

Bio-Systems as Super-Conductors: Part II

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Abstract

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

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

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

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

1. The selectivity of the cell membrane implies that channels cannot be simple sieves and there must be complex information processing involved.
2. The needed number of pumps specialized to particular ions is astronomical and the first question is where to put all these channels and pumps. On the other hand, if the cell constructs the pump or channel specialized to a given molecule only when needed, how does it know what the pump looks like if it has never seen the molecule? The needed metabolic energy to achieve all the pumping and channelling is huge. Strangely enough, pumping does not stop when cell metabolism stops.
3. One can also wonder why the ionic currents through cell membrane look quantal and are same through cell membrane and silicon rubber membrane.

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

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

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

2. *Two models of cell membrane*

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

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

2. It has been clear from the beginning that the nearly vacuum extremals of Kähler action could play key role in living systems. The reason is their criticality making them ideal systems for sensory perception. These extremals carry classical em and Z^0 fields related to each other by a constant factor and this could explain the large parity breaking effects characterizing living matter. The assumption that at least some cell membranes are nearly vacuum extremals and that nuclei can feed their Z^0 charges to this kind of space-time sheets (not true for atomic electrons) in living matter leads to a modification of the model for the cell membrane as Josephson junction. Also a model of photoreceptors explaining the frequencies of peak sensitivity as ionic Josephson frequencies and allowing the dual identifications Josephson radiation as biophotons (energies) and EEG radiation (frequencies) emerge since the values of Planck constant can be very large. Contrary to the original believe, this model does not require non-standard value of Weinberg angle and this model and first model allow a hybrid.

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

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

1. There are several levels of dynamics. In topological condensation the internal dynamics of ions is unaffected and h_{eff} has the ordinary value. For instance, the formation of Cooper pairs involves dynamics at $k_d = 24 = 151 - 127$ level of dark matter hierarchy if one assumes that electrons and Cooper pairs have size given by the cell membrane thickness $L(151)$. Also the dynamics of ionic Cooper pairs remains unaffected in the topological condensation to magnetic flux quanta obeying $k_d > 24$ dynamics.
2. Cyclotron energies scale as h_{eff} so that for a sufficiently high value of k_d thermal stability of cyclotron states at room temperature is achieved for a fixed value of B . Same applies to spin flip transitions in the recent scenario. The model for EEG based on dark matter hierarchy involves the hypothesis that EEG quanta correspond to Josephson radiation with energies in the visible and UV range and that they produce in the decay to ordinary photons either bunches of EEG photons or visible/UV photons. This identification allows to deduce the value of k_d when the frequency of the dark photon is fixed. The Mersenne hypothesis for the preferred p-adic length scales and values of Planck constants leads to very precise predictions.
3. Cyclotron energies $E = (h_{eff}/2\pi) \times ZeB/Am_p$ are scaled up by a factor $r = 2^{k_d}$ from their ordinary values and for 10 Hz cyclotron frequency are in the range of energies of visible light for $k_d = 46$.
4. These B-E condensates might be favored by the large negative spin interaction energies of spins with the magnetic field (proportional to h_{eff}) so that spontaneous magnetization of the magnetic body becomes possible. This kind of process would make possible for the system to gain energy and angular momentum by feeding charged particles to its magnetic body.

4. *The model of ionic superconductivity*

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

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

This model applies to both electrons and fermionic ions and if the proposal that h_{eff} is proportional to the mass of ion, it predicts same binding energies for all Cooper pairs as their spin-spin interaction energy. This hypothesis predicts universal spectrum of bio-photons

energies if they result from dark photons and is motivated by the identification of gravitational Planck constant with h_{eff} . In this case binding energies would be in eV range and much above thermal energy at room temperature.

5. Atmospheric phenomena and superconductivity

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

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

1 Introduction

This chapter is devoted to further applications of the theory of high T_c superconductors as quantum critical superconductors involving dark matter hierarchy and large values of h_{eff} . The theory is applied to explain the strange findings about ionic currents through cell membrane, exotic neutrino superconductivity and the notion of cognitive neutrino pair are discussed, and the possibility that superconductivity and Bose-Einstein condensates are involved with atmospheric phenomena is considered.

