$. $f_c(MB)$ corresponds to EEG frequency in the case of brain and biophotons are produced from dark EEG photons as ordinary photons in phase transition reducing $h_{eff} = n \times h$ to h.

   In the modified model the sum $f_c + f_{J,n}$ ($f_{J,n} = E_J/n \times h$) of h_{eff}-independent cyclotron frequency and Josephson frequency proportional to $1/h_{eff}$ equals to cyclotron frequency $f_c(MB)$ at "personal" magnetic body varying slowly along the flux tube: $f_c + f_{J,n} = f_c(MB)$. If also the variation of f_J assignable to the action potential is included, the total variation of membrane potential gives rise to a frequency band with width roughly

$$\frac{\Delta f}{f} \simeq \frac{2f_{J,n}}{f_c + f_{J,n}} = \frac{2f_{J,1}}{nf_c + f_{J,1}} \quad .$$

   If dark photons correspond to biophotons the energy is of cyclotron photon is in visible and UV range one has $nf_c = E_{bio}$ and

$$\frac{\Delta f}{f} \simeq \frac{2ZeV}{E_{bio} + ZeV} \quad .$$

   The prediction is scale invariant and same for all ions and also electron unless E_{bio} depends on ion. For $eV = .05$ eV, $Z = 1$, and $E_{bio} = 2$ eV ($f \simeq 5 \times 10^{14}$ Hz) one has $\Delta f/f \sim .1$ giving 10 per cent width for EEG bands assumed in the simpler model.

If this vision is on the correct track, the fundamental description of osmosis would be in terms of a phase transition to the fourth phase of water involving generation of dark matter transferred to the magnetic flux tubes. For instance, the swelling of cell by an in-flow of water in presence of higher concentration inside cell could be interpreted as a phase transition extending exclusion zone as a process accompanied by a phase transition increasing the value of h_{eff} so that the lengths of the flux tube portions inside the cell increase and the size of the exclusion zone increases. In general case the phase transitions changing h_{eff} and B_{end} by power of two factor are possible. This description should bring magnetic body as part of bio-chemistry and allow understanding of both equilibriumion distributions, generation of nerve pulse, and basic metabolic processes leading to the generation of ATP.

One can also model sensory receptors and try to understand the maximal sensitivity of color receptors to specific wavelengths in this framework. The new degrees of freedom make this task easy if one is only interested in reproducing these frequencies. More difficult challenge is to understand the color receptors from the first principles. It is also possible to combine the new view with the assumption that sensory receptor cells are near to vacuum extremals. This would add a cyclotron contribution to the generalized Josephson frequency depending only weakly on particle and being non-vanishing also for em neutral particles.

7.3.3 Why would charge separation generate large h_{eff}?

The basic question is whether and how the separation of electron and proton charges generates large h_{eff}? A possible mechanism emerged from a model [K40] explaining anomalously large gravimagnetic effect claimed by Tajmar *et al* [E2, E4] to explain the well-established anomaly related to the mass of Cooper pairs in rotating super-conduction. The mass is too large by fraction of order 10^{-4} and the proposal is that gravimagnetism changes slightly the effective Thomson magnetic field associated with the rotating super-conductor leading to wrong value of Cooper pairs mass when only ordinary Thomson field is assumed to be present. The needed gravimagnetic field is however gigantic: 28 orders larger than that predicted by GRT. Gravimagnetic field is proportional h_{eff}^2 in TGD and if one uses h_{gr} for electron-Earth system one obtains correct order of magnitude.

Nottale's finding that planetary orbits seem to correspond to Bohr orbits in gravitational potential with gigantic value of gravitational Planck constant is the basic input leading to the model of gravimagnetic anomaly.

1. By Equivalence Principle h_{gr} has the general form $h_{gr} = GMm/v_0$, where M and m are the interacting masses and v_0 is a parameter with dimensions of velocity. For 4 inner planets one has $v_0/c \simeq 2^{-11}$.

2. The notion of h_{gr} generalizes to that for other interactions. For instance, in electromagnetic case the formation of strong em fields implying charge separation leads to systems in which $h_{em} = Z_1 Z_2 e^2/v_0$ is large. Pollack's exclusion zone and its complement define this kind of systems and is identified as prebiotic life form.

3. Since the natural expansion parameter of perturbative expansion is the $g^2/4\pi\hbar$, one can say that transition to dark matter phase make the situation perturbative. Mother Nature is theoretician friendly.

h_{em} might be large in the exclusion zones (EZ) appearing in the water bounded by gel and their variants could play central role in living matter.

1. EZ carries very large negative charge with positive charge outside the exclusion zone.

2. TGD interpretation is in terms of $H_{1.5}O$ phase of water formed when every 4: th proton is transferred to magnetic body as dark particle with large value of h_{eff}. The proposal is that primitive life form is in question.

3. The pair formed by EZ and its complement could have large value of $h_{eff} = h_{em} = Z^2 e^2/v_0$.

4. The velocity parameter v_0 should correspond to some natural rotation velocity. What comes in mind is that complement refers to Earth and v_0 is the rotation velocity at the surface of Earth. The prediction for h_{eff} would be of order $h_{em}/h = 4\pi\alpha Z^2 \times .645 \times 10^6 \simeq 5.9 \times 10^4 Z^2$.

5. Cell membrane involves also large charge separation due to very strong electric field over the cell membrane. Also now dark phases with large h_{em} or h_{gr} could be formed.

I have proposed that metabolic machinery generates large h_{eff} phase somehow. $h_{eff} = h_{em}$ hypothesis allows to develop this hypothesis in more detail.

1. I have speculated earlier [K21] that the rotating shaft of a molecular motor associated with ATP synthase plays a key role in generating dark matter phase. What comes in mind is that charge separation takes place associating exclusion zone with the shaft and the rotational velocity v_0 of the shaft appears in the formula for h_{em}. Of course, some numerical constant not far from unity could be present. The electric field over the mitochondrial membrane generates charge separation. One can imagine several identifications for the product of charges. The charge Z associated with the complement would be naturally associated with single dark flux tube containing dark nucleon consisting of dark protons. For instance, the charge associated with the exclusion zone could be the charge of the electronic Cooper pair giving $h_{em} = 2e \times Z/v_0$.

2. The value of v_0/c is expected to be of order 10^{-14} from the angular rotation rate of ADP synthase about few hundred revolutions per second. The order of magnitude for h_{em} could be same as for h_{gr} associated with Earth-particle system.

$h_{eff}(ATPsynthase) = h_{gr}(2e, Earth)$ would make possible reconnection of electromagnetic flux tubes with gravimagnetic flux tubes [K35].

7.3.4 Which came first: metabolism or cell membrane?

One of the basic questions of biology is whether metabolism preceded basic biopolymers or vice versa. RNA world scenario assumes that RNA and perhaps also genetic code was first.

1. The above view suggests that both approaches are correct to some degree in TGD Universe. Both metabolism and genetic code realized in terms of dark proton sequences would have emerged simultaneously and bio-chemistry self-organized around them. Dark proton sequences defining analogs of amino-acid sequences could have defined analogs of protein catalysts and played a key role in the evolution of the metabolic pathways from the primitive pathways involving only the phase transition between ordinary water and fourth phase of water.

2. There is very interesting article (see `http://tinyurl.com/ycdhd4fd`) [**?**]eporting that complex metabolic pathways are generated spontaneously in laboratory environments mimicking hot thermal vents. Glycolysis and pentose phosphate pathway were detected. The proposal is that these pathways are catalyzed by metals rather than protein catalysts.

3. In standard biology these findings would mean that these metabolic pathways emerged before basic biopolymers and that genetic code is not needed to code for the metabolic pathways during this period. In TGD framework dark genetic code [K19, L2] would be there, and could code for the dark pathways. Dark proton strings in one-one correspondence with the amino-acid sequences could be responsible for catalysts appearing in the pathways. Only later these catalysts would have transformed to their chemical counterparts and might be accompanied by their dark templates. One cannot even exclude the possibility that the chemical realization of the DNA-amino-acid correspondence involves its dark analog in an essential manner.

7.4 Could Pollack effect make cell membrane a self-loading battery?

The so called Clarendon dry pile is 175 years old battery still working. The current is very weak (nano Ampere) but the working of the battery is claimed to be not well-understood. The TGD inspired model for cold fusion leads to the proposal that Pollack effect is part of electrolysis. This inspires the idea that Pollack effect and possibly also the associated cold fusion could make Clarendon dry pile a self-loading battery. Cell membrane can be regarded as the analog of self-loading battery, and in TGD framework also as a generalised Josephson junction. Hence one can ask whether also cell membrane could be seen as a self-loading battery utilizing Pollack's mechanism. This would also allow to understand why hyperpolarization stabilizes the membrane potential and why depolarization generates nerve pulse.

7.4.1 Clarendon pile: 175 years old battery still working

Elemer Rosinger had a Facebook link to an article telling about Clarendon dry pile, a very long-lived battery providing energy for an electric clock (see `http://tinyurl.com/zeut69y`, `http://tinyurl.com/jhrww2a`, and `http://tinyurl.com/gvbrhra`). This clock known also as Oxford bell has been ringing for 175 years now and the article suggests that the longevity of the battery is not really understood. The bell is not actually ringing so loud that human ear could hear it but one can see the motion of the small metal sphere between the oppositely charged electrodes of the battery in the video.

The function principle of the clock is simple. The gravitational field of earth is also present. When the sphere touches the negative electrode, it receives a bunch of electrons and gives the bunch away as it touches positive electrode so that a current consisting of these bunches is running between

electrons. The average current during the oscillation period of 2 seconds is nanoampere so that nanocoulomb of charge is transferred during each period (Coulomb corresponds to a 6.242×10^{18} elementary charges (electrons)).

The dry pile was discovered by priest and physicist Giuseppe Zamboni at 1812 (see `http://tinyurl.com/jkvtj6f`). The pile consists of 2,000 pairs of pairs of discs of tin foil glued to paper impregnated with Zinc sulphate and coated on the other side with manganese dioxide: 2,000 thin batteries in series. The operation of battery gradually leads to the oxidation of Zinc and the loss of magnase dioxide but the process takes place very slowly. One might actually wonder whether it takes place too slowly so that some other source of energy than the electrostatic energy of the battery would be keep the clock running. Karpen pile is analogous battery discover by Vasily Karpen (see `http://tinyurl.com/jpzcs32`). It has now worked for 50 years.

Cold fusion is associated with electrolysis. Could the functioning of this mystery clock involve cold fusion taken seriously even by American Physical Society thanks to the work of the group of prof. Holmlid. Electrolytes have of course been "understood" for aeons. Ionization leads to charge separation and current flows in the resulting voltage. With a feeling of deep shame I must confess that I cannot understand how the ionization is possible in standard physics. This of course might be just my immense stupidity - every second year physics student would immediately tell that this is "trivial" - so trivial that he would not even bother to explain why. The electric field between the electrodes is immensely weak in the scale of molecules. How can it induce the ionisation? Could ordinary electrolytes involve new physics involving cold fusion liberating energy? These are the questions which pop up in my stupid mind. Stubborn as I am in my delusions, I have proposed what this new physics might be with inspiration coming from strange experimental findings of Gerald Pollack, cold fusion, and my own view about dark matter has phases of ordinary matter with non-standard value $h_{eff} = n \times h$ of Planck constant. Continuing with my weird delusions I dare ask: Could cold fusion provide the energy for the "miracle" battery?

7.4.2 What batteries are?

To understand what might be involved one must first learn some basic concepts. I am trying to do the same.

1. Battery (see `http://tinyurl.com/8xqsnab`) consistes of two distinct electrochemical cells (see `http://tinyurl.com/jq8ljmo`). Cell consists of electrode and electrolyte. The electrodes are called anode and catode. By definition electron current along external wire flows to catode and leaves anode.

2. There are also ionic currents flowing inside the battery. In absence of the ionic currents the electrodes of the battery lose their charge. In the loading the electrodes get their charges. In the ideal situation the ionic current is same as electron current and the battery does not lose its charging. Chemical reactions are however taking place near and at the electrodes and in their reversals take place during charging. Chemical changes are not completely reversible so that the lifetime of the battery is finite.

   The ionic current can be rather complex: the carriers of the positive charge from anode can even change during the charge transfer: what matters that negative charge from catode is transferred to anode in some manner and this charge logistics can involve several steps. Near the catode the currents of positive ions (cations) and electrons from the anode combine to form neutral molecules. The negative current carriers from catode to the anode are called anions.

3. The charge of the clectrochemical cell is in the electrolyte near the surface of the electrode rather than inside it as one might first think and the chemical processes involve neutralization of ion and the transfer of neutral outcome to or from the electrode.

4. Catode - or better, the electrochemical cell containing the catode - can have both signs of charge. For positive charge one has a battery liberating energy as the electron current connecting the negative and positive poles goes through the load, such as LED. For negative charge current flows only if there is external energy feed: this is loading of the battery. External voltage source and thus energy is needed to drive the negative charges and positive

charges to the electrodes. The chemical reactions involved can be rather complex and proceed in reverse direction during the loading process. Travel phone battery is a familiar example.

During charging the roles of the anode and catode are changed: understanding this helps considerably.

7.4.3 Could dark cold fusion make possible self-loading batteries?

Could cold fusion help to understand why the Clarendon dry pile is so long lived?

1. The battery is series of very many simpler batteries. The mechanism should reduce to the level of single building brick. This is assumed in the following.

2. The charge of the battery tends to be reduced unless the ionic and electronic currents are identical. Also chemical changes occur. The mechanism involved should oppose the reduction of the charging by creating positive charge to the catode and negative charge to the anode or induce additional voltage between the electrodes of the battery inducing its loading. The energy feed involved might also change the direction of the basic chemical reactions as in the ordinary loading by raising the temperature at catode or anode.

3. Could be formation of Pollack's exclusion zones (EZs) in the elecrolytic cell containing the anode help to achieve this? EZs carry a high electronic charge. According to TGD based model protons are transformed to dark protons at magnetic flux tubes. If the positive dark charge at the flux tubes is transferred to the electrolytic cell containing catode and transformed to ordinary charge, it would increase the positive charge of the catode. The effect would be analogous to the loading of battery. The energy liberated in the process would compensate for the loss of charge energy due to electronic and ionic currents.

4. In the ordinary loading of the battery the voltage between batteries induces the reversal of the chemical processes occurring in the battery. This is due to the external energy feed. Could the energy feed from dark cold fusion induce similar effects now? For instance, could the energy liberated at the catode as positively charged dark nuclei transform to ordinary ones raise the temperature and in this manner feed the energy needed to change the direction of the chemical reactions.

7.4.4 Cell membrane as self-loading battery and how nerve pulse is generated?

This model might have an interesting application to the physics of cell membrane.

1. Cell membrane consisting of two lipid layers defines the analog of a battery. Cell interior plus inner lipid layer (anode) and cell exterior plus outer lipid layer (catode) are analogs of electrolyte cells.

   What has been troubling me for two decades is how this battery manages to load itself. Metabolic energy is certainly needed and ADP-ATP mechanism is essential element. I do not however understand how the membrane manages to keep its voltage.

   Second mystery is why it is hyperpolarization rather than polarization, which tends to stabilize the membrane potential in the sense that the probability for the spontaneous generation of nerve pulse is reduced. Neither do I understand why depolarization (reduction of the membrane voltage) leads to a generation of nerve pulse involving rapid change of the sign of the membrane voltage and the flow of various ionic currents between the interior and exterior of the cell.

2. In the TGD inspired model for nerve pulse cell interior and cell exterior or at least their regions near to lipid layers are regarded as super-conductors forming a generalized Josephson junction. For the ordinary Josephson junction the Coulombic energy due to the membrane voltage defines Josephson energy. Now Josephson energy is replaced by the ordinary Josephson energy plus the difference of cyclotron energies of the ion at the two sides of the membrane. Also ordinary Josephson radiation can be generated. The Josephson currents are assumed to run along magnetic flux tubes connecting cell interior and exterior. This

assumption receives support from the strange finding that the small quantal currents associated with the membrane remain essentially the same when the membrane is replaced with polymer membrane.

3. The model for Clarendon dry pile suggests an explanation for the self-loading ability. The electrolytic cell containing the anode corresponds to the negatively charged cell interior, where Pollack's EZs would be generated spontaneously and the feed of protonic charge to the outside of the membrane would be along flux tubes as dark protons to minimize dissipation. Also ions would flow along them. The dark protons driven to the outside of the membrane transform to ordinary ones or remain dark and flow spontaneously back and provide the energy needed to add phosphate to ADP to get ATP.

4. The system could be quantum critical in the sense that a small reduction of the membrane potential induces nerve pulse. Why the ability to generate Pollack's EZs in the interior would be lost for a few milliseconds during nerve pulse? The hint comes from the fact that Pollack's EZs can be generated by feeding infrared radiation to a water bounded by gel. Also the ordinary Josephson radiation generated by cell membrane Josephson junction has energy in infrared range!

   Could the ordinary Josephson radiation generate EZs by inducing the ionization of almost ionized hydrogen bonded pairs of water molecules. The hydrogen bonded pairs must be very near to the ionization energy so that ordinary Josephson energy of about .06 eV assignable to the membrane voltage is enough to induce the ionization followed by the formation of $H_{3/2}O$. The resulting EZ would consist of layers with the effective stoichiometry $H_{3/2}O$.

   As the membrane voltage is reduced, Josephson energy would not be anymore enough to induce the ionization of hydrogen bonded pair of water molecules, EZs are not generated, and the battery voltage is rapidly reduced: nerve pulse is created. In the case of hyperpolarization the energy excees the energy needed for ionization and the situation becomes more stable.

5. This model could also allow to understand the effect of anesthetes [K33] [L13]. Anesthetes could basically induce hyperpolarization so that Josephson photons would continually generate Pollack's EZ:s and creating of dark particles at the magnetic flux tubes. This need not mean that consciousness is lost at the cell level. Only sensory and motor actions are prevented because nerve pulses are not possible. This prevents formation of sensory and motor mental images at our level of hierarchy.

   Meyer-Overton correlation states that the effectiveness of the anesthete correlates with its solubility to the lipid membrane. This is the case if the presence of anesthete in the membrane induces hyperpolarization so that the energies of the photons of Josephson radiation would be higher than needed for the generation of EZs accompanied by magnetic flux tubes along which ionic Josephson currents would flow between cell interior and exterior. For these quantal currents evidence exists [K37]. In the case of battery these dark ions would flow from the cell containing anode to that containing catode. For depolarization the energy of Josephson photons would be too low to allow the kicking off protons from hydrogen bonded pairs of water molecules so that EZs would not be created and self-loading would stop and nerve pulse would be generated.