1.1 Strange Behavior Of Cellular Water And Quantal Ionic Currents Through Cell Membrane

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

The empirical findings challenging the notions of ionic pumps and channels, nicely summarized by G. Pollack in his book [18]. provide a strong support for the notions of many-sheeted space-time and ionic super-conductivity.

1. The selectivity of the cell membrane implies that channels cannot be simple sieves and there must be complex information processing involved.
2. The needed number of pumps specialized to particular ions is astronomical and the first question is where to put all these channels and pumps. On the other hand, if the cell constructs the pump or channel specialized to a given molecule only when needed, how does it know what the pump looks like if it has never seen the molecule? The needed metabolic energy to achieve all the pumping and channelling is huge. Strangely enough, pumping does not stop when cell metabolism stops.
3. One can also wonder why the ionic currents through cell membrane look quantal and are same through cell membrane and silicon rubber membrane.

These observations suggest strongly the presence non-dissipative ionic currents and quantum self-organization. The TGD based explanation would be in terms of high T_c electronic and possibly even ionic superconductivity associated with cell membrane made possible by the large h_{eff} phase for nuclei and electrons in the interior of cell. It however seems that thermal stability conditions allow only protonic Cooper pairs in the model of ionic Cooper pairs based on direct generalization of the model of high T_c electronic super conductivity. This does not however mean that quantal ionic currents would be absent. This empirical input also supports a view about homeostasis as a many-sheeted ionic flow equilibrium controlled by larger space-time sheets with the mediation of massless extremals (MEs) serving as space-time correlates for Bose-Einstein condensates of massless bosons (also of scaled down dark electro-weak bosons and gluons).

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

One can argue that pumps in case of basic ions are needed only when the cell interior and exterior are connected by join along boundaries bonds and that this connection is built only for diagnostic purposes in order to measure the concentrations of ions by measuring the ionic currents by their dissipation. The remote metabolism made possible by many-sheeted lasers reduces further the energy costs when pumping actually occurs. The transfer as Josephson current might apply only to the biologically important ions and pumps might be needed to achieve more efficient transfer also in this case. Pumps (active transport) and channels (passive transport) for more complex polar molecules realized as genetically coded proteins are certainly needed.

1.1.1 How noble gases can act as anesthetes?

Chemically inert noble gases are known to act as anesthetes. Somehow these atoms affect neuronal membrane, probably reducing the nerve pulse activity. A possible explanation is in terms of anomalous weak isospin due to the charged color bonds inside nuclei of noble gas generated in the cellular environment. This bonds carry also em charge so that noble gas atom would behave like ion with nuclear charge $Z+1$ or $Z-1$. Also the long ranged color force and dark weak force with range $L_w = .2 \mu\text{m}$ associated with noble gas nuclei in dark phase could be part of the solution of the mystery.

1.1.2 Two models of cell membrane

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

1. There are several constraints on the first model coming from the TGD based identification of bio-photons as energy conserving decay products of dark photons and one ends up to a new view about metabolism and generalization to of the notion of Josephson junction so that Josephson energy includes besides electrostatic energy also the difference of cyclotron energies at two sides of the membrane. It seem that that the first model might be enough when generalized along lines inspired by Pollack's findings about the fourth phase of water.
2. It has been clear from the beginning that the nearly vacuum extremals of Kähler action could play key role in living systems. The reason is their criticality making them ideal systems for sensory perception. These extremals carry classical em and Z^0 fields related to each other by a constant factor and this could explain the large parity breaking effects characterizing living matter. The assumption that at least some cell membranes are nearly vacuum extremals and that nuclei can feed their Z^0 charges to this kind of space-time sheets (not true for atomic electrons) in living matter leads to a modification of the model for the cell membrane as Josephson junction. Also a model of photoreceptors explaining the frequencies of peak sensitivity as ionic Josephson frequencies and allowing the dual identifications Josephson radiation as biophotons (energies) and EEG radiation (frequencies) emerge since

the values of Planck constant can be very large. Contrary to the original believe, this model does not require non-standard value of Weinberg angle and this model and first model allow a hybrid.