8 Implications Of Strong Gravimagnetism For TGD Inspired Quantum Biology

Physicists M. Tajmar and C. J. Matos and their collaborators working in ESA (European Satellite Agency) have made an amazing claim of having detected strong gravimagnetism with gravimagnetic field having a magnitude which is about 20 orders of magnitude higher than predicted by General Relativity [E2]. If the findings are replicable they mean a revolution in the science of gravity and, as one might hope, force a long-waited serious reconsideration of the basic assumptions of the dominating super-string approach.

Tajmar *et al* have proposed [E4] the gravimagnetic effect as an explanation of an anomaly related to the superconductors. The measured value of the mass of the Cooper pair is slightly

larger than the sum of masses whereas theory predicts that it should be smaller. The explanation would be that actual London field is larger than it should be because of gravimagnetic contribution to quantization rule used to deduce the value of London field.

TGD explanation of the discrepancy accepting the theory of Tajmar *et al* comes from the proposal inspired by Nottale's observations [E1] suggesting that Bohr's rules apply in planetary system with Planck constant replaced by $\hbar_{gr} = GMm/v_0$. Here M and m are the masses of Sun and planet. $v_0/c \simeq 2^{-11}$ holds true for the 4 inner planets Mercury, Venus, Earth, Mars and $v_0 \to v_0/5$ and principal quantum number $n_P \geq 2$ for the outer planets. Mars could be also though of as having $v_0/5$ and $n_P = 1$. The rotation velocities of the planets are related to v_0 by Bohr rules. h_{gr} clearly characterizes the pair Sun-planet rather than being fundamental constant whereas the gravitational Compton length GM/v_0 depends on M only. In the TGD framework one assigns gravitational Planck constant to the flux tube connecting the masses and along which the gravitational massless extremals mediating the gravitational interaction are mediated. By Equivalence Principle it is possible to apply the hypothesis only in elementary particle length scales (this does not exclude its application in longer scales) and in these scales $h_{eff} = h_{gr}$ makes sense.

Gravimagnetic London field is proportional to the square of Planck constant and the obvious guess is that the replacement h with h_{gr} could explain the enormous discrepancy with GRT if gravimagnetism is in question. This predicts correctly the magnitude of the effect and one also ends up with the identification of the $h_{gr} = h_{eff}$ in elementary particle scales.

Also a vision about the fundamental role of quantum gravitation in living matter emerges. The earlier hypothesis that dark EEG photons decay to biophotons with energies in visible and ultraviolet range [K13, K6] receives strong quantitative support. This leads also to a simple model for how magnetic bodies control molecular transitions via dark cyclotron radiation with varying frequencies vary but universal energy spectrum since for a given magnetic field all charged particles gives rise to biophotons with same energy. The values of h_{gr}/m and endogenous magnetic field $B_{end} \simeq .2$ Gauss are such that the spectrum of biophotons is in the range of molecular binding energies. This vision would conform with Penrose intuitions about the fundamental role of gravitation in quantum biology.

8.1 The Theory fof Tajmar *et al* for fhe Anomaly ff Cooper Pairs Mass

The starting point of the theory of Tajmar and Matos [E4] is the so called London magnetic moment generated in rotating charged super-conductors adding a constant contribution to the exponentially damped Meissner contribution to the magnetic field. This contribution can be understood as being due to the massivation of photons in super-conductors. The modified Maxwell equations are obtained by just adding scalar potential mass term to Gauss law and vector potential mass term to the equation related the curl of the magnetic field to the em current.

The expression for the London magnetic field is given by

$$B = 2\omega_R n_s \times \lambda_\gamma^2 \ , \tag{8.1}$$

where ω_R is the angular velocity of superconductor, n_s is charge density of super-conducting particles and $\lambda_\gamma = \hbar/m_\gamma$ is the wave length of a massive photon at rest. In the case of ordinary superconductor one has $\lambda_\gamma = \sqrt{m^*/q^* n_s}$, where $m^* \simeq 2m_e$ and $q^* = -2e$ are the mass and charge of Cooper pair. Hence one has

$$B = -2\frac{m^*}{2e}\omega_R \ . \tag{8.2}$$

Magnetic field extends also outside the super-conductor and by measuring it with a sufficient accuracy outside the super-conductor one can determine the value of the electron mass. Instead of the theoretical value $m^*/2m_e = .999992$ which is smaller than one due to the binding energy of the Cooper pair the value $m^*/2m_e = 1.000084$ was found by Tate [E3]. This inspired the theoretical work generalizing the notion of London field to gravimagnetism and the attempt to explain the anomaly in terms of the effects caused by the gravimagnetic field.

Note that in the case of ordinary matter the equations would lead to an inconsistency at the limit $m_\gamma = 0$ since the value of London magnetic field would become infinite. The resolution of the problem proposed in [E4] is based on the replacement of rotation frequency ω with electron's spin precession frequency $\omega_L = -eB/2m$ so that the consistency equation becomes $B = -B = 0$ for a unique choice $1/\lambda_\gamma^2 = -\frac{q}{m}n$. One could also consider the replacement of ω with electron's cyclotron frequency $\omega_c = 2\omega_L$. To my opinion there is no need to assume that the modified Maxwell's equations hold true in the case of ordinary matter.

8.1.1 Gravimagnetic field

The perturbative approach to the Einstein equations leads to equations, which are essentially identical with Maxwell's equations. The g_{tt} component of the metric plays the role of scalar potential and the components g_{ti} define gravitational vector potential. Also the generalization to the super-conducting situation in which graviphotons develop a mass is straightforward. Just add the scalar potential mass term to the counterpart of Gauss law and vector potential mass term to the equation relating the curl of the gravimagnetic field to the gravitational mass current.

In the case of a rotating superconductor London magnetic field is replaced with its gravimagnetic counterpart

$$B_{gr} = -2\omega_R\rho_m\lambda_{gr}^2 \ . \tag{8.3}$$

Obviously this formula would give rise to huge gravimagnetic fields in ordinary matter approaching infinite values at the limit of vanishing gravitational mass. Needless to say, these kind of fields have not been observed.

Equivalence Principle however suggests that the gravimagnetic field must be assigned with the rotating coordinate frame of the super-conductor. Equivalence principle would state that seing the things in a rotating reference frame is equivalent of being in a gravimagnetic field $B_{gr} = -2\omega_R$ in the rest frame. This fixes the graviphoton mass to

$$\frac{1}{\lambda_{gr}^2} = (\frac{m_{gr}}{\hbar})^2 = G\rho_m \ . \tag{8.4}$$

For a typical condensed matter density parameterized as $\rho_m = Nm_p/a^3$, $a = 10^{-10}$ m this gives the order of magnitude estimate $m_{gr} \sim N^{1/2}10^{-21}/a$ so that graviton mass would be extremely small.

If this is all what is involved, gravimagnetic field should have no special effects. In [E4] it is however proposed that in superconductors a small breaking of Equivalence Principle occurs. The basic assumptions are following.

1. Super-conducting phase and the entire system obey separately the gravitational analogs of Maxwell field equations.

2. The ad hoc assumption is that for super-conducting phase the sign of the gravimagnetic field is opposite to that for the ordinary matter. If purely kinematic effect were in question so that graviphotons were pure gauge degrees of freedom, the value of m_{gr}^2 should should be proportional to ρ_m and $\rho_m - \rho_m^*$ respectively.

3. Graviphoton mass is same for both ordinary and super-conducting matter and corresponds to the net density ρ_m of matter. This is essential for obtaining the breaking of Equivalence Principle.

With these assumptions the gravimagnetic field giving rise to acceleration field detected in the rest system would be given by

$$B_{gr}^* = \frac{\rho_m^*}{\rho} \times 2\omega \tag{8.5}$$

This is claimed to give rise to a genuine acceleration field

$$g^* = -\frac{\rho_m^*}{\rho} a \tag{8.6}$$

where a is the radial acceleration due to the rotational motion.

8.1.2 Explanation for the too high value of measured electron mass in terms of gravimagnetic field

A possible explanation of the anomalous value of the measured electron mass [E3] is in terms of gravimagnetic field affecting the flux Bohr quantization condition for electrons by adding to the electromagnetic vector potential term $q^* A_{em}$ gravitational vector potential $m^* A_{gr}$. By requiring that the quantization condition

$$\oint (m^* v + q^* A_{em} + m^* A_{gr}) dl = 0 \tag{8.7}$$

is satisfied for the superconducting ring, one obtains

$$B = -\frac{2m}{e}\omega - \frac{m}{e} B_{gr} \ . \tag{8.8}$$

This means that the magnetic field is slightly stronger than predicted and it has been known that this is indeed the case experimentally.

The higher value of the magnetic field could explain the slightly too high value of electron mass as determined from the magnetic field. This gives

$$B_{gr} = \frac{\Delta m_e}{m_e} \times 2\omega = \frac{\Delta m_e}{m_e} \times e m_e \times B \ . \tag{8.9}$$

The measurement implies $\Delta m_e/m_e = 9.2 \times 10^{-5}$. The model discussed in [E4] predicts $\Delta m_e/m_e \sim \rho^*/\rho$. The prediction is about 23 times smaller than the experimental result.

8.2 Is The Large Gravimagnetic Field Possible In TGD Framework?

TGD allows top consider several alternative solutions for the claimed effect.

Many-sheeted space-time could be an essential part of the effect (if real!).

1. In TGD framework both induced metric and various gauge fields are expressible in terms of CP_2 coordinates and their gradients. Hence the gravimagnetic field would be very probably accompanied by an ordinary magnetic field and could be even proportional to it.

2. The ordinary London magnetic field could be accompanied by analogous magnetic field at different space-time sheet playing the same role as gravimagnetic field in the proposed model. Cooper pair would experience both fields by forming topological sum contacts to both space-time sheets carrying ordinary London magnetic field $B = m_e/e\omega_R$ and much smaller London magnetic field $\Delta B = \Delta m/e\omega_R$? There would be no need to introduce gravitation but one should explain why the value of the parameter $\epsilon = \Delta m_e/m_e$ is what it is.

3. In many-sheeted space the gravimagnetic field and accompanying magnetic field would be associated with the flux tubes mediating gravitational interaction with dark matter fraction of Earth's mass. It would not be surprising if the size of the parameter ϵ might be determined by this fraction. Pioneer and Flyby effects [K39] allow to make a rough estimate for the size of this fraction and the outcome is about 2×10^{-4} which is not far from $\epsilon.9 \times 10^{-4}$.

An alternative explanation is that the experiments probe single space-time sheet and that also other Z^0 magnetic field contributes below weak scale which is scaled up for $h_{eff} = n \times h$ and can be macroscopic.

1. TGD predicts the possibility of classical electro-weak fields at larger space-time sheets. If these couple to Cooper pairs generate exotic weak charge at super-conducting space-time sheets the Bohr quantization conditions modify the value of the magnetic field. Exotic weak charge would however mean also exotic electronic em charge so that this option is excluded. It would also require that the Z^0 charge of test bodies used to measure the acceleration field is proportional to their gravitational mass.

2. According to the simplest recent view about Kähler-Dirac action [K44] the modes of Dirac operator are confined to 2-D string world sheets at which classical W boson fields vanish. This guarantees that em charge is well-defined for the modes. The stronger condition that also classical Z^0 field vanishes makes also sense and should hold at least in the length scales in which weak bosons do not appear. This guarantees the absence of axial couplings and parity breaking effects. In living matter parity breaking effects are large and one could consider the possibility that weak length scale is scaled up for $h_{eff} > h$ and that classical Z^0 fields are present below the weak scale.

3. One cannot exclude the possibility that the classical weak fields vanish for entire space-time surface. In this case spinor modes can still be seen as continuous superpositions of 2-D ones. In principle one can consider also other options - such as vanishing of induced Kḧler form or classical em field besides that of W fields.

The conservative option is that classical weak fields vanish in the situation considered so that there is room for the strong gravimagnetic field. The following model starts from the model of Tajmar *et al* and generalizes it by replacing Planck constant with its gravitational counterpart.

8.2.1 Modification of the model of Tajmar *et al* by replacing h with h_{gr}

Gravimagnetic London field is proportional to the square of Planck constant and the obvious guess is that the replacement h with h_{gr} could explain the enormous discrepancy with GRT if gravimagnetism is in question. This predicts correctly the magnitude of the effect and one also ends up with the identification of the $h_{gr} = h_{eff}$ in elementary particle scales.

One can of course develop an objection against the gravimagnetic field proportional h_{eff}^2: also ordinary London magnetic field should be scaled in the same manner due to the proportionality to λ_γ^2. The resulting magnetic field would be enormous. One can however argue that the increase of Planck constant cannot affect the value of the ordinary London magnetic field. The scaling up of length scales by h_{eff} and flux conservation suggest that the value of B scales down like $1/h_{eff}^2$. This factor is compensated by the h_{eff}^2 factor in the expression of London magnetic field coming from the expression of magnetic penetration length in terms of mass of photon. One can of course ask why magnetic and gravimagnetic London field are different.

1. The formula used by Tajmar *et al* [E4] for the gravimagnetic variant of London magnetic field is direct generalization for the London field for ordinary super-conductor. The gravimagnetic field is proportional to the product $B_g = \omega_R r^2$ of the rotation frequency ω_R of super-conductor and square of the ratio $r = (\lambda_g/\lambda_{g,T})$, where $\lambda_g = \hbar/m_g$ is graviton wave length and $\lambda_{g,T}$ is gravimagnetic penetration length obtained as generalization of the magnetic penetration length for super-conductors by replacing charge with mass. The latter is purely classical quantity whereas graviton wave length depends on Planck constant. Graviton mass can be argued to result in gravitational Meissner effect and can be estimated from the value of cosmological constant Λ being essentially its square root. The resulting value of B_g is too small by 28 orders of magnitude.

2. Tajmar *et al* [E4] suggests that graviton mass is larger by a factor of order 10^{14} in conflict with the experimental upper bound of order 10^{55} kg for m_g. TGD proposal is that it is Planck constant which should be replaced with effective Planck constant $h_{eff} = nh$ equal to gravitational Planck constant h_{gr} for electron Cooper pair in Earth's gravitational field. The model for planetary orbits as Bohr orbits together with Equivalence Principle implies $\hbar_{gr} = GMm/v_0$ at flux tubes connecting particle with mass m to Sun with mass M. v_0 has dimensions of velocity and has order of magnitude correlating with a typical rotation velocity of planetary orbit by Bohr quantization rules.

3. In the recent case the rotation velocity v_0 is the rotation velocity of Earth at its surface: $v_0(E)/c = 2.16 \times 10^{-6}$ to be compared with $v_0(S)/c \simeq .5 \times 10^{-3}$ for Sun-Earth system. The scaling of λ_g is given by $h_{gr}(E, pair)/h = (h_{gr,S,pair}/h) \times (M_E/M_S) \times v_0(S)/v_0(E)$. This gives

$$r \equiv \frac{h_{gr,S,pair}}{h} = \frac{\lambda(h_{gr,S,pair}}{\lambda(h, pair)} = \frac{\frac{GM}{v_0(S)}}{\lambda_c(pair)} = \frac{\frac{r_S}{v_0(S)}}{\lambda_c(e)} \quad .$$

   Using $r_S = 3km$ and $\lambda_e = .243 \times 10^{-12}$ m and $v_0(S) \simeq 2^{-11}$, $M_E/M_S = 3.0 \times 10^{-6}$ one obtains $r \simeq 3.6 \times 10^{14}$. This happens to be correct order of magnitude! Maybe the model might have something to do with reality. Even better, also the value of h_{eff} is consistent with its value spectrum appearing in EEG if one requires that the energy of dark EEG photon with frequency of order 10 Hz is that of biophoton with frequency of about 5×10^14 Hz. If this picture is correct the values of $h_{eff} = h_{gr}$ would comes as proportional to the masses of particles and cyclotron energies proportional to heB/m would not depend on the mass of the particle at all.

4. What is nice that the model unifies the notions of gravitational Planck constant and dark Planck constant. The basic observation is that Equivalence Principle allows to understand the effects of h_{gr} by reducing it to elementary particle level interpreted in terms of flux tubes connecting particle to the bigger system. This allows to avoid gigantic values of h_{gr} and gives connection with TGD inspired quantum biology. The new quantum physics associated with gravitation would also become key part of quantum biology.

8.2.2 Could $h_{gr} = h_{eff}$ hold true?

The obvious question is whether the gravitational Planck constant deduced from the Nottale's considerations and the effective Planck constant $h_{eff} = nh$ deduced from ELF effects on vertebrate brain and explained in terms of non-determinism of Kähler action could be identical. At first this seems to be non-sensical idea since $\hbar_{gr} = GMm/v_0$ has gigantic value.

It is however essential to realize that by Equivalence Principle one describe gravitational interaction by reducing it to elementary particle level. For instance, gravitational Compton lengths do not depend at all on the masses of particles. Also the radii of the planetary orbits are independent of the mass of particle mass in accordance with Equivalence Principle. For elementary particles the values of h_{gr} are in the same range as in quantum biological applications. Typically 10 Hz ELF radiation should correspond to energy $E = h_{eff}f$ of UV photon if one assumes that dark ELF photons have energies of biophotons and transform to them. The order of magnitude for n would be therefore $n \simeq 10^{14}$.

The experiments of M. Tajmar *et al* [E2, E4] discussed in [K40] provide a support for this picture. The value of gravimagnetic field needed to explain the findings is 28 orders of magnitude higher than theoretical value if one extrapolates the model of Meissner effect to gravimagnetic context. The amazing finding is that if one replaces Planck constant in the formula of gravimagnetic field with h_{gr} associated with Earth-Cooper pair system and assumes that the velocity parameter v_0 appearing in it corresponds to the Earth's rotation velocity around its axis, one obtains correct order of magnitude for the effect requiring $r \simeq 3.6 \times 10^{14}$.

The most important implications are in quantum biology and Penrose's vision about importance of quantum gravitation in biology might be correct.

1. This result allows by Equivalence Principle the identification $h_{gr} = h_{eff}$ at elementary particle level at least so that the two views about hierarchy of Planck constants would be equivalent. If the identification holds true for larger units it requires that space-time sheet identifiable as quantum correlates for physical systems are macroscopically quantum coherent and gravitation causes this. If the values of Planck constant are really additive, the number of parallel space-time sheets corresponding to non-determinism evolution for the flux tube connecting systems with masses M and m is proportional to the masses M and m using Planck mass as unit. Information theoretic interpretation is suggestive since hierarchy of Planck constants is assumed to relate to negentropic entanglement very closely in turn providing physical correlate for the notions of rule and concept.

2. That gravity would be fundamental for macroscopic quantum coherence would not be surprising since by EP all particles experience same acceleration in constant gravitational field, which therefore has tendency to create coherence unlike other basic interactions. This in principle allows to consider hierarchy in which the integers $h_{gr,i}$ are additive but give rise to the same universal dark Compton length.

3. The model for quantum biology relying on the notions of magnetic body and dark matter as hierarchy of phases with $h_{eff} = n \times h$, and biophotons [K13, K6] identified as decay produces of dark photons. The assumption $h_{gr} \propto m$ becomes highly predictable since cyclotron frequencies would be independent of the mass of the ion.

   (a) If dark photons with cyclotron frequencies decay to biophotons, one can conclude that biophoton spectrum reflects the spectrum of endogenous magnetic field strengths. In the model of EEG [K14] it has been indeed assumed that this kind spectrum is there: the inspiration came from music metaphors suggesting that musical scales are realized in terms of values of magnetic field strength. The new quantum physics associated with gravitation would also become key part of quantum biophysics in TGD Universe.

   (b) For the proposed value of h_{gr} 1 Hz cyclotron frequency associated to DNA sequences would correspond to ordinary photon frequency $f = 3.6 \times 10^{14}$ Hz and energy 1.2 eV just at the lower limit of visible frequencies. For 10 Hz alpha band the energy would be 12 eV in UV. This plus the fact that molecular energies are in eV range suggests very simple realization of biochemical control by magnetic body. Each ion has its own cyclotron frequency but same energy for the corresponding biophoton.

   (c) Biophoton with a given energy would activate transitions in specific bio-molecules or atoms: ionization energies for atoms except hydrogen have lower bound about 5 eV (`http://tinyurl.com/233vcad`). The energies of molecular bonds are in the range 2-10 eV (`http://tinyurl.com/bfsy4ft`). If one replaces v_0 with $2v_0$ in the estimate, DNA corresponds to.62 eV photon with energy of order metabolic energy currency and alpha band corresponds to 6 eV energy in the molecular region and also in the region of ionization energies.

   Each ion at its specific magnetic flux tubes with characteristic palette of magnetic field strengths would resonantly excite some set of biomolecules.This conforms with the earlier vision about dark photon frequencies as passwords.

   It could be also that biologically important ions take care of their ionization self. This would be achieved if the magnetic field strength associated with their flux tubes is such that dark cyclotron energy equals to ionization energy. EEG bands labelled by magnetic field strengths could reflect ionization energies for these ions.

   (d) The hypothesis means that the scale of energy spectrum of biophotons depends on the ratio M/v_0 of the planet and on the strength of the endogenous magnetic field, which is.2 Gauss for Earth (2/5 of the nominal value of the Earth's magnetic field). Therefore the astrophysical characteristics of planets should be tuned for molecular life. Taking v_0 to be rotational velocity one obtains for the ratio $M(planet)/v_0(planet)$ using the ratio for Earth as unit the following numbers for the planets (Mercury, Venus, Earth, Mars, Jupiter, Saturnus, Uranus, Neptune): $M/v_0 = (8.5, 209, 1, .214223, 1613, 6149, 9359)$. If the energy scale of biophotons is required to be the same, the scale of endogenous magnetic field should be divided by this ratio in order to obtain the same situation as in Earth. For instance, in Mars the magnetic field should be roughly 5 times stronger: in reality the magnetic field of Mars is much weaker. Just for fun one can notice that for Sun the ratio is 1.4×10^6 so that magnetic field should be by the inverse of this factor weaker.

4. An interesting question is how large systems can behave as coherent units with $\hbar_{gr} = GMm/v_0$. In living matter one might consider the possibility that entire organism might be this kind of system. Interestingly, for larger masses the gravitational quantum coherence would be easier. For particle with mass m $h_{gr}/h > 1$ requires larger mass to satisfy $M > M_P^2/m_e$. The first guess that life has evolved from long to shorter scales and reached

elementary particle last. Planck mass is the critical mass corresponds to the mass of water blog with volume of size scale of 10^{-4} m (big neuron) is the limit.

5. The Universal gravitational Compton wave length of $GM/v_0 \simeq 864$ meters gives an idea about largest possible living matter system if Earth is the second body. Of course, also other large bodies are possible.In the case of solar system this length is 3×10^3 km. The radius of Earth is 6.37×10^3 km - roughly twice the Compton length. The radii of Mercury, Venus, Earth, Mars, Jupiter, Saturnus, Uranus, Neptunus are (.38, .99, .533, 1, 10.6, 8.6, 4.0, 3.9) using Earth radius as unit the value of h_{gr} is by factor 5 larger than for 4 inner planets so that the values are reasonably near to gravitational Compton length or twice it. Does this mean that dark matter associated with Earth and maybe also other planets is in macroscopic quantum state at some level of the hierarchy of space-time sheets? Does this mean that Mother Gaia as conscious entity might make sense. One can of course make same question in the case of Sun. The universal gravitational Compton length in Sun would be 18 per cent of the radius of Sun if v_0 is taken to be the rotational velocity at the surface of Sun. The radius of solar core, where fusion takes place, is 20-25 per cent of solar radius.

6. There are further interesting numerical co-incidences. One can for a moment forget the standard hostility of scientist towards horoscopes and ask whether Sun and Moon could have somehow affect our life via astrocopic quantum coherence. The gravitational Compton length for particle-Moon or particle-Sun system multiplied by the natural value of magnetic field is the relevant parameter. For Sun the parameters in question are mass of Sun, and rotational velocity of Earth with respect to Sun, plus magnetic fields of Sun at flux tubes associated with solar magnetic field measured to be about 5 nT at the position of Earth and 100 times stronger than expected from dipole field behavior. This gives that the range of biophoton energies is scaled down with factor of 1/4 in good approximation so that Father Sun might affect terrestrial biology! If one uses for the rotational velocity of particle at surface of Moon as parameter v_0 (particle would be at Moon), biophoton energy scaled scaled up by factor 1.2.

The general proposal discussed above is testable. In particular, a detailed study of molecular energies with those associated with resonances of EEG could be highly rewarding and reveal the speculated spectroscopy of consciousness.

8.2.3 What about $h_{em} = h_{eff}$?

The notion of h_{gr} generalizes to that for other interactions. For instance, in electromagnetic case the formation of strong em fields implying charge separation leads to systems in which $h_{em} = Z_1 Z_2 e^2/v_0$ is large. Pollack's exclusion zone [L10] (`http://tinyurl.com/oyhstc2`) and its complement define this kind of system and TGD inspired identification is as prebiotic life form. I have proposed a TGD inspired model for the fourth phase of water [K23] [L10].

I have proposed that metabolic machinery generates large h_{eff} phase somehow. $h_{eff} = h_{em}$ hypothesis allows to develop this hypothesis in more detail.

1. The rotating shaft of a molecular motor associated with ATP synthase is proposed to play a key role.

2. What comes in mind is that the rotational velocity v_0 of the shaft appears in the formula for h_{em}. The electric field over the mitochondrial membrane generates charge separation and the product of charges of shaft and its complement should appear in the expression for h_{em}.

3. The value of v_0/c is expected to be of order 10^{-14} from the angular rotation rate of ADP synthase about few hundred revolutions per second. The lower bound for the magnitude for h_{em} is same as for h_{gr} associated with Earth-particle system.

Rotating magnetic systems are claimed to exhibit anomalous effects such as spontaneous acceleration and over unity energy production. I have discussed these in [K4].

1. The proposal is that rotating magnetic systems give rise to dark matter at magnetic flux tubes and sheets associated with the system and that the metabolic energy is needed to rotate the motor to generate the dark matter, which in turn makes possible negentropic entanglement characterized the density matrix proportional to unit matrix. This kind of matrix results if entanglement coefficients form a unitary S-matrix characterizing also quantum computation as unitary process.

2. The parameter v_0 appearing in the general formula for h_{eff} assigned with either em - or gravitational flux tubes is identifiable as the rotation velocity. One has $v_0/c \simeq 3 \times 10^{-8}$.

3. Since these systems are strongly charged, a natural guess is that large h_{em} system is in question.

8.3 Gravitational Mother Gaia And Life

Negentropic entanglement (NE) is one of the key notions of TGD inspired quantum biology. For instance, it would seem that NE would look more natural metabolic resource than energy. Nutrients should carry it. NE is however not single particle property but between nutrient and some other system in the recent case. What can one say about this system? Can it be part of nutrient? Could it correspond to oxygen molecules? Or could it be Mother Gaia identified in some sensible manner?

If one believes on the presence of gravimagnetic flux tubes and their role as generator of macroscopic quantum coherence in biology then one is forced to consider seriously also NE between its ends. If this is the case then the view of religions about life might be nearer to truth than that of hard-born materialists.

To make this more concrete, let us first look what the transfer of NE could mean.

1. Suppose that nutrient N has NE with unknown system A which a priori could be part of nutrient. Assume that the transfer of NE of nutrient with A is formed by reconnection of U-shaped flux tubes associated with N (or glucose G produced from it) and A so that two parallel flux tubes connecting N and A are formed.

2. The basic operation allowing transformation of $N - A$ NE to $P - A$ NE is following. The two flux tube portions of U-shaped flux associated with the receiver R are reconnected with the two parallel flux tubes connecting N and A so that two flux tubes connecting R to A are formed. NMP strongly suggests that the entanglement remains negentropic in the process.

3. NE is first transferred to P using this process so that P and A are now NE-connected. After this P attaches to ADP to yield ATP and ATP attaches to B and the transfer process leads to NE between B and A.

   For ATP synthase the h_{em} consisting two elementary charges is of the same order as h_{gr}. This is probably not an accident. Could this mean that this kind of flux tube can reconnect with gravitational flux tube? Could this make possible a reconnection transforming N-Earth NE to P-Earth NE? This looks plausible.

Consider now the identification of A.

1. If one assumes that the negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) corresponds to gravitational flux tubes for N-Earth system then A should be gravitational Mother Gaia, whatever its precise definition might be. N (and glucose) molecules would be alive in the sense that they have NE with Mother Gaia.

2. Could oxygen have some deeper role? For instance, could O_2 molecules serve as analogs of cell membrane receptors for Mother Gaia meaning that gravitational flux tubes go through O_2 molecules? This does not look plausible since metabolism is possible also as fermentation involving no oxygen.

3. In this picture the role of breathing and fermentation would be to make possible the transfer of NE from nutrients to the living system.

This picture allows to imagine about what might happen in biological death. Biological death takes first place only at the highest level of self hierarchy assignable to the our biological body. Cells continue for some time their life even after the last breath. The notion of h_{gr} together with Equivalence Principle suggests that the living biological body has negentropic flux tube connections to both electromagnetic magnetic body (personal magnetic body) and to gravitational Mother Gaia (MG) representing collective consciousness in the scale of Earth. Also personal magnetic body has flux tube connections to MG. The latter especially during sleep. Also connections to higher levels in hierarchy are possible. At the moment of biological death the negentropic flux tube pairs connecting the personal magnetic body to biological body are split and only those with MG remain or are generated in this process. This would happen later at lower levels of biological self hierarchy such as organ and organelles and eventually for cells and biopolymers. On the other hand, new life forms using the decay products as nutrients would take the available NE to use during the decay process.

The quantum model for metabolism allows to understand life as a process in which negentropic entanglement of gravitational Mother Gaia with nutrients is transformed to that of molecules of biological body with personal magnetic body and further processed and enriched. At the moment of biological death this information returns to the gravitational Mother Gaia. By NMP information is not lost but increases steadily giving rise to "Akashic records". This view conforms with the core ideas of spiritual and religious teachings.

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

I have developed already earlier [K9, K10, K34, K35] a rough model for high T_c super conductivity [D15, D16, D17, D7, D5, D19]. The members of Cooper pairs are assigned with parallel flux tubes carrying fluxes which have either same or opposite directions. The essential element of the model is hierarchy of Planck constants defining a hierarchy of dark matters.

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

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

2. The phase transition to super-conductivity is analogous to a percolation process in which flux tube pairs fuse by a reconnection to form longer super-conducting pairs at the lower critical temperature. This requires that flux tubes carry anti-parallel fluxes: this is in accordance with the anti-ferro-magnetic character of high T_c super conductivity. The stability of flux tubes very probably correlates with the stability of Cooper pairs: coherence length could dictate the typical length of the flux tube.

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

There are two energies involved.

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

2. The interaction energy of spins with magnetic fluxes, which can be parallel or antiparallel contributes also to the gap energy of Cooper pair and gives rise to mixing of spin singlet

and spin triplet. In TGD based model of quantum biology antiparallel fluxes are of special importance since U-shaped flux tubes serve as kind of tentacles allow magnetic bodies form pairs of antiparallel flux tubes connecting them and carrying supra-currents. The possibility of parallel fluxes suggests that also ferro-magnetic systems could allow super-conductivity.

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

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

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

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

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

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

9.1 A More Detailed Flux Tube Model For Super-Conductivity

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

9.2 Simple Quantitative Model

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

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

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

$$B = \frac{\mu_0}{4\pi a^3} \times (3nn \cdot \mu - \mu) \quad . \tag{9.1}$$

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

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

$$E = \frac{1}{4\pi a^3} \times (-3\mu_1 \cdot n\mu_2 \cdot n + \mu_1 \cdot \mu_2) \ . \tag{9.2}$$

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

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

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

$$H_{s-s} = \frac{1}{4\pi a^3} \times (\frac{ge\hbar}{2m})^2 \times O \ , \quad O = -3(m_1)_x(m_2)_x + m_1 \cdot m_2 \ . \tag{9.3}$$

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

$$(m_1)_x(m_2)_x = \frac{1}{4}\sum_{i=\pm,j=\pm}(m_i)_1(m_j)_2 \ . \tag{9.4}$$

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

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

$$\begin{aligned} &H_{s-s} = E_{s-s} \times O \ , \quad E_{s-s} = \frac{1}{4\pi a^3} \times (ge\hbar/2m)^2 \times O \ , \\ &O = O_1 + O_2(S) \ , \quad O_1 = -\frac{3}{4}\sum_{i=\pm,j=\pm}(m_i)_1(m_j)_2 \ , \\ &O_2(singlet) = -\frac{3}{4} \ , \quad O_2(triplet) = \frac{1}{4} \ . \end{aligned} \tag{9.5}$$

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

$$\begin{aligned} &H_{s-flux} = -(\mu_Z)_1 B_1 - (\mu_Z)_2 B_2 = \frac{ge}{\hbar 2m}(m_1)_z B_1 + (m_2)_z B_2 \\ &= E_{s-flux} \times ((m_1)_z + \epsilon(m_2)_z) \ , \ E_{s-flux} = \frac{ge\hbar B}{2m} \ . \end{aligned} \tag{9.6}$$

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

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

$$O = \begin{pmatrix} \frac{1}{4} & 1 \\ 1 & \frac{1}{4} \end{pmatrix} \ . \tag{9.7}$$

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

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

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

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

$$\begin{aligned} H(anti, S_z = 0) &= -\frac{E_{s-s}}{2} \begin{pmatrix} 1 & x \\ x & 0 \end{pmatrix} \\ x &= -\frac{4E_{s-flux}}{E_{s-s}} = -32\pi \frac{ma^3}{ge\hbar B} \ , \\ E_{s-s} &= \frac{1}{8\pi} (\frac{ge\hbar}{2m})^2 \frac{1}{a^3} \ . \end{aligned} \tag{9.8}$$

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

$$E_\pm = -\frac{E_{s-s}}{4}(1 \pm \sqrt{1 + 4x^2}) \ . \tag{9.9}$$

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

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

9.3 Fermionic Statistics And Bosons

What about fermionic statistics and bosons?

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

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

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

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

9.4 Interpretation In The Case Of High T_c Super-Conductivity

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

1. The four eigen values of total Hamiltonian are

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

$$\lambda \in \{\frac{5}{4}, -\frac{3}{4}, -\frac{1}{4}(1 \pm \sqrt{1+4x^2})\} \ . \tag{9.10}$$

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

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

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

4. If one takes the model deadly seriously despite its strong simplifying assumptions one is forced to consider a more complex interpretation. What comes in mind is that both kind of Cooper pairs appear first and super-conductivity becomes possible at T_c. T^* would correspond

to the emergence of $S_z = \pm 1$ mixtures. The critical temperature T^{**} for the emergence $S_z = 0$ pairs would not be lower than $T^{**}_{min} = (2/3) \times 300 = 200$ K. At temperature T_c the flux tubes carrying the two kinds of pairs become thermally stable by a percolation type process involving re-connection of U-shaped flux tubes to longer flux tube pairs and supra-currents can run in long length scales. This model conforms with the interpretation of pseudo-gap in terms o pre-formed Cooper pairs not able to form coherent supra-currents (`http://tinyurl.com/yc543vbl`).

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

9.5 Quantitative Estimates In The Case Of TGD Inspired Quantum Biology

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

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

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

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

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

4. The hypothesis $\hbar_{eff} = n \times \hbar = \hbar_{gr} = GMm/v_0$ [K29, **?**] implies that cyclotron energy spectrum is universal (no dependence on the mass of the charged particle. Same would hold true for the spin-flux interaction energy. Spin spin interaction energy is proportional to h^2_{eff}/m^2a^3, where a is minimum distance between members of the Cooper pair. It is invariant under the simultaneous scaling of h_{eff} and m so that all charged particles can form Cooper pairs and spin currents for flux tubes with same distance and same magnetic field strength. This would correspond to the universality of the bio-photons [K6]. This would be also consistent with the earlier explanation for the finding of Hu and Wu [J13] that proton spin-spin interaction frequency for the distance defined by cell membrane thickness is in ELF frequency scale. The proposal was that dark proton sequences are involved at both sides of the membrane.

   Universality of Cooper pair binding energies implies universality of super-conductivity all fermionic ions can form superconducting Cooper pairs as has been assumed in the models for strange effects of ELF em fields on vertebrate brain, for cell membrane as Josephson junction, and for EEG [K14], and in the model for nerve pulse [K37]. As found, Bose-Einstein condensates of bosonic ions could give rise to spontaneous dark magnetization and spin currents along single flux tube so that bosons would be associated with flux tubes and fermions with pairs of them.