1.2 TGD Inspired Model For High T_c Superconductivity

The following minimal model looks the most realistic model of high T_c superconductivity found hitherto. It also applies to ions and if the proposal that h_{eff} is proportional to the mass of ion, it predicts same binding energies for all Cooper pairs as their spin-spin interaction energy. This hypothesis predicts universal spectrum of bio-photons energies if they result from dark photons and is motivated by the identification of gravitational Planck constant [K18] with h_{eff} .

1. The general idea is that magnetic flux tubes are carriers of supra currents. In anti-ferromagnetic phases these flux tube structures form small closed loops so that the system behaves as an insulator. Some mechanism leading to a formation of long flux tubes must exist. Doping creates holes located around stripes, which become positively charged and attract electrons to the flux tubes.
2. Usually magnetic field tends to destroy Cooper pairs since it tends to flip the spins of electrons of pair to same direction. In TGD flux quantization comes in rescue and magnetic fields favor the formation of Cooper pairs. If one has two parallel flux tubes with opposite directions of magnetic fluxes with large value of $h_{eff} = nh$, $S = 0$ Cooper pairs with even $L \geq 2$ are favored. This situation is encountered in systems near antiferromagnetic phase transition in small scales leading to formation of sequences of flux loops carrying Cooper pairs. Macroscopic super-conductivity results when the loops are reconnected to two long flux tubes with opposite fluxes. If the magnetic fluxes have same sign, $S = 1$ Cooper pairs with odd $L \geq 1$ are favored.

1.3 Hierarchies Of Preferred P-Adic Length Scales And Values Of Planck Constant

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

The hypothesis that Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1+i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241.. \}$ (the number theoretical miracle is that all the four p-adic length scales with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μ m) define scaled up copies of electro-weak and QCD type physics with ordinary value of h_{eff} and that these physics are induced by dark variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_a}$, $k_d = k_i - k_j$, and the resulting picture finds support from the ensuing models for biological evolution and for EEG [K5]. This hypothesis - to be referred to as Mersenne hypothesis - replaces the earlier rather ad hoc proposal $r = h_{eff}/h = 2^{11k}$ for the preferred values of Planck constant.

1.4 Bose-Einstein Condensates At Magnetic Flux Quanta In Astrophysical Length Scales

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

1. There are several levels of dynamics. In topological condensation the internal dynamics of ions is unaffected and h_{eff} has the ordinary value. For instance, the formation of Cooper pairs involves dynamics at $k_d = 24 = 151 - 127$ level of dark matter hierarchy if one assumes that electrons and Cooper pairs have size given by the cell membrane thickness $L(151)$. Also the dynamics of ionic Cooper pairs remains unaffected in the topological condensation to magnetic flux quanta obeying $k_d > 24$ dynamics.
2. Cyclotron energies scale as h_{eff} so that for a sufficiently high value of k_d thermal stability of cyclotron states at room temperature is achieved for a fixed value of B . Same applies to spin flip transitions in the recent scenario. The model for EEG based on dark matter hierarchy involves the hypothesis that EEG quanta correspond to Josephson radiation with energies in the visible and UV range and that they produce in the decay to ordinary photons either bunches of EEG photons or visible/UV photons. This identification allows to deduce the value of k_d when the frequency of the dark photon is fixed. The Mersenne hypothesis for the preferred p-adic length scales and values of Planck constants leads to very precise predictions.
3. Cyclotron energies $E = (h_{eff}/2\pi) \times ZeB/Am_p$ are scaled up by a factor $r = 2^{k_d}$ from their ordinary values and for 10 Hz cyclotron frequency are in the range of energies of visible light for $k_d = 46$.
4. These B-E condensates might be favored by the large negative spin interaction energies of spins with the magnetic field (proportional to h_{eff}) so that spontaneous magnetization of the magnetic body becomes possible. This kind of process would make possible for the system to gain energy and angular momentum by feeding charged particles to its magnetic body.

1.5 Atmospheric Phenomena And Superconductivity

There is a considerable evidence that various electromagnetic time scales associated with the atmospheric phenomena correspond to those associated with brain functioning. If magnetic sensory canvas hypothesis holds true, this is just what is expected. In this section these phenomena are considered in more detail with the aim being to build as concrete as possible a vision about the dynamics involving the dark matter Bose-Einstein condensates at super-conducting magnetic flux quanta, and