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

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

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

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

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

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

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

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

9.6.1 A brief summary about strengths and weakness of BCS theory

First I try to summarize basics of BCS theory.

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

2. BCS theory has also failures.

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

   (b) High-Tc SC is not understood. Antiferromagnetism is known to be important. The quite recent experiment demonstrates conductivity- maybe even conductivity - in topological insulator in presence of magnetic field [L12]. This is compete paradox and suggests in TGD framework that the flux tubes of external magnetic field serve as the wires [L12].

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

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

9.6.2 TGD based view about SC

TGD proposal for high Tc SC and bio-SC relies on many-sheeted space-time and TGD based view about dark matter as $h_{eff} = n \times h$ phase of ordinary matter emerging at quantum criticality [K35].

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

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

Now come the heretic questions.

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

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

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

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

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

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

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

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

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

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

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

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

Some time ago I learned about a claim of Ivan Kostadinov [D14] about superconductivity at temperature of 373 K (100 C) (see `http://tinyurl.com/y9hk83ak`). There is also claims by E. Joe Eck about superconductivity: the latest at 400 K [D6] (see `http://tinyurl.com/yc483hsf`). I am not enough experimentalist to be able to decide whether to take the claims seriously or not.

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

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

The data represented by Figs. 12, 13,14 of [D14] (see `http://tinyurl.com/y9hk83ak`) suggest $n = 2$ for $Z = 2$. The alternative explanation would be that the step is for some reason $\Delta V = 2hf/Ze$ corresponding to second harmonic or that the charge of the charge carrier is $Z = 1$. I have not been able to find any error in my calculation.

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

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

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

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

9.6.4 Room temperature superconductivity for alkanes

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

Alkanes (see `http://tinyurl.com/6pm7mz6`) can be linear (C_nH_{2n+2}) with carbon backbone forming a snake like structure, branched (C_nH_{2n+2}, $n \geq 2$) in which carbon backbone splits in one, or more directions or cyclic (C_nH_{2n}) with carbon backbone forming a loop. Methane CH_4 is the simplest alkane.

What makes the finding so remarkable is that alkanes serve as basic building bricks of organic molecules. For instance, cyclic alkanes modified by replacing some carbon and hydrogen atoms by other atoms or groups form aromatic 5-cycles and 6-cycles as basic building bricks of DNA. I have proposed that aromatic cycles are superconducting and define fundamental and kind of basic units of molecular consciousness and in case of DNA combine to a larger linear structure.

Organic high T_c superconductivity is one of the basic predictions of quantum TGD. The mechanism of super-conductivity would be based on Cooper pairs of dark electrons with non-standard value of Planck constant $h_{eff} = n \times h$ implying quantum coherence is length scales scaled up by n (also bosonic ions and Cooper pairs of fermionic ions can be considered).

The members of dark Cooper pair would reside at parallel magnetic flux tubes carrying magnetic fields with same or opposite direction: for opposite directions one would have $S = 0$ and for the same direction $S = 1$. The cyclotron energy of electrons proportional to h_{eff} would be scaled up and this would scale up the binding energy of the Cooper pair and make super-conductivity possible at temperatures even higher than room temperature [K35].

This mechanism would explain the basic qualitative features of high T_c superconductivity in terms of quantum criticality. Between gap temperature and T_c one one would have superconductivity in short scales and below T_c superconductivity in long length scales. These temperatures would correspond to quantum criticality at which large h_{eff} phases would emerge.

What could be the role of graphite? The 2-D hexagonal structure of graphite is expected to be important as it is also in the ordinary super-conductivity: perhaps graphite provides long flux tubes and n-alkanes provide the Cooper pairs at them. Either graphite, n-alkane as organic compound, or both together could induce quantum criticality. In living matter quantum criticality would be induced by different mechanism. For instance, in microtubules it would be induced by AC current at critical frequencies [L13].

9.6.5 How the transition to superconductive state could be induced by classical radiation?

Blog and Facebook discussions have turned out to be very useful and quite often new details to the existing picture emerge from them. We had interesting exchanges with Christoffer Heck in the comment section to "Are microtubules macroscopic quantum systems?" (see `http://tinyurl.com/hwnnfcd`) and this pleasant surprise occurred also now.

Recall that Bandyopadhyay's team claims to have detected the analog of superconductivity, when microtubules are subjected to AC voltage [J6, J11] (see `http://tinyurl.com/ze366ny`). The transition to a state resembling superconductivity would occur at certain critical frequencies. For the TGD inspired model see [L9].

The TGD proposal for bio-superconductivity - in particular that appearing in microtubules - is same as that for high T_c superconductivity [K34, K35]. Quantum criticality, large $h_{eff}/h = n$ phases of Cooper pairs of electrons, and parallel magnetic flux tube pairs carrying the members of Cooper pairs for the essential parts of the mechanism. $S = 0$ ($S = 1$) Cooper pairs appear when the magnetic fields at parallel flux tubes have opposite (same) direction.

Cooper pairs would be present already below the gap temperature but possible super-currents could flow in short loops formed by magnetic flux tubes in ferromagnetic system. AC voltage at

critical frequency would somehow induce transition to superconductivity in long length scales by inducing a phase transition of microtubules without helical symmetry to those with helical symmetry and fusing the conduction pathways with length of 13 tubulins associated with microtubules of type B to much longer ones associated with microtubules of type A by the reconnection of magnetic flux tubes parallel to the conduction pathways.

The phonon mechanism responsible for the formation of Cooper pair in ordinary superconductivity cannot be involved with high T_c superconductivity nor bio-superconductivity. There is upper bound of about 30 K for the critical temperature of BCS superconductors. Few days ago I learned about high T_c superconductivity around 500 K for n-alkanes (see `http://tinyurl.com/hwac9e9`) so that the mechanism for high T_c is certainly different [K35].

The question of Christoffer was following. Could microwave radiation for which photon energies are around 10^{-5} eV for the ordinary value of Planck constant and correspond to the gap energy of BCS superconductivity induce phase transition to BCS super-conductivity and maybe to microtubular superconductivity (if it exists at all)?

This inspires the question about how precisely the AC voltage at critical frequencies could induce the transition to high T_c - and bio-super-conductivity. Consider first what could happen in the transition to high T_c super-conductivity.

1. In high T_c super conductors such as copper-oxides the anti-ferromagnetism is known to be essential as also 2-D sub-lattice structures. Anti-ferromagnetism suggests that closed flux tubes form of squares with opposite directions of magnetic field at the opposite sides of square. The opposite sides of the square would carry the members of Cooper pair.

2. At quantum criticality these squares would reconnect to very long flattened squares by reconnection. The members of Cooper pairs would reside at parallel flux tubes forming the sides of the flattened square. Gap energy would consists interaction energies with the magnetic fields and the mutual interaction energy of magnetic moments.

   This mechanism does not work in standard QM since the energies involved are quite too low as compared to thermal energy. Large $h_{eff}/h = n$ would however scale up the magnetic energies by n. Note that the notion of gap energy should be perhaps replaced with collective binding energy per Cooper pair obtained from the difference of total energies for gap phase formed at higher temperature and for superconducting phase formed at T_c by dividing with the number of Cooper pairs.

   Another important distinction to BCS is that Cooper pairs would be present already below gap temperature. At quantum criticality the conduction pathways would become much longer by reconnection. This would be represent an example about "topological" condensed matter physics. Now hover space-time topology would be in question.

3. The analogs of phonons could be present as transversal oscillations of magnetic flux tubes: at quantum criticality long wave length "magneto-phonons" would be present. The transverse oscillations of flux tube squares would give rise to reconnection and formation of

If the irradiation or its generalization to high T_c works the energy of photon should be around gap energy or more precisely around energy difference per Cooper pair for the phases with long flux tubes pairs and short square like flux tubes.

1. To induce superconductivity one should induce formation of Cooper pairs in BCS superconductivity. In high T_c super-conductivity it should induce a phase transition in which small square shaped flux tube reconnect to long flux tubes forming the conducting pathways. The system should radiate away the energy difference for these phases: the counterpart of binding energy could be defined as the radiated energy per Cooper pair.

2. One could think the analog of stimulated emission (see `http://tinyurl.com/hwac9e9`). Assume that Cooper pairs have two states: the genuine Cooper pair and the non-superconducting Cooper pair. This is the case in high T_c superconductivity but not in BCS superconductivity, where the emergence of superconductivity creates the Cooper pairs. One can of course ask whether one could speak about the analog of stimulated emission also in this case.

3. Above T_c but below gap temperature one has the analog of inverted population: all pairs are in higher energy state. The irradiation with photon beam with energy corresponding to energy difference gives rise to stimulated emission and the system goes to superconducting state with a lower energy state with a lower energy.

This mechanism could explain the finding of Bandyopadhyay's team [J6, J11] that AC perturbation at certain critical frequencies gives rise to a ballistic state resembling superconductivity (no dependence of the resistance on the length of the wire so that the resistance must be located at its ends). The team used photons with frequency scales of MHz, GHz, and THz. The corresponding photon energy scales are about 10^{-8} eV, 10^{-5}, 10−2 eV for the ordinary value of Planck constant and are below thermal energies.

In TGD classical radiation should have also large $h_{eff}/h = n$ photonic counterparts with much larger energies $E = h_{eff} \times f$ to explain the quantal effects of ELF radiation at EEG frequency range on brain [K28]. The general proposal is that h_{eff} equals to what I have called gravitational Planck constant $\hbar_{gr} = GMm/v_0$ [**?**, K29]. This implies that dark cyclotron photons have universal energy range having no dependence on the mass of the charged particle. Bio-photons have energies in visible and UV range much above thermal energy and would result in the transition transforming dark photons with large $h_{eff} = h_{gr}$ to ordinary photons.

One could argue that AC field does not correspond to radiation. In TGD framework this kind of electric fields can be interpreted as analogs of standing waves generated when charged particle has contacts to parallel "massless extremals" representing classical radiation with same frequency propagating in opposite directions. The net force experienced by the particle corresponds to a standing wave.

Irradiation using classical fields would be a general mechanism for inducing bio-superconductivity. Superconductivity would be generated when it is needed. The findings of Blackman and other pioneers of bio-electromagnetism about quantal effects of ELF em fields on vertebrate brain stimulated the idea about dark matter as phases with non-standard value of Planck constant. The precise mechanism for how this happens has remained open. Also these finding could be interpreted as a generation of superconducting phase by this phase transition.

9.7 The implications of TGD view about magnetic fields for superconductivity

TGD predicts two kinds of magnetic fields depending on whether flux tubes carry monopole flux or not. In Maxwellian framework flux tubes cannot carry any monopole flux. In TGD based model of high Tc superconductivity [K34, K35] monopole flux tubes current carriers are dark having nonstandard value $h_{eff} = n \times h_0$ of effective Planck constant. Also in bio-superconductivity monopole flux tubes are current carriers. An open question has been whether also ordinary superconductivity could correspond to monopole flux tubes and I have considered the possibility that this is the case.

The recent progress in understanding the relationship between two kinds of magnetic fields allows to consider more precisely the relationship between these two kinds of super-conductivities. In particular, one can try to understand Meissner effect in ordinary super-conductivity and its absence in the predicted super-conductivity based on monopole flux tubes. The conclusion is that ordinary super-conductivity corresponds to ordinary flux tubes and that Meissner effect has no counterpart in monopole superconductivity.

It is best to start from the ordinary super-conductivity by making an unpleasant question. Meissner effect (see `http://tinyurl.com/hesedf2`) relates to the possible penetration of magnetic field to super-conductor. Supra-current creates a local magnetic field. Why doesn't this magnetic field destroy super-conductivity?

The answer would be in TGD space-time following.

1. The super-conductor consists of parallel cylindrical tubes carrying supra-currents at their boundaries. These currents create magnetic fields rotating around the cylinders but have no component in z- direction. Magnetic fields vanish at the boundaries of the cylinders.

2. Superconductors can be classified to two types. For superconductors of type I (see `http://tinyurl.com/y4wkzcql`) one has $\lambda/\xi < 1/\sqrt{2}$ whereas for superconductors of type II (see

http://tinyurl.com/y279phzb) one has $\lambda/\xi > 1/\sqrt{2}$. Here λ is the magnetic penetration length, which is roughly the radius of magnetic flux tube. ξ is the coherence length which is roughly the radius of cylinder carrying supra current at its boundary.

Supra-current generates vortices and in this manner serves as a source for magnetic field inside magnetic flux tube of field possibly penetrating into superconductor. Flux tube must contain at least one current carrying flux tube. This cannot the case for superconductor of type I. Therefore, when ordinary magnetic field penetrates to super-conductor of type I above critical value of B, it must do so in the entire super-conductor . For superconductor of type II magnetic field can penetrate superconductor of type II in a cylinder of radius of order λ containing several current carrying cylinders. In this region the super-conductivity is destroyed since supra currents have component rotating along the cylinder giving rise to a longitudinal magnetic field inside the cylinder.

What about Meissner effect in monopole superconductors?

1. Monopole flux does not require current as its source. Therefore Meissner effect does not prevent super-conductivity by requiring the super-current to be rotational to generate the magnetic field.

2. Also now the presence of supra current inside monopole flux tube serves as a source for an additional rotational contribution to the magnetic field and the rotor of this additional contribution equals to the supra current. Monopole flux tube is deformed as a consequence. This does not however make supra-current rotational.

   Monopole superconductor can be said to be intermediate between types I and II since both coherence length and magnetic length correspond to flux tube radius. A possible interpretation is that monopole superconductivity is at quantum criticality between superconductivities of type I and II.

3. The most plausible option is that the penetration of ordinary magnetic field to monopole super-conductor occur along non-monopole flux tubes at different space-time sheets so that it would therefore not spoil the super-conductivity at the monopole flux tubes.

The group of Suchitra Sebastian has discovered very unconventional condensed matter system, which seems to be simultaneously both insulator and conductor of electricity but only in presence of magnetic field. Science article is entitled "Unconventional Fermi surface in an insulating state" [L12] (see http://tinyurl.com/y79qo7lp). There is also a popular article with title "Paradoxical Crystal Baffles Physicists" in Quanta Magazine summarizing the findings (see http://tinyurl.com/qhwdmxj). I learned about the finding first from the blog posting of Lubos Motl (see http://tinyurl.com/yacm6bj7).

9.7.1 Observations

The crystal studied at superlow temperatures was Samarium hexaboride - briefly SmB_6. The high resistance implies that electron cannot move more that one atom's width in any direction. Sebastian et al however observed electrons traversing over a distance of millions of atoms- a distance of orde 10^{-4} m, the size of a large neuron. So high mobility is expected only in conductors. SmB_6 is neither metal or insulator or is both of them! The finding is described by Sebastian as a "big schock" and as a "magnificent paradox" by condensed matter theorists Jan Zaanen. Theoreticians have started to make guesses about what might be involved but accorrding to Zaanen there is no even remotely credible hypothesis has appeared yet.

On basis of its electronic structure SmB_6 should be a conductor of electricity and it indeed is at room temperature: the average number conduction electrons per SmB_6 is one half. At low temperatures situation however changes. At low temperatures electrons behave collectivily. In superconductors resistance drops to zero as a consequence. In SmB_6 just the opposite happens. Each Sm nucleus has the average 5.5 electrons bound to it at tight orbits. Below 223 degrees of Celsius the conduction electrons of SmB_6 are thought to "hybridize" around samarium nuclei so that the system becomes an insulator. Various signatures demonstrate that SmB_6 indeed behaves like an insulator.

During last five years it has been learned that SmB_6 is not only an insulator but also so called topological insulator. The interior of SmB_6 is insulator but the surface acts as a conductor. In their experiments Sebastian *et al* hoped to find additional evidence for the topological insulator property and attempted to measure quantum oscillations in the electrical resistance of their crystal sample. The variation of quantum oscillations as sample is rotated can be used to map out the Fermi surface of the crystal. No quantum oscillations were seen. The next step was to add magnetic field and just see whether something interesting happens and could save the project. Suddenly the expected signal was there! It was possible to detect quantum oscillations deep in the interior of the sample and map the Fermi surface! The electrons in the interior travelled 1 million times faster than the electrical resistance would suggest. Fermi surface was like that in copper, silver or gold. A further surprise was that the growth of the amplitude of quantum oscillations as temperature was decreased, was very different from the predictions of the universal Lifshitz-Kosevich formula for the conventional metals.

9.7.2 Could TGD Help To Understand The Strange Behavior Of SmB_6?

There are several indications that the paradoxical effect might reveal the underlying dynamics of quantum TGD. The mechanism of conduction must represent new physics and magnetic field must play a key role by making conductivity possible by somehow providing the "current wires". How? The TGD based answer is completely obvious: magnetic flux tubes - one of the basic distinctions between electrodynamics of Maxwell and its TGD variant! Also the failure of Lischitz-Kosevich formulas should be understood.

1. Single sheet of many-sheeted space-time resembles topological insulator

One should also understand topological insulator property at deeper level, that is the conduction along the boundaries of topological insulator. One should understand why the current runs along 2-D surfaces. In fact, many exotic condensed matter systems are 2-dimensional in good approximation. In the models of integer and fractional quantum Hall effect electrons form a 2-D system with braid statistics possible only in 2-D system. High temperature super-conductivity is also an effectively 2-D phenomenon. By strong form of holography these aspects are also key aspects of quantum TGD at the fundamental level of single space-time sheet when the approximation replacing many-sheeted space-time with that of GRT and standard model does not mask the simplicity of the fundamental dynamics.

1. Many-sheeted space-time is second fundamental prediction TGD. The dynamics of single sheet of many-sheeted space-time should be very simple by the strong form of holography implyhing effective 2-dimensionality. The standard model description of this dynamics masks this simplicity since the sheets of many-sheeted space-time are replaced with single region of slightly curved Minkowski space with gauge potentials sums of induced gauge potentials for sheets and deviation of metric from Minkowski metric by the sum of corresponding deviations for space-time sheets. Could the dynamics of exotic condensed matter systems give a glimpse about the dynamics of single sheet? Could topological insulator and anyonic systems [K30] provide examples of this kind of systems?

2. Second basic prediction of TGD is strong form of holography: string world sheets and partonic 2-surfaces serve as kind of "space-time genes" and the dynamics of fermions is 2-D at fundamental level. It must be however made clear that at QFT limit the spinor fields of embedding space replace these fundamental spinor fields localized at 2-surface. One might argue that the fundamental spinor fields do not make them directly visible in condensed matter physics. Nothing however prevents from asking whether in some circumstances the fundamental level could make itself visible.

   In particular, for large h_{eff} dark matter systems (, whose existence can be deduced from the quantum criticality of quantum TGD) the partonic 2-surfaces with CP_2 size could be scaled up to nano-scopic and even longer size scales. I have proposed this kind of surfaces as carriers of electrons with non-standard value of h_{eff} in QHE and FQHE [K30].

   The long range quantum fluctuations associated with large, $h_{eff} = n \times h$ phase would be quantum fluctuations rather than thermal ones. In the case of ordinary conductivity thermal

energy makes it possible for electrons to jump between atoms and conductivity becomes very small at low temperatures. In the case of large scale quantum coherence just the opposite happens as observed. One therefore expects that Lifshitz-Kosevich formula for the temperature dependence of the amplitude does not hold true.

The generalization of Lifschitz-Kosevich formula to quantum critical case deduced from quantum holographic correspondence by Hartnoll and Hofman [D13] (`http://tinyurl.com/ybednd85` is expected to hold true qualitatively also for quantum criticality in TGD sense. The first guess is that by underlying super-conformal invariance scaling laws typical for critical systems hold true. In the proposed formula the dependence on temperature is via a power of dimensionless parameter $x = T/mu;$, where μ is chemical potential for electron system. As a matter fact, exponent of power of x appears and reduces to first for Lifshitz-Konsevich formula. Since magnetic field is important, one also expects that the ratio of cyclotron energy scale $E_c \propto \hbar_{eff} eB/m_e$ to Fermi energy appears in the formula. One can even make an order of magnitude guess for the value of $h_{eff}/h \sim 10^6$ from the facts that the scale of conduction and conduction velocity were millions times higher than expected.

Strings are 1-D systems and strong form of holography implies that fermionic strings connecting partonic 2-surfaces and accompanied by magnetic flux tubes are fundamental. At light-like 3-surfaces fermion lines can give rise to braids. In TGD framework AdS/CFT correspondence generalizes since the conformal symmetries are extended. This is possible only in 4-D space-time and for the embedding space $H = M^4 \times CP_2$ making possible to generalize twistor approach [K42].

3. Topological insulator property means from the perspective of modelling that the action reduces to a non-abelian Chern-Simons term. The quantum dynamics of TGD at space-time level is dictated by Kähler action. Space-time surfaces are preferred extremals of Kähler action and for them Kähler action reduces to Chern-Simons terms associated with the ends of space-time surface opposite boundaries of causal diamond and possibly to the 3-D light-like orbits of partonic 2-surfaces. Now the Chern-Simons term is Abelian but the induced gauge fields are non-Abelian. One might say that single sheeted physics resembles that of topological insulator.

4. The effect appears only in magnetic field. I have been talking a lot about magnetic flux tubes carrying dark matter identified as large h_{eff} phases: topological quantization distinguishes TGD from Maxwell's theory: any system can be said to possess "magnetic body", whose flux tubes can serve as current wires. I have predicted the possibility of high temperature super-conductivity based on pairs of parallel magnetic flux tubes with the members of Cooper pairs at the neighboring flux tubes forming spin singlet or triplet depending on whether the fluxes are have same or opposite direction.

   Also spin and electric currents assignable to the analogs of spontaneously magnetized states at single flux tube are possible. The obvious guess is that the conductivity in question is along the flux tubes of the external magnetic field. Could this kind of conductivity explains the strange behavior of SmB_6. The critical temperature would be that in which the parallel flux tubes are stable. The interaction energy of spin with the magnetic field serves as a possible criterion for the stability if the presence of dark electrons stabilizes the flux tubes.

2. Magnetic flux tubes as dark current carriers in quantum criticality

The following represents an extremely childish attempt of a non-specialist to understand how the conductivity might be understood. The current carrying electrons at flux tubes near the top of Fermi surface are current carriers. $h_{eff} = n \times h$ and magnetic flux tubes as current wires bring in the new elements. Also in the standard situation one considers cylinder symmetric solutions of Schrödinger equation in external magnetic field and introduces maximal radius for the orbits so that formally the two situations seem to be rather near to each other. Physically the large h_{eff} and associated many-sheeted covering of space-time surface providing the current wire makes the situation different since the collisions of electrons could be absent in good approximation so that the velocity of charge carriers could be much higher than expected as experiments indeed demonstrate.

Quantum criticality is the crucial aspect and corresponds to the situation in which the magnetic field attains a value for which a new orbit emerges/disappears at the surface of the flux tube: in this situation dark electron phase with non-standard value of h_{eff} can be generated. This mechanism is expected to apply also in bio-superconductivity and to provide a general control tool for magnetic body.

1. Let us assume that flux tubes cover the whole transversal area of the crystal and there is no overlap. Assume also that the total number of conduction electrons is fixed, and depending on the value of h_{eff} is shared differently between transversal and longitudinal degrees of freedom. Large value of h_{eff} squeezes the electrons from transversal to longitudinal flux tube degrees of freedom and gives rise to conductivity.

2. Consider first Schrödinger equation. In radial direction one has harmonic oscillator and the orbits are Landau orbits. The cross sectional area behaves like $\pi R^2 = n_T h_{eff}/2m\omega_c$ giving $n_T \propto 1/h_{eff}$. Increase of the Planck constant scales up the radii of the orbits so that the number of states in cylinder of given radius is reduced. Angular momentum degeneracy implies that the number of transversal states is $N_T = n_T^2 \propto 1/h_{eff}^2$. In longitudinal direction one has free motion in a box of length L with states labelled by integer n_L. The number of states is given by the maximum value N_L of n_L.

3. If the total number of states is fixed to $N = N_L N_T$ is fixed and thus does not depend on h_{eff}, one has $N_L \propto h_{eff}^2$. Quanta from transversal degrees of freedom are squeezed to longitudinal degrees of freedom, which makes possible conductivity.

4. The conducting electrons are at the surface of the 1-D "Fermi-sphere", and the number of conduction electrons is $N_{cond} \simeq dN/d\epsilon \times \delta\epsilon \simeq dN/d\epsilon T = NT/2\epsilon_F \propto 1/h_{eff}^4$. The dependence on h_{eff} does not favor too large values of h_{eff}. On the other hand, if scattering of electrons at flux tubes could be absent. The assumption $L \propto h_{eff}$ increases the range over which current can flow.

5. To get a non-vanishing net current one must assume that only the electrons at the second end of the 1-D Fermi sphere are current carriers. The situation would resemble that in semiconductor. The direction of electric field would induce symmetry breaking at the level of quantum states. The situation would be like that for a mass in Earth's gravitational field treated quantally and electrons would accelerate freely. Schrödinger equation would give rise to Airy functions as its solution.

3. Quantum critical quantum oscillations

What about quantum oscillations in TGD framework?

1. Quantum oscillation refers to de Haas-van Alphen effect (`http://tinyurl.com/yaaljv9j`) - an oscillation of the induced magnetic moment as a function of $1/B$ with period $\tau = 2\pi e/\hbar A$, where A is the area of the extremal orbit of the Fermi surface, in the direction of the applied field. The effect is explained to be due to the Landau quantization of the electron energy. I failed to really understand the explanation of this source and in my humble opinion the following arguments provide a clearer view about what happens.

2. If external magnetic field corresponds to flux tubes, Fermi surface decomposes into cylinders parallel to the magnetic field since the motion in transversal degrees of freedom is along circles. In the above thought experiment also a quantization in the longitudinal direction occurs if the flux tube has finite length so that Fermi surface in longitudinal direction has finite length. One expects on basis of Uncertainty Principle that the area S of the cross section of Fermi cylinder in momentum space is given by $S \propto h_{eff}^2/\pi R^2$. This follows also from the equation of motion of electron in magnetic field. As the external magnetic field B is increased, the radii of the orbits decrease inside the flux tube, and in momentum space the radii increase.

3. Why does the induced magnetic moment (magnetization) and other observables oscillate?

(a) The simplest manner to understand this is to look at the situation at space-time level. Classical orbits are harmonic oscillator orbits in radial degree of freedom. Suppose that the area of flux tube is fixed and B is increased. The orbits have radius $r_n^2 = (n+1/2) \times \hbar/eB$ and shrink. For certain field values the flux $eBA = n\hbar$ corresponds to an integer multiple of the elementary flux quantum . of a new orbit at the boundary of the flux tube emerges if the new orbit is near the boundary of Fermi sphere providing the electrons. This is clearly a critical situation.

(b) In de Haas- van Alphen effect the orbit $n+1$ for B has same radius as the orbit n for $1/B + \Delta(1/B)$: $r_{n+1}(1/B) = r_n(1/B + \Delta(1/B))$. This gives approximate differential equation with respect to n and one obtains $(1/B)(n) = (n+1/2) \times \Delta(1/B)$. $\Delta(1/B)$ is fixed from the condition the flux quantization. When largest orbit is at the surface of the flux, tube the orbits are same for $B(n)$ and $B(n+1)$, and this gives rise to the de Haas - van Alphen effect.

(c) It is not necessary to assume finite radius for the flux tube, and the exact value of the radius of the flux tube does not play and important role. The value of flux tube radius can be estimated from the ratio of the Fermi energy of electron to the cyclotron energy. Fermi energy about .1 eV depending only on the density of electrons in the lowest approximation and only very weakly on temperature. For a magnetic field of 1 Tesla cyclotron energy is .1 meV. The number of cylinders defined by orbits is about $n = 10^4$.

4. What happens in TGD Universe in which the areas of flux tubes identifiable as space-time quanta are finite? Could quantum criticality of the transition in which a new orbit emerges at the boundary of flux tube lead to a large h_{eff} dark electron phase at flux tubes giving rise to conduction?

   (a) The above argument makes sense also in TGD Universe for the ordinary value of Planck constant. What about non-standard values of Planck constant? For $h_{eff}/h = n$ the value of flux quantum is n-fold so that the period of the oscillation in de Haas - van Alphen effect becomes n times shorter. The values of the magnetic field for which the orbit is at the surface of the flux tube are however critical since new orbit emerges assuming that the cyclotron energy corresponds is near Fermi energy. This quantum criticality could give rise to a phase transition generating non-standard value of Planck constant.

   What about the period $\Delta(1/B)$ For $h_{eff}/h = n$? Modified flux quantization for extremal orbits implies that the area of flux quantum is scaled up by n. The flux changes by n units for the same increment of $\Delta(1/B)$ as for ordinary Planck constant so that de Haas -van Alphen effect does not detect the phase transition.

   (b) If the size scale of the orbits is scaled up by $\sqrt{n}$ as the semiclassical formula suggests the number of classical orbits is reduced by a factor $1/n$ if the radius of the flux tube is not changed in the transition $h \to h_{eff}$ to dark phase. n-sheetedness of the covering however compensates this reduction.

   (c) What about possible values of h_{eff}/h? The total value of flux seems to give the upper bound of $h_{eff}/h = n_{max}$, where n_{max} is the value of magnetic flux for ordinary value of Planck constant. For electron and magnetic field for $B = 10$ Tesla and has $n \leq 10^5$. This value is of the same order as the rough estimate from the length scale for which anomalous conduction occurs.

   Clearly, the mechanism leading to anomalously high conductivity might be the transformation of the flux tubes to dark ones so that they carry dark electrons currents. The observed effect would be dark, quantum critical variant of de Haas-van Alphen effect!

   Also bio-superconductivity is quantum critical phenomenon and this observation would suggests sharpening of the existing TGD based model of bio-super-conductivity. Super-conductivity would occur for critical magnetic fields for which largest cyclotron orbit is at the surface of the flux tube so that the system is quantum critical. Quantization of magnetic fluxes would quantify the quantum criticality. The variation of magnetic field strength would serve as

control tool generating or eliminating supra currents. This conforms with the general vision about the role of dark magnetic fields in living matter.

To sum up, a breakthrough of TGD is continuing. I have written about thirty articles during this year - more than one article per week. There is huge garden there and trees contain fruits hanging low! It is very easy to pick them: just shatter and let them drop to the basket! New experimental anomalies having a nice explanation using TGD based concepts appear on weekly basis and the mathematical and physical understanding of TGD is taking place with great leaps. It is a pity that I must do all alone. I would like to share. I can only hope that colleagues could take the difficult step: admit what has happened and make a fresh start.

10 A New Control Mechanism Of TGD Inspired Quantum Biology

The idea that TGD Universe is quantum critical, is the corner stone of quantum TGD and fixes the theory more or less uniquely since the only coupling constant parameter of the theory - Kähler coupling strength - is analogous to critical temperature. Also more than one basic parameters are in principle possible - maximal quantum criticality fixes the values of all of them - but it seems that only Kähler coupling strength is needed. TGD Universe is a quantum critical fractal: like a ball at the top of hill at the top of hill at.... Quantum criticality allows to avoid the fine tuning problems plaguing as a rule various unified theories.

10.1 Quantum Criticality

The meaning of quantum criticality at the level of dynamics has become only gradually clearer. The development of several apparently independent ideas generated for about decade ago have led to the realization that quantum criticality is behind all of them. Behind quantum criticality are in turn number theoretic vision and strong forms of general coordinate invariance and holography.

1. The hierarchy of Planck constants defining hierarchy of dark phases of ordinary matter corresponds to a hierarchy of quantum criticalities assignable to a fractal hierarchy of sub-algebras of super-symplectic algebra for which conformal weights are n-ples of those for the entire algebra, n corresponds to the value of effective Planck constant $h_{eff}/h = n$. These algebras are isomorphic to the full algebra and act as gauge conformal algebras so that a broken super-conformal invariance is in question.

2. Quantum criticality in turn reduces to the number theoretic vision about strong form of holography. String world sheets carrying fermions and partonic 2-surfaces are the basic objects as far as pure quantum description is considered. Also space-time picture is needed in order to test the theory since quantum measurements always involve also the classical physics, which in TGD is an exact part of quantum theory.

   Space-time surfaces are continuations of collections of string world sheets and partonic 2-surfaces to preferred extremals of Kähler action for which Noether charges in the sub-algebra of super-symplectic algebra vanish. This condition is the counterpart for the reduction of the 2-D criticality to conformal invariance. This eliminates huge number of degrees of freedom and makes the strong form of holography possible.

3. The hierarchy of algebraic extensions of rationals defines the values of the parameters characterizing the 2-surfaces, and one obtains a number theoretical realization of an evolutionary hierarchy. One can also algebraically continue the space-time surfaces to various number fields - reals and the algebraic extensions of p-adic number fields. Physics becomes adelic. p-Adic sectors serve as correlates for cognition and imagination. One can indeed have string world sheets and partonic 2-surfaces, which can be algebraically continued to preferred extremals in p-adic sectors by utilizing p-adic pseudo constants giving huge flexibility. If this is not possible in the real sector, figment of imagination is in question! It can also happen that only part of real space-time surface can be generated: this might relate to the fact that imaginations can be seen as partially realized motor actions and sensory perceptions.

10.2 Quantum Criticality And TGD Inspired Quantum Biology

In TGD inspired quantum biology quantum criticality is in crucial role. First some background.

1. Quantum measurement theory as a theory of consciousness is formulated in zero energy ontology (ZEO) and defines an important aspect of quantum criticality. Strong form of NMP states that the negentropy gain in the state function reduction at either boundary of causal diamond (CD) is maximal. Weak form of NMP allows also quantum jumps for which negentropic entanglement is not generated: this makes possible ethics (good and evil) and morally responsible free will: good means basically increase of negentropy resources.

2. Self corresponds to a sequence state function reductions to the same boundary of CD and h_{eff} does not change during that period. The increase of h_{eff} (and thus evolution!) tends to occur spontaneously, and can be assigned to the state function reduction to the opposite boundary of CD in zero energy ontology (ZEO). The reduction to the opposite boundary means death of self and living matter is fighting in order to avoid this even. To me the only manner to make sense about basic myth of Christianity is that death of self generates negentropy.

3. Metabolism provides negentropy resources for self and hopefully prevents NMP to force the fatal reduction to the opposite boundary of CD. Also homeostasis does the same. In this process self makes possible evolution of sub-selves (mental images dying and re-incarnating) state function by state function reduction so that the negentropic resources of the Universe increase.

10.3 A New Mechanism Of Quantum Criticality

Consider now the mechanisms of quantum criticality. The TGD based model [L12] [**?**] (`http://tinyurl.com/y8oblpl9`) for the recent paradoxical looking finding [L12] (`http://tinyurl.com/y79qo7lp`) that topological insulators can behave like conductors in external magnetic field led to a discovery of a highly interesting mechanism of criticality, which could play a key role in living matter.

1. The key observation is that magnetic field is present. In TGD framework the obvious guess is that its flux tubes carry dark electrons giving rise to anomalous currents running in about million times longer time scales and with velocity, which is about million times higher than expected. Also supra-currents can be considered.

   The currents can be formed of the cyclotron energies of electrons are such that they correspond to energies near the surface of the Fermi sphere: recall that Fermi energy for electrons is determined by the density of conduction electrons and is about 1 eV. Interestingly, this energy is at the lower end of bio-photon energy spectrum. In the field of 10 Tesla the cyclotron energy of electron is .1 mV so that the integer characterizing cyclotron orbit must be $n \simeq 10^5$ if conduction electron is to be transferred to the cyclotron orbit.

2. The assumption is that external magnetic field is realized as flux tubes of fixed radius, which correspond to space-time quanta in TGD framework. As the intensity of magnetic field is varied, one observes so called de Haas-van Alphen effect (`http://tinyurl.com/hoywcnq`) used to deduce the shape of the Fermi sphere: magnetization and some other observables vary periodically as function of $1/B$ (for a model for the quantum critical variant of the effect see [D13]).

   This can be understood in the following manner. As B increases, cyclotron orbits contract. For certain increments of $1/B$ $n+1$:th orbit is contracted to n:th orbit so that the sets of the orbits are identical for the values of $1/B$, which appear periodically. This causes the periodic oscillation of say magnetization.

3. For some critical values of the magnetic field strength a new orbit emerges at the boundary of the flux tube. If the energy of this orbit is in the vicinity of Fermi surface, an electron can be transferred to the new orbit. This situation is clearly quantum critical.

If the quantum criticality hypothesis holds true, $h_{eff}/h = n$ dark electron phase can be generated for the critical values of magnetic fields. This would give rise to the anomalous conductivity perhaps involving spin current due to the spontaneous magnetization of the dark electrons at the flux tube. Even super-conductivity based on the formation of parallel flux tube pairs with either opposite or parallel directions of the magnetic flux such that the members of the pair are at parallel flux tubes, can be considered and I have proposed this a mechanism of bio-superconductivity and also high Tc super-conductivity.

10.4 A New Mechanism Of Quantum Bio-Control

The quantum criticality of the process in which new electron orbit emerges near Fermi surface suggests a new mechanism of quantum bio-control by generation of super currents or its reversal.

1. In TGD inspired quantum biology magnetic body uses biological body as motor instrument and sensory receptor and EEG and its fractal variants with dark photons with frequencies in EEG range but energy $E = h_{eff}f$ in the range of bio-photon energies make the necessary signalling possible.

2. Flux tubes can become braided and this makes possible quantum computation like processes [K1]. Also so called 2-braids - defined by knotted 2-surfaces imbedded in 4-D space-time surface - are possible for the string world sheets defined by flux tubes identified to be infinitely thin, are possible. As a matter fact, also genuine string world sheets accompany the flux tubes. 2-braids and knots are purely TGD based phenomenon and not possible in superstring theory or M-theory.

3. It is natural to speak about motor actions of the magnetic body. It is assumed that the flux tubes of the magnetic body connect biomolecules to form a kind of Indra's web explaining the gel like character of living matter. h_{eff} reducing phase transitions contract flux tubes connecting biomolecules so that they can find each other by this process and bio-catalysis becomes possible. This explains the mysterious looking ability of bio-molecules to find each other in the dense molecular soup. In fact the dark matter part is far from being soup! The hierarchy of Planck constants and $h_{eff} = h_{gr}$ hypothesis imply that dark variants of various particles with magnetic moment are neatly at their own flux tubes like books in shelf.

   Reconnection of the U-shaped flux tubes emanating from two subsystems generates a flux tube pair between them and gives rise to supracurrents flowing between them. Also cyclotron radiation propagating along flux tubes and inducing resonant transitions is present. This would be the fundamental mechanism of attention.

4. I have proposed that the variation of the thickness of the flux tubes could serve as a control mechanism since it induces a variation of cyclotron frequencies allowing to get in resonance or out of it. For instance, two molecules could get in flux tube contact when the cyclotron frequencies are identical and this can be achieved if they are able to vary their flux tube thickness. The molecules of immune system are masters in identifying alien molecules and the underlying mechanism could be based on cyclotron frequency spectrum and molecular attention. This would be also the mechanism behind water memory and homeopathy (`http://tinyurl.com/yda3d6se` [K19] which still is regarded as a taboo by mainstreamers.

5. Finally comes the promised new mechanism of bio-control. The variation of the magnetic field induced by that of flux tube thickness allows also to control whether there is quantum criticality for the generation of dark electron supra currents of electrons. The Fermi energy of the conduction electrons at the top of Fermi sphere is the key quantity and dictated by the density of these electrons. This allows to estimate the order of magnitude of the integers N characterizing cyclotron energy for ordinary Planck constant and the maximal value of $h_{eff}/h = n$ cannot be larger than N.

11 TGD based model for graphene superconductivity

A highly interesting new effect associated with graphene is discussed in Phys.Org article (see `http://tinyurl.com/ydyqgk56`). The original research articles by Cao *et al* are published in

Nature [D9, D10]. There is also a popular article In Nature (see http://tinyurl.com/ya5jzadc). What is found that a bilayer formed by parallel graphene sheets becomes superconducting for critical values of twist angle θ. The largest critical value of θ is $\theta = 1.1$ degrees.

The finding of Cao *et al* is believed to be highly significant concerning the understanding of high T_c super-conductivity and motivates the development of a model of Mott insulators based on TGD based views about valence bond inspired by the identification of dark matter as $h_{eff}/h = n$ phases of ordinary matter emerging naturally in adelic physics [K2] [L20]. Also a more detailed version about the model of high T_c superconductivity in TGD Universe developed in [K9, K10, K34, K35] emerges.

11.1 Basic observations

Consider first the basic facts. The surprising discovery was that graphene becomes unconventional superconductor at temperature 1.7 K. It was already earlier discovered that the coupling of graphene to a superconductor can make also graphene superconducting.

1. The system studied consists of two graphene (see http://tinyurl.com/8os5eas) layers twisted by angle θ with respect to each other (rotation of the second sheet by angle θ around the axis normal to sheets). For a generic value of θ the graphene layers behave as separate conductors. For certain critical twist angles below 1.1 degrees the two-layered system however behaves like single unit and Mott insulator (see http://tinyurl.com/ybqblvc7): this is due to the increase of the conduction band gap. In an applied electric field the system becomes a super conductor. The electric field provides the energy needed to kick the current carries to the conduction band, which for Mott insulators has higher energy than for the corresponding conductor: at the top of the band Cooper pairs are formed as in the case of ordinary superconductors.

2. A kind of Moire effect (see http://tinyurl.com/qchunes) is involved. The twist creates a superlattice with larger unit cell and the electrons associated with periodically occurring C-atom pairs above each other give rise to a narrow band where the superconducting electrons are. Electric field would kick the electrons to this band.

3. There are intriguing analogies with high T_c superconductivity. Electron density as function of temperature has a pattern similar to that for cuprates. Superconductivity occurs at electron density, which is 10^{-4} times that for conventional superconductors at the same temperature. The pairing of electrons cannot be due to phonon exchange since the density is so low. Unidentified strong interaction between electrons is believed to be the reason.

11.2 Mott insulators, transition metals, antiferromagnets, and high T_c superconductors in TGD framework

In 1937 Jan Hendrik de Boer and Evert Johannes Willem Verwey pointed out that a variety of transition metal oxides are insulators although they should be conductors since they have odd number of electrons per lattice cells. Nevill Mott and Rudolf Peierls predicted that the effect can be explained by taking into account the interaction between electrons neglected in the band theory of solids. These materials became known as Mott insulators (see http://tinyurl.com/ybqblvc7).

1. 1949 Mott proposed a model for NiO as insulator (Ni is transition metal). The conduction was based on the process $(Ni^{2+}O^{2-})^2 \to Ni^{3+}O^{2-} + Ni^{1+}O^{2-}$. In this process electron is transferred between the neighboring sites. For critical values of parameters NiO however becomes insulator.

   The formation of energy gap preventing conduction can be understood as competition between Coulomb potential U between 3d electrons at the same site and the transfer integral t of 3d electrons between neighboring sites characterizing the transfer of electron between neighboring sites. The total energy bap is $U - 2zt$, where z is the total number of nearest-neighbor atoms. As U is increased by varying parameters a transition to insulator takes place when the energy gap becomes too large.

t is essentially the matrix element of atomic potential ΔU due to the neighboring atoms taken between two electronic orbitals associated with neighboring atoms. Usually this matrix element is small.

2. It is believed that ordinary quantum mechanics can explain the needed large magnitude of t. The calculations are however not first principle calculations and involve experimental input from chemical bond energy data. Therefore one can ask whether some new physics possible related to the notion of valence bond might be needed.

   In TGD framework one indeed ends up to a model of valence bonds involving non-standard value of $h_{eff}/n = n$ for valence bonds. This could lead to a delocalization of electron wave functions and generate strong interaction between valence electrons of neighboring atoms. This mechanism might apply to all strongly interacting many-electron systems (such as that appearing in QHE and FQHE [K30]) so that the physics of dark matter would make itself visible in condensed matter physics thought to be thoroughly understood at the level of basic principles.

   Remark: The original motivation for the hierarchy of Planck constants was the idea that Nature loves theoreticians [K16, **?**]. The phase transition increasing the value of Planck constant reduces the large value of gauge coupling constant $\alpha = g^2/4\pi\hbar$ making perturbation theory impoessible by factor $1/n$ and makes perturbation theory possible.

The TGD based picture about Mott insulators relies on $h_{eff}/h = n$ hierarchy giving rise to dark matter as phases of ordinary matter. In particular, one ends up with a model for valence bonds with valence electrons having value of n larger than for atoms. This in turn leads to a model of high T_c superconductivity generalizing to a model of Mott insulators. Also graphene superconductivity would rely on these mechanisms.

11.2.1 Dark matter as $h_{eff}/h = n$ phases

It is good to explain first the development of the ideas related to $h_{eff}/h = n$ hierarchy.

1. I ended up to the discovery of dark matter hierarchy and eventually to adelic physics [L20], where $h_{eff}/h = n$ has number theoretic interpretation along several roads starting from anomalous findings.

   One of these roads began from the claim about the existence of strange form of matter by David Hudson [**?**]. Hudson associated with these strange materials several names: White Gold, monoatomic elements, and ORMEs (orbitally re-arranged metallic elements). Any colleague without suicidical tendencies would of course refuse to touch anything like White Gold even with a 10 meter long pole but I had nothing to lose anymore. The basic feature is that these elements would form metal like strongly correlates structure although the atoms are separate so that their is no lattice in the usual sense.

   My question was how to explain these elements if they are actually real [K9, K15]. If all valence electrons of this kind of element are dark these element have effectively full electron shells as far as ordinary electrons are considered and behave like noble gases with charge in short scales and do not form molecules. Therefore "monoatomic element" is justified. Of course, only the electrons in the outermost shell could be dark and in this case the element would behave chemically and also look like an atom with smaller atomic number Z. So called Rydberg atoms for which valence electrons are believed to reside at very large orbitals could be actually dark atoms in the proposed sense.

   Obviously also ORME is an appropriate term since some valence electrons have re-arranged orbitally. White Gold would be Gold but with dark valence electron. The electron configuration of Gold is $[Xe]4f^{14}5d^{10}6s^1$. There is single unpaired electron with principal quantum number $m = 6$ and this would be dark for White Gold and chemically like Platinum (Pt), which indeed has white color.

   Remark:: The precious metals involved are also transition metals near the end point of the group along the row of the periodic table as are also Mott insulators.

The ability of ORMES consisting of single isolated atoms to behave like condensed matter system would be due to the presence of long magnetic flux tubes assignable to valence electrons with large n and connecting the atoms of ORMUS together. For ordinary valence bonds the flux tubes are short and one obtains ordinary metal lattice.

2. Developments at quantitative level began with the TGD based explanation [L19] (see `http://tinyurl.com/y8pqcc8s`) for the finding that in heating of a system involving transition metal unpaired valence electrons mysteriously disappear. The increase of $h_{eff} = n \times h$ for valence electrons in transition metals from their normal value would explain how they become dark matter in TGD sense. Since the binding energy associated with the bond increases with n, energy is required to kick electrons to the dark valence band and heating provides it. In TGD inspired quantum biology, metabolic energy increases the value of n for valence bonds and makes possible quantum coherence in unusually long length scales.

3. This model led soon to a TGD inspired model for valence bonds [L18] (see `http://tinyurl.com/ycg94xpl`). The value of n for valence bond depends on the valence of the atom having larger electronegativity (more towards right along the row of the Periodic Table) and increases as one moves along the row: this guarantees that the bond energies vary only weakly along the row of the periodic table. The simple expectation form ordinary quantum theory is that the dependence of bond energy should be rather strong.

   The outcome is a vision about biochemistry and the roles of various valence bonds in metabolism. The valence bonds associated with atoms with high electronegativity carry especially larger metabolic energy identified as the difference of the bond energies for the actual value n_{bond} of n and its value n_{atom} for free atom. Catabolism would liberate this energy by reducing the values of n_{bond}.

11.2.2 Many-sheeted description of conductors

The first question is what electrons and elementary particles are at space-time level in TGD Universe.

1. In many-sheeted space-time elementary particles are two-sheeted structures consisting of two wormhole contacts, whose throats are connected by flux tubes at both sheets. The flux tubes at other sheet defining the magnetic body of the particle could have large value of $h_{eff}/h = n$ and be rather long. For instance, in atomic nucleus the flux tubes connecting nuclei to a nuclear string would be short with length L of order nucleon size but the flux tubes at the sheet defining magnetic body would be considerably longer - naturally given by nuclear length scale [L2, K12]. The length would be even longer for dark nuclei [L17].

2. Many-sheeted space-time predicts a hierarchy of space-time sheets and magnetic fields in various scales would correspond to these sheets and be represented as flux tubes. Flux tubes within flux tubes is what comes naturally in mind. Valence bonds would correspond to flux tubes defining only one level in this length scale hierarchy. Certainly this level is higher than elementary particle level, which corresponds to the Compton size of elementary particle.

3. Valence flux tubes could correspond to the magnetic body of the particle and have large valued of n. In accordance with the TGD view about valence bonds [L18] (see `http://tinyurl.com/ycg94xpl`) the value of n for valence bonds making possible also conductivity is larger than for free atoms.

   Remark: TGD Universe is fractal and this picture about elementary particles and their magnetic body is very similar to the view about galaxies as knots in long flux tube and having protuberances analogous to the flux loops and containing stars as sub-knots [L24] (see `http://tinyurl.com/ybbs9zhp`).

What makes the system a conductor?

1. Suppose that valence bonds indeed correspond to flexible loop like structures, which can be rather long for large values of n. Could the hopping of electrons between neighboring molecules (or atoms) be basically a topological process?

Could the valence flux loops of neighboring molecules (say NiO) temporarily reconnect to form a pair of flux tubes connecting the molecules so that electrons can propagate along the these flux tubes between molecules?

There would be no resistance during the flow along flux tube but the stopping at the end of the flux tubes would contribute to the resistance. In absence of electric field the currents are in random direction but the presence of electric field would make possible a net current.

2. One can try to relate this picture also to the standard description of conductivity obtained replacing many-sheeted space-time with that of special relativity so that all information about space-time topology is lost. What remains are the parameters U and t defined as matrix element of ΔU and the gap energy for the conduction band defined as $U - 2zt$.

   A de-localization of electrons occurs in conductivity due to temporary reconnections inducing hopping of electrons between neighboring sites. The increase of n increases various quantum scales. In particular, the length of valence bond increases and the wave functions for valence electrons are de-localized in a larger volume.

   Therefore the matrix elements of ΔU receive contributions from a volume, where ΔU is large. For flux tubes connecting neighboring unit cells it could be even larger than this.

   Also the value of U as expectation value of Coulombic energy for single site is affected. When the value of the competing parameter U becomes large enough, band gap becomes so large that conductivity is lost and one has Mott insulator.

11.3 Mott insulators in TGD framework

In TGD framework the new view about valence bonds and anti-ferromagnetism provides new insights about Mott insulators.

1. The valence bonds for oxides such as NiO should have high values of n and for certain critical parameter values (quantum criticality) n might become even higher than for ordinary valence bonds. This would increase the quantum coherence length measured by the flux tubes connecting neighboring molecules: the naïvest guess is that it is proportional to n (for the atomic orbitals it is proportional to n^2). This makes makes possible quantum coherence in longer scales than usually possibly leading to a formation of Cooper pairs implying superconductivity at least in short scales at low enough temperatures.

2. Transition metal property is essential for being a Mott insulator. The table of Wikipedia article gives an overall view about transition metals (see `http://tinyurl.com/ydyqunm4`). There are 4 groups corresponding to the values $r = 4, 5, 6, 7$ labelling the rows of the Periodic Table.

   Ni atoms appearing in Mott insulator NiO and Cu atoms appearing in copper oxide high T_c superconductors belong to the group 4 of transition metals, which means that they belong to the fourth row of the Periodic Table (principal quantum number of highest valence electrons equals to 4). Ni and Cu are at the right end of the portion of 4th row containing transition metals. The value of n for copper oxides is predicted by TGD based model of valence bond to be highest in group 4 and second highest for Ni [L18] (see `http://tinyurl.com/ycg94xpl`). Copper oxides are therefore ideal candidates for high T_c superconductors in TGD Universe!

   For the groups 5, 6, and 7 the oxides of the elements towards the ends of these rows, in particular those of the rightmost elements in the group are Ag, Au, and Hs are good candidates for high T_c superconductors if the TGD based interpretation makes sense. One can also ask whether T_c could be higher for the transition metals of higher groups.

   Remark: ORMEs are precious metals belonging to 5th and 6th groups of transition metals and claimed to be superconducting at room temperatures. Their claimed healthy effects could be due to the large metabolic energy content of the valence bonds involved liberated when utilized.

3. Anti-ferromagnetism is also essential for Mott insulator property besides the property called "mottism" summarized above. Also copper oxides are anti-ferromagnetic (AFM) and the

TGD based model relies on the existence of parallel flux tubes carrying magnetic fluxes with same magnitudes but opposite directions [K34, K35]. The members of Cooper pairs are at different flux tubes and form spin singlets.

4. An intriguing property of Mott insulators is the existence of bosonic excitations with charge 2e. They must consist of 2 electrons (see `http://tinyurl.com/ydyqunm4`) and are therefore natural candidates for the precursors of Cooper pairs in unconventional superconductivity.

11.3.1 Transition to non-conventional superconductivity

What could happen in the transition to non-conventional superconductivity?

1. Anti-ferromagnetism is a necessary ingredient. It requires the presence of flattened square shaped flux tube loops with opposite directions of magnetic flux for the opposite sides of the flattened square. Also the flux tubes defining the valence bonds and assignable to the magnetic bodies of electrons are present. The temporary reconnection of the valence flux loops would give rise to ohmic conductivity.

   Could the valence flux tubes temporarily reconnect with AFM flux tubes inducing the transfer of electrons to them so that supra current would flow along the resulting flux tube pairs and one would have high T_c superconductivity.

   There is however an objection against this idea. Valence electrons are responsible for ferromagnetism: can one really distinguish between the AFM flux loops and valence flux loops. Many-sheeted space-time suggests that this is spossible. AFM loops would correspond to a higher level in the hierarchy of space-time sheets than valence loops do. Cooper pairs reside at these flux tubes whereas Ohmic current carriers reside at the valence loops.

2. How exactly are the Cooper pairs formed? Are they formed as Cooper pairs with members assignable to neighboring lattice sites and are these pairs transferred to AFM flux tube pairs by temporary reconnections? If so, the basic mechanism giving rise to supra current would be purely topological.

   As already mentioned, Mott insulators are characterized by the existence of bosonic excitations with charge 2e, which must consist of 2 electrons (see `http://tinyurl.com/ydyqunm4`). This would suggest that they are precursors for the Cooper pairs of high T_c super-conductors appearing below the upper critical temperature T_{c1} but not yet giving rise to superconductivity in long length scales? The transition to superconductivity for Mott insulators would be analogous to the transition to super-conductivity for high T_c superconductors.

3. According to TGD based model of high T_c superconductors [K9, K10, K34, K35] the transition to superconductivity would take place at two steps. At higher critical temperature T_{c1} a phase transition to a state containing Cooper pairs takes place but there is no superconductivity in long scales yet. Supra currents would be associated with AFM flux loops having the shape of a flattened rectangle such that magnetic fluxes have opposite directions at the opposites sides of the rectangle. At lower temperature T_c a phase transition to a genuine super-conductivity takes place: sequences of the flux loops would reconnect to much longer flux loops making possible macroscopic supra currents.

11.4 TGD description for the super-conductivity of graphene

The above general model for high T_c super-conductivity and Mott insulators can be applied also to graphene bi-layer.

1. Graphene sheets are hexagonal lattices formed from aromatic rings of 6 C-atoms. Delocalization occurs for valence electrons inside 6-rings and a further delocalization occurs as the hexagonal lattice is formed and gives rise to conductivity. The current flow would be along routes associated with the flux tube network formed from the hexagons. As already explained, in the TGD based model for valence bonds the value of $h_{eff}/h = n$ is higher for valence bonds than for atoms.

2. For the generic twist angle θ the graphene sheets behave like independent conductors with a weak interaction. For critical twist angles the system behaves as a single coherent unit and becomes Mott insulator. The increase of h_{eff} increases the energy of the valence bond increasing band gap so that it becomes difficult to kick electrons to valence band by thermal energy. Conductivity is lost. The increase of quantum coherence length can however lead to a formation of Cooper pairs (as in Mott insulators quite generally) and an applied electric field can kick the electrons to a new conduction band allowing super-conductivity.

3. The critical twist angle can be understood in terms of a generation of lattice like structure with an increased size of the lattice cell. At the nodes of this super-lattice the carbon atoms of two sheets would be directly above each other. The formation of this super-lattice is known as Moire effect (see `http://tinyurl.com/qchunes`).

   Cooper pairs would have periodic wave functions in the superlattice. Wave length would be equal to the lattice constant of the superlattice in the simplest situation. $h_eff/h = n$ view about dark matter would suggest that the members of Cooper pair are dark ($n = n_s$) and that the ratio of the lattice cells sizes for super-lattice (l_s) and the original lattice (l) equals to the ratio of corresponding values of n: $l_s/l_1 = n_s/n$.

4. Precursors of the Cooper pairs should be associated with the combination of flux tube networks defined by the two graphene lattices and would be transferred to AFM flux loops having longer length and reconnecting to long flux flux tube pairs.

   Since superconductivity occurs only for a critical twist angle, a pairing of flux tubes connecting the nodes of the super-lattice should take place. The members of Cooper pair should be associated with members of these flux tube pairs. The distance between Cooper pairs would have upper bound give by l_s.

12 Rydberg polarons as a support for TGD view about space-time

I learned about very weird looking phenomenon (see popular article at `http://tinyurl.com/y96p48u5`) involving Bose-Einstein condensate (BEC) of strontium atoms at ultralow temperature corresponding to $T = 1.5\times10^{-7}$ K and thus thermal energy of order 10^{-11} eV. Experimenters create Rydberg atoms by applying a laser beam to BEC of strontium atoms: second valence electron of Sr is kicked to at an orbital with very large classical radius characterized by the principal quantum number n. This leads to a formation of "molecules" of BEC atoms inside the orbit of Rydberg electron - Rydberg polarons as they are called. The term polaron comes from charge separation in the scale of polaron.

It seems strange that a tiny electron would be able to confine BEC molecules inside its orbit. The Rydberg polaron has several counter intuitive properties distinguishing it from ordinary polarons. Skeptic can also ask whether the formation of Rydberg atoms only makes the detection of BEC molecules possible when the atom to become Rydberg atom belongs to an already existing BEC molecule.

12.1 Experimental findings

From the research article [D8] (see `http://tinyurl.com/ybqb7bmv`) one learns that the experimenters use in a very clever manner the information about low energy scattering of Rydberg atoms in s and p partial waves to deduce so called Born-Oppenheimer potential (BOP). BOP is analogous to that used in molecular physics to deduce electronic states assuming molecular positions fixed. Now however Rydberg state for electron is fixed and one solves the states of BEC in this potential! The idea is that BEC behaves as a single particle. The objection to this is is that the states are reported to be more like molecules of some BEC molecules containing also the Rydberg atom.

BOP is a combination of $|\Psi_R|^2$ and $|\nabla\Psi_R|^2$ with coefficients proportional to s- and p-wave scattering lengths A_s and A_p (which is momentum dependent) deduced from the low energy scattering of Rydberg atoms from BEC. The explicit expression for the BOP is given as

$$V(r) = \frac{2\pi\hbar^2}{m_e}\left[A_s|\Psi_R|^2 + 3A_p|\nabla\Psi_R|^2\right] \quad . \tag{12.1}$$

Here $\Psi(r)$ is the wave function of Rydberg electron. By using rather advanced methods (functional determinant approach (FDA) and mean field theory) the experimenters estimate the bound state energies of BEC atoms in BOP numerically. The bound states would be localized states associated with the minima of the BOP having oscillatory behavior.

The claim is that the experimental findings provide support the existence of these bound states. Usually polarons involve positive energy excitations of the surrounding medium - "cloud" - but now it would be negative energy excitations - bound states - that would be excited. The excitation means that energy is drawn from BEC by dropping some particle to negative energy state: this would be an analog of metabolism.

One can test this proposal experimentally by using two laser beams with frequencies 689 nm and 319 nm. The first beam generates intermediate excitations $5s^2 \to 5s5p^3P_1$ and latter beam the Rydberg excitations $5s5p^3P_1 \to 5snp^3S_1$. The frequency of 319 nm beam must be varied to cover the excitations corresponding to various values of n. Since the dependence of the bound states energy is of form $1/n^2$, a rather slight variation is enough to cover a wide range of values of n. One obtains peaks corresponding to various values of n.

The peaks labelled by n have however sub-structure. One can vary the beam frequency slightly downwards from the frequency $\nu_R(n)$, which generates free Rydberg atom. For given n one finds spectral peaks at lower frequencies $\nu = \nu_R(n) - \Delta\nu$. The data is expressed in terms of function $A(\nu)$ telling the intensity of the absorption of laser photons at given frequency ν, and one can estimate binding energies from the values of $\Delta E = h\Delta\nu$. For $n = 38$ $\Delta\nu$ is in the range $[1, 40]$ MHz so that the binding energies ΔE are in the range $[1, 40]\times.4\times10^{-8}$ eV. The peak gets narrower for larger values n scaling like $1/n^3$ suggesting that the values of $\Delta\nu$ scales like $1/n^3$.

Remark: This is true for the ordinary value of Planck constant. For non-standard value $h_{eff}/h = n$ of Planck constant the estimate for the binding energies $\Delta E = h_{eff}\Delta\nu$ would be scaled up. This would mean that also the beam energy is scaled up and this looks unrealistic. Since the temperature is extremely low, large $h_{eff}/h = n$ is not needed for macroscopic quantum coherence. Indeed, the thermal wavelength $\sqrt{1/2m_eT}$ of electron giving an idea about the scale of spatial quantum coherence is at the temperature considered of order 100 μm.

Fig. 2 of the article (see `http://tinyurl.com/ybqb7bmv`) shows for $n = 38$ clearly the peaks at multiples of -5 MHz corresponding to $\Delta E = -2.1 \times 10^{-8}$ eV for the corresponding energy interpreted as binding energy rather than positive excitation energy in the initial state. The appearance of integer multiples suggests that harmonic oscillator excitations involving one or several oscillators are in question. What looks strange that the spectrum of excitations has negative rather than positive energies. The finding is interpreted as a direct evidence for the existence of BEC molecules - Rydberg polarons predicted by the model based on scattering length data. For a small number of BEC atoms one can even study the molecules.

Remark: The analogy with harmonic oscillator spectrum leads to ask whether a genuine harmonic oscillator spectrum with positive excitation energies could be in question - say cyclotron energy spectrum for electrons in an external magnetic field B_R assignable to the pair of s-wave electrons of Rydberg atom and having therefore positive excitation energies. The interpretation would be in terms of the analog of metabolism analogy also now. The excited Rydberg atom would drop some BEC atoms to lower energy state and in this manner extract energy from BEC.

Authors report several features distinguishing the Rydberg polaron from ordinary polaron. Ordinary polaron corresponds to a ground state of a many-particle system but now one has multiple excitations from the ground state. Also the importance of bound states would distinguish Rydberg polaron from ordinary polarons. A universal behavior of the spectral line shape decreasing like $1/n^3$ as a function of principal quantum number characterizing the Rydberg electron suggests that quantum criticality. Also the narrowing of the spectral features with n is reported.

In the model of experimenters the binding energy spectrum depends on the value of the principal quantum number n since the positions of zeros of $V(r)$ depend on n. Since $V(r)$ is product of exponent function and polynomial of order $2n$, $dV(r)/dr$ has at most $2n-1$ real zeros and at most n minima. One expects that harmonic oscillator strength has different values for these zeros,

which also depends on n. One obtains in harmonic oscillator approximation integer multiples of the basic energy depending on the minimum of $V(r)$.

On basis of the article, I am not able to tell whether the authors have any concrete model for what the assumed (effectively contact -) interaction between the Rydberg atoms and BEC atom is. What this interaction is and how it leads to a generation of bound states (not necessarily!) in the case of BEC atoms but not in the case of ordinary atoms, remains a mystery to me. The question whether TGD might provide some ideas about in this respect, served as the basic motivation for the following considerations. This led to a considerably more detailed understanding about how TGD differs from Maxwellian electrodynamics.

12.2 Could TGD say something interesting about Rydberg polarons?

The obvious question in TGD framework is whether this mysterious interaction giving rise to the BEC molecules (or whatever they are) could be understood using the notions of many-sheeted space-time, magnetic flux quanta, and possibly also the identification of dark matter as phases of ordinary matter with non-standard value of $h_{eff}/h = n$.

12.2.1 Some applications of TGD view about space-time

I have applied this general rule in various scales with inspiration coming from the fractality of TGD Universe.

1. Elementary particles correspond in TGD pairs of wormhole contacts connected by flux tubes at both space-time sheets involved. Hadrons involve color flux tube structures carrying most of the energy of the hadron [K22, K24, K25].

2. Atomic nuclei and their dark variants explaining "cold fusion" are nuclear strings [L11, L17]. Dark nuclear strings are also in central role in TGD inspired quantum biology [L22] and their states are in correspondence with DNA, RNA, tRNA, and amino-acids [L14].

3. In TGD based view about chemistry valence bonds correspond to flux tubes with non-standard value of $h_{eff}/h = n$ [L18]. In biology valence bonds are carriers of metabolic energy with n measuring the amount of metabolic energy and increasing along the row of the Periodic Table. The model conforms with empirical facts and explains why the molecules towards the right end of the rows of the Periodic Table are carriers of metabolic energy.

4. Superconductivity and superfluidity are natural applications [**?**, K29]. Flux tubes would serve as correlates for the correlation of the members of Cooper pair. In high T_c superconductivity supra currents flow along the flux tubes [K34, K35].

5. In neuroscience and biology the quantum entangled networks of neurons and cells define the correlates of mental images at the level of brain and body and also the part of magnetic body outside biological body is in central role [L16, L23]. Gravitational and other interactions are mediated along flux tubes and here the notion of gravitational (electromagnetic, etc) Planck constant is very useful [K39, K27, K29]. The notion of gravitational Planck constant $h_{eff} = h_{gr}$ is assignable to the flux tubes mediating gravitational interaction and having very large value is involved also with TGD inspired quantum biology and neuroscience [K6, K13].

6. At the second end of the scale hierarchy there is a model for the formation of galaxies as knots of long flux tubes carrying dark energy and dark matter and having stars as sub-knots of these knots. Second example is nuclear physics and its dark variants.

12.2.2 What guidelines to follow?

The listed successful applications encourage to ask whether the TGD could provide a model for Rydberg polaron. There are several guidelines to follow.

1. The key question concerns the role of Rydberg atom. Does its formation lead to the generation of Rydberg molecules or are they already present in BEC. The mechanism for the formation of the Rydberg molecules depends crucially on the answer to this question. If

Rydberg atom is necessary, the magnetic field induced by the formation of Rydberg atom could be crucial for understanding what happens. This would also force the intepretation about the role of bound states unless the arrow of geometric time changes temporarily in the process. If Rydberg atom is not necessary, then alternative options can be considered.

2. The notion of cyclotron BEC as a condensate of cyclotron states of charged bosons or Cooper pairs playing important role in TGD inspired biology is of special interest since it could explain the appearance of excitation energies as basic energy identifiable as cyclotron energy. The BECs of electron Cooper pairs and of biologically important ions or their Cooper pairs are central in TGD based of quantum biology and neuroscience. What is encouraging that the energies identified as bound state energies have scale assignable to cyclotron states in magnetic field which is roughly $3.3 \times B_E$, where $B_E \simeq .5$ Gauss is the nominal value of the magnetic field B_E of Earth.

   Remark: The strength of B_E varies in the range $[.25, .65]$ Gauss and one cannot exclude the possibility that $B_{end} = .2$ Gauss corresponds to minimum value of B_E achieved at equator. In dipole approximation the strength at poles is two times higher.

3. One can of course argue that the introduction of an external magnetic field is unrealistic. I do not know whether this is the case: dark magnetic fields would not be observable using the detection methods of standard physics. On the other hand, the origin of B_{end} has remained a mystery. Could its flux tubes connect charged particles of opposite spin so that B_R and B_{end} would accompany essentially same physical phenomenon?

4. The analogy with metabolism suggests the possible relevance of zero energy ontology (ZEO) leading to the proposal of what I call remote metabolism involving temporary reversal of the arrow of time at some level of the hierarchy of space-time sheets labelled by preferred p-adic primes and values of n and making possible for the system to extract energy from environment in apparent contradiction with the second law.

   In the recent case the problem is that one would expect that the energy of laser photon is shared between the Rydberg atom and other BEC atoms. Just the opposite happens. One might argue that this is not a problem since temperature is so low but I am not certain about this. There is also a second problem: if B_R is responsible for the cyclotron states, then the only sensible interpretation is that the arrow of geometric time is temporarily changed since before its cyclotron BEC providing the "metabolic energy" is not present.

   In ZEO "big" state function reduction behind TGD inspired theory of consciousness means temporary reversal of arrow of time for the entire system [L21]. Conscious entity as a generalized Zeno effect in turn would correspond to a sequence of ZEO analogs of weak measurements and dying when the big reduction takes place.

   What looks for the observed with standard arrow of time like extraction of metabolic energy from BEC would correspond to sharing it with BEC if the arrow of time changes temporarily. This might relate to the finding that the entanglement between electrons of Sr^+ ions lasts surprisingly long time - 15 seconds. Could this time correspond to the duration of the time reversed state.

5. A further possible guideline comes from the general vision replacing many-particle states with tensor networks [L15] having particles as nodes connected by magnetic flux tubes carrying magnetic flux (possibly monopole flux). The general rule is that if there is quantum correlation/entanglement, it has flux tube as a space-time correlate. The model for valence bond based on $h_{eff}/h = n$ hierarchy could help here although the fact that valence bonds are between atoms with opposite electro-negativities suggests that this is not a correct guide line to follow.One can however ask whether Cooper pair as spin singlet bonded by flux tube might replace the valence bond.

One can imagine several options.

1. The energy scale of the excitations is very low suggesting that magnetic interaction energies are in question. Since Sr atoms have vanishing nuclear magnetic moment, the magnetic field

generated by the two s-wave electrons of the Rydberg atom could serve as candidate for this external magnetic field. In Maxwellian framework this option fails but in flux tube picture for the magnetic field created by the electrons the situation changes as already briefly described in the interoduction.

2. Could the formation of Rydberg molecules (or whatever they might be) be due to a formation of flux tube contacts between BEC atoms serving as analogs of valence bonds. An immediate objection is that in chemistry valence bond is between states of opposite electronegativity. Pairing might however occur by spin-spin interaction.

   Now Maxwellian expression for the magnetic spin-spin interaction energy varies in a range involving 9 orders of magnitude and for the average distance of order .1 μm it is several orders of magnitude too low. This means a loss of predictivity. One could imagine for instance a molecule of 3 BEC atoms ABC in which the distances between A and B and A and C would be different: this would give a non-trivial binding energy. Again Fermi statistics is a problem: it seem very difficult to avoid p-wave excitations of electrons.

   Flux tubes distinguish TGD microscopically from Maxwell's theory. Could flux tubes be generated between the s-wave electrons of different BEC atoms. Also now the net interaction energy tends to cancel by statistics constraints in Maxwellian approach. TGD based model of superconductivity suggests a solution of the problem: the two s-electrons are condensed at different flux tubes and the spin-spin interaction between them gives rise to binding energy or at least binds them to Cooper pair (strontium-titanate is super-conductor!).

3. TGD inspired quantum biology suggests the most promising approach found hitherto. An external magnetic field would be present: either the Earth's magnetic field B_E with nominal value of .5 Gauss (experimental arrangement might eliminate B_E) or its "endogenous" dark variant with a nominal valued $B_{end} = 2/5B_E = .2$ Gauss possibly characterized by $h_{eff}/h = n > 1$. Actually B_{end} has spectrum of strengths in TGD inspired quantum biology and explains bio-photons as ordinary photons resulting from dark photons in the transition $n > 1$.

   The model of authors could be perhaps understood in terms of negative magnetic dipole interaction energy of electrons with this magnetic field. The two electrons in s^2 state would topologically condense at flux tubes with opposite magnetic fluxes and could have negative spin-spin interaction energy binding them to a Cooper pair. There is however a problem: the shape of the spectral peak depends on the principal quantum number n suggesting that the value of the magnetic field involved behaves like $B \propto 1/n^3$.

   Skeptic of course argues that the introduction of external magnetic field is a desperate last attempt before giving up. The origin of B_{end} has however remained a mystery. Could it be that B_R and B_{end} are aspects of the same phenomenon? If so then also the $B \propto 1/n^3$ dependence could be understood.

4. An alternative model gives up the assumption that bound states are in question but allows temporarily time reversal. cyclotron excitations of the BEC condensate containing electrons of the BEC atoms still experiencing the Coulomb force would be in question. Magnetic field with strength $3.3 \times B_E \simeq 8B_{end}$ could explain the frequency spectrum quantitatively as cyclotron energy spectrum so that instead of bound states one would have positive energy states but the metabolic analogy would still apply.

12.2.3 Brief summary of TGD based model

TGD inspired model is based on a more detailed model for flux tubes.

1. The strength of the constant valued flux tube magnetic field B_R associated with the flux tube model of electron plays the role of the physical dipole as a region of constant magnetization associated with a real world dipole field. The flux tube carries a monopole flux made possible by CP_2 topology so that the Maxwellian counterpart does not exists for it. This view about dipole magnetic field is a signature of many-sheeted space-time.

2. One can model the quadrupole field B_R associated with two-sheeted closed flux tube connecting 5s and ns electrons of Rydberg atom. In Maxwellian theory B_R would vanish along

the line between the dipoles but in TGD it has opposite directions at parallel (essentially same M^4 projection) space-time sheets so that it vanishes only at QFT limit. The members of BEC s^2 electron pairs topologically condense at separate flux tube sheets to minimize the magnetic interaction energy associated with their spins. This mechanism could also give rise to Cooper pairs. Negative energy spectrum could correspond to a generation of several electron pairs in energy minimum.

3. B_R gives rise to the analog harmonic oscillator potential with ground state energy defined by the interaction energy of spins with B_R. If B_R depends on the distance L between the s-wave electrons of the Rydberg atom in a universal manner $B_R \propto 1/L^{3/2}$, one can understand the universal $1/n^3$ dependence of the width of the observed peak.

   The distances associated with the maxima of $|\Psi|^2$ give sub-peaks defining preferred Larmor frequencies so that the structure of the peak gives a map of $|\Psi(r)|^2$. If Rydberg atom moves with respect to BEC, one must add the p-wave contribution just like one does in the model of authors and find maxima for this. The basic difference with respect to the BOP approach of experimenters is that one has maxima rather than minima.

4. ZEO allows also to consider the possibility that the arrow of time is temporily changed in the state function reduction creating the Rydberg atom: this interpretation would allow the excitation of cyclotron states with reversed arrow of time. For an observer living in standard direction of time the process would look like dropping cyclotron electrons to lower energy states to get surplus energy so that the laser photon energy need be so high. This would give harmonic oscillator spectrum for each electron pair behaving like Cooper pair. It should be easy to experimentally test for the correctness of the two proposals.

12.3 Maxwellian and TGD pictures for the magnetic interaction energy

TGD suggests that the proper way to model the spin-spin interaction is to use the flux tube picture. Maxwellian approach provides a second approach and one might hope that it could give a reasonable approximation.

12.3.1 Maxwellian approach

QFT limit of TGD with flux tubes replaced with Maxwellian magnetic fields is expected to give a good approximation of electromagnetic interactions. Therefore it is realistic to start from a Maxwellian picture for the electromagnetic fields. If Maxwellian picture gives reasonable order of magnitude estimates one can hope that also the TGD view based on the notion of magnetic body (MB) does so.

1. The obvious idea is that the magnetic field in atom is created by the total electron current of electrons. In particular, valence electrons give to this kind of current via Maxwell's equations: $\nabla \times B = j_e/4\pi$. This would give connection between electron current and B analogous to that appearing in BOP where modulus squared for electron's Schrödinger amplitude and its gradient appear.

   This picture applies also Coulomb interaction: now the charge density of electrons would serve as the source of electric field via $\nabla \cdot E = \rho$.

2. The two electrons of Sr Rydberg atom create a magnetic field, call it B_R. Same applies to the valence electrons of s^2 state of BEC atom. In the first approximation the magnetic moment of the unexcited electron determines the magnetic field at large distances. Since the electron's wave functions depend on the radial coordinate only in s-wave, the current $\overline{j}_e$ due to the gradient of Ψ is radial for both electrons. One can reduce the equation $\nabla \times \overline{B} = \overline{j}_e/4\pi$ to a Laplace equation by using $\overline{B} = \nabla \times \overline{A}$ and Coulomb gauge $\nabla \cdot \overline{A} = 0$. This gives $\nabla^2 \overline{A} = \overline{j}_e \equiv j\overline{r}/4\pi$.

   Besides this there is a contribution due to the spin of the electron and in the direction of spin projection for spin eigenstates. In the lowest order approximation the $n = 5$ electron looks like point-like magnetic dipole and generates dipole field. Same in principle applies

also in the case of s^2 state of two electrons and also in case of electrons inside [Kr] shell (the electronic configuration of Sr is [Kr]s^2).

I do not know whether the above approach has been proposed earlier. In any case, it could be motivated by the following argument.

1. Also the electrons of BEC atom have spin-spin interaction and the first thing that comes into mind is to estimate its contribution to the energy by taking expectation value in the two fermion state defined by s-wave valence electrons. If the pair of s^2 electrons transforms a Cooper pair, one must be able to estimate the change in energy, in particular spin-spin interaction energy.

2. If found no mention about spin-spin interaction in web but found a popular article telling that the measurement of the spin-spin interaction energy is extremely difficult but was carried for a pair of Sr^+ ions (!) at distance of order 2 μm (see `http://tinyurl.com/yasjvufz`): this would partially explain why it has not been calculated. It was also found that the coherence time for entangled electron pair was unexpectedly long: 15 seconds.

   In the popular article the calculation of the effect was mentioned to be very difficult. The repulsive interaction between fermions gives a competing contribution which - being expectation of $1/|r_1 - r_2|$ - is finite. As a matter of fact, I realized that the integral defining the expectation value of $1/|r_1 - r_2|^3$ appearing in the expectation value of spin-spin interaction energy in s-wave state in two fermion state diverges logarithmically!

The pragmatic way out of the difficulty would be straightforward: do not try to calculate anything giving an ill-defined answer! To gain more respectability for this view one could formulate the state of affairs as a general rule. One is allowed to estimate only the effects of external fields - say that of nucleus when calculating spin-orbit interaction energy or interactions between atoms - by using this approach. The external field depends in this case on the electron configuration involved so that one cannot regard spin-spin interaction as being due to an external magnetic field.

Atomistic skeptic can however argue that in Born-Oppenheimer approach assumes the configuration of atoms to be given and calculates electron states associated with this and then solves Schrödinger equation for the atoms. Also in the calculation of color-magnetic spin-spin splitting of mesons and baryons this approach is used. Therefore the problem is real and one must solve it.

The proposed approach could however allow to get rid of the divergence associated with spin-spin interaction since the magnetic field determined by the total current defined by electrons gives smoothed out magnetic field free of singularity associated with point-like magnetic dipole.

12.3.2 How flux tubes as mediators of magnetic spin-spin interaction would relate to the Maxwellian picture?

In TGD based approach flux tubes would mediate the magnetic interaction. For two different atoms electrons would be connected by flux tubes and the electrons at its end or possibly moving freely in the interior would interact with essentially 1-D magnetic flux. This picture could apply also to electrons inside single atom. Also Coulomb interaction energy could be estimated in the same manner between electrons of single atom. In the case of separate atoms one can argue that repulsive Coulomb interaction can be neglected in excellent approximation.

Remark: Strong form of holography (SH) implies that at least in the sense of information theory electrons at space-time level can be thought of as being localized at 2-D string world sheets - that is electron states are fixed by 2-D data. In this picture flux tubes are accompanied by fermionic strings with fermions at their ends assignable to the light-like orbits of partonic 2-surfaces at which the signature of the induced metric changes from Minkowskian to Euclidian. At the level of embedding space $M^4 \times CP_2$ the spinors characterizing ground states of super-conformal representations are however 8-D and it is these spinors that correspond to those of standard model.

One must have rules for how to replace Maxwellian field with flux tubes.

1. Flux tubes carry a conserved magnetic flux. Therefore the magnetic field is essentially constant inside flux tube and the situation is effectively 1-dimensional. One can consider also the possibility that the magnetic flux is quantized. In TGD framework it is also possible to have

closed flux tubes carrying monopole flux looking locally like pair of flux tubes with opposite fluxes: they could appear in super-conductors and in cosmology. No currents are needed to create these magnetic fields made possible by the topology of CP_2. The cross section of this kind of flux tube is closed 2-surface rather than a disk with holes. For these flux tube pairs Maxwellian limit does not exist.

2. Flux conservation implies that the spin-spin magnetic interaction energy for given flux tube does not depend on distance.

3. There is a distribution of magnetic flux tubes, which should correspond to the Maxwellian field. The intuitive picture is that the density dn/dS of flux tubes normal to given 2-surface having normal direction $\overline{n}$ multiplied by possibly quantized magnetic flux corresponds to the value of Maxwellian magnetic field:

$$\overline{B} \leftrightarrow \frac{dn}{dS}\Phi\overline{n} \ . \tag{12.2}$$

dn/dS would be determined by the wave function for 3-surfaces in the "world of classical worlds" (WCW). This picture would hold true at larger distances from the source - say dipole.

4. Flux tubes field could mimic Maxwellian field with a better accuracy if the flux tubes can branch at larger distances. This would look natural for dipole fields. The outcome be a kind of fractal tree like structure growing in the radial direction. This would involve reduction of the field strength and possible also the net flux which could be large in the vicinity of dipole but reduce later.

This picture generalizes to electric flux tubes/quanta carrying constant electric flux. By effective one-dimensionality the electric potential is proportional to distance along flux tube.

Interesting questions relate to the possibility of space-time sheets parallel in $M^4 \times CP_2$ and having same M^4 projection: at QFT limit they are replaced region of M^4 with deformed metric.

1. One can imagine that both valence electrons with opposite spins are accompanied magnetic flux tubes such that they correspond 4-surfaces on top of each other and extremely near to each other in $M^4 \times CP_2$ such that the magnetic fluxes are in opposite directions but of the same magnitude. At QFT limit the total magnetic field would vanish on test particle if it touches all parallel sheets and experiences the fields from all of them.

2. Consider a situation involving two magnetic flux tubes as different sheets associated with spins in opposite directions so that magnetic fluxes are opposite at them. One can imagine a deformation implying that space-time sheets at not at top of each other. Now the magnetic spin-spin interaction would be non-trivial in these regions and favor the formation of bound state spin singlet identifiable as Cooper pairs. Could energy minimization favor the formation of pairs of this kind of single-sheeted regions? For instance, the formation of groups of BEC atoms connected by flux tubes could involve this mechanism. In the situation when the flux tubes project to same region of M^4, bound states would not be possible.

12.3.3 What could happen when the Maxwellian approach fails?

To understand the flux tube picture and connect with with the Rydberg polaron, it helps to ponder what happens when the Maxwellian approach fails. For the magnetic dipole field the region near the locus of the dipole represents a situation, where Maxwellian description might indeed fail. One can take the TGD inspired model of electron itself as a starting point.

1. Electron (actually any elementary particle) would be a pair of wormhole contacts (I and II with throats I1,I2 and II1,II2) connecting two space-time sheets with electron at the throat I1 of contact I and left-handed neutrino ν_L at throat II1 and right-handed neutrino $\overline{\nu}_R$ at throat II2 of contact II. The flux tubes would carry monopole magnetic flux flowing also through the contacts and stabilizing it: otherwise the space-time sheets would only touch for some time.

In scales shorter than the length L of the flux tubes electron would have also weak isospin. At longer scales electron would effectively have only em charge just as standard model predicts.

2. The flux tubes at given space-time sheet would be a correlate for the dipole assigned with dipole magnetic field and carry a constant flux. This corresponds to constant magnetization for a non-ideal dipole created by an inductance in circuit theory.

   Now no current is needed to create the constant magnetic field since monopole flux is in question and the cross section of flux tube is a closed 2-surface. The absence of the current corresponds to the fact that electron's magnetic moment is due to spin and is not created by a current. Monopole flux tube would however give a space-time correlate for the dipole created by spin.

   The strength of the magnetic field would be proportional to $1/S$, S the area of the flux tube projection in M^4. Magnetic dipole would be effectively a pair of magnetic charges (TGD does not however allow isolated magnetic charges) made possible by the topology of CP_2. For non-standard values of h_{eff} these dipoles could have even macroscopic sizes. Monopole fluxes could explain even the mysterious existence of long length scale magnetic fields in cosmological scales.

12.4 A model for Rydberg polaron

The proposd picture for spin dipoples allows to imagine a concrete model for the quadrupole type magnetic field created by a pair of s-wave electrons taken far apart as in the formation of Rydberg atom. This model applies also to Cooper pairs and perhaps even to s^2 pairs of electrons in atom.

1. What happens when one has two electrons identifiable as dipoles with opposite spins as in the case of Rydberg atom? Suppose that the spins are oriented along the connecting line. In the region between electrons the magnetic field vanishes in the Maxwellian world. In many-sheeted space-time it is enough that the magnetic fields have opposite direction but exist as induced magnetic fields at parallel space-time sheets. At QFT limit the field vanishes as sum of these fields.

   One could imagine the following model for the resulting magnetic field. The monopole flux tube pairs associated with electrons would reconnect to a single flux tube pair so that the wormhole throats carrying ν_L and $\overline{\nu}_R$ disappear and $\nu_L\overline{\nu}_R$ pairs at throats opposite to electron carrying throats to take care about the vanishing of weak isospin at longer length scales correlating with the massivation causing the short range of weak forces. The magnetic fields at the opposite throats of both wormhole contacts would have opposite values and at QFT limit the total magnetic field would vanish. This effect is not possible in Maxwellian electrodynamics.

2. The magnetic field would be constant at the flux tubes and equal to $eB = \Phi/S$, $\Phi = BS = n$. One can imagine a topological condensation of the BEC atoms at this flux tube pair. The s^2 electrons of BEC atom would condense at different flux tubes to minimize their magnetic interaction energies $E = -\mu_e \times B$, $\mu_e = e\hbar/2m_e$. Maybe this kind of process could produce the Rydberg polaron.

3. What would be the dependence of the surface area S of the flux tube on the distance L between the electrons? The naïve guess that B has dependence $B \propto 1/L^3$ classically would give $S \propto L^3$. This does not make sense as detailed checks demonstrated.

   If I have interpreted correctly the findings about Rydberg atom, the spectral width as the width of absorption spectrum as function of frequency becomes narrower and scales down as $1/n^3$: the experimenters talk about universality. The $B \propto 1/n^3$ scaling of the magnetic interaction energies would explain this. If the magnetic interaction energies are responsible for the observed spectrum then the proportionality of the size scale of Rydberg atom to n^2 would require $S \propto L^{3/2} \propto n^3$. For $n = 38$ one has $\Delta f = -5$ MHz. This gives the rough estimate

$$\frac{\mu_B\Phi}{S(n=38)} == \frac{\mu_B\Phi}{\pi R^2(n=5)}(\frac{5}{38})^3 = 2.1 \times 10^{-8}\ \ eV\ \ .$$

This condition fixes the radius $R(n=5)$ of the flux tube at distance $L(n=5) \sim 6.3$ Angstrom to be $R \simeq 10^4 a_0 \simeq .5$ μm. More generally, the basic length scales of biology might be hidden to many-sheeted atomic physics.

4. One could hope that this dependence of S on the distance L between electrons of opposite spin with the line connecting the electrons serving as quantization axis is universal. Could this idea have some explanatory power?

   In TGD inspired quantum biology one encounters the notion of endogenous magnetic field $B_{end} = 2/5B_E$, which is roughly by factor $x = 1/7.5 \sim 2^{-3}$ weaker than $B(n=38)$. As a matter of fact, B_{end} must have spectrum reflected directly in the spectrum of bio-photons in visible and UV [K6, K13] and in the spectrum of audible frequencies [K36]. The origin of this magnetic field has remained a mystery. Could it correspond to a magnetic field associated with a flux tube connecting electron dipoles with opposite directions at distance L_{end}?

   The proposed model would give the factor

$$x = \frac{S(38)}{S} = (\frac{L(38)}{L_{end}})^{3/2}$$

   allowing to estimate corresponding distance L_{end} between electrons as

$$L_{end} = x^{-2/3}L(38) = 4 \times L(38) = (\frac{38}{5})^2 L(5) \simeq 231 L(5) \ .$$

   Assuming that Sr atom behaves for $n=5$ state like hydrogen atom with effective nuclear charge $Z_{eff} = 2$ (screening would be due to [Kr] shell), one obtains a rough estimate for $L(5)$ would be $5^2 a_0/2 \simeq 6.3$ Angstrom. This would give $L_{end} \sim 1.5$ μm. It is encouraging that this corresponds to the p-adic length scale $L(169) \simeq 1.5$ μm assignable to cell nucleus size. Note that the p-adic length scale $L(167) = 2.5$ μm corresponds to Gaussian Mersenne $M_{G,n=167} = (1+i)^n - 1$.

   The factor 2 would suggest that the B_{end} corresponds to Rydberg atom with $n = 2 \times 38 = 76$. This is only a rough estimate: the estimate for $L(5)$ assumes hydrogen-like atom and this assumes is only approximate since the s^2 electrons spend considerable time inside [Kr] shell which tends to reduce the radius $L(5)$. An interesting question concerns the identification of Rydberg atom(s) possibly responsible for the generation of B_{end}. The spectrum for $B_{end}(n)$ would be of form $1/n^3$. For given n there would br a spectrum along the n:th row of Periodic Table.

   Spin-spin interaction energy at temperature of 1.5×10^{-11} eV would correspond to an energy which is by a factor 10^{-3} lower than that associated with $L(n=38)$. This corresponds to the scaling $n \to 10n$ and $L(38) \to 100L(38)$.

5. In the realistic situation the Rydberg electron has wave function Ψ. $|\Psi|^2$ has several maxima and minima which correspond to zeros for a polynomial closely related to the square of Laguerre polynomial and having degree $2n$ so that the number of real maxima would be at most $n-1$. One would have a quantum superposition of also flux tube pairs with different lengths L.

   The flux tube lengths L associated with the maxima would be visible as peaks in the absorption spectrum. One would have peaks at the corresponding Larmor frequencies (and possibly also cyclotron frequencies if temporary time reversal takes place). This picture includes only s wave scattering length and the reason would be that one indeed has pure s-wave electrons.

   The BOP of authors includes also a term proportional to p-wave scattering length: one must adds to Ψ a term proportional to the gradient of Ψ representing the change of the wave function due to the motion. When the Rydberg atom moves with respect to BEC, the wave function has also p-wave component and the scattering length A_p is indeed momentum dependent going to zero at the limit of vanishing momentum. If one can neglect the cross terms proportional to $p \cdot (\overline{\Psi}\nabla\Psi + c.c)$ one obtains the BOP. It therefore seems that TGD might be able to explain the basic properties of the Rydberg polaron.

To sum up, Rydberg polaron could provide a clearcut evidence for the notions of many-sheeted space-time, flux tube, and ZEO and also allow to assign "endogenous" magnetic fields to Rydberg atoms.

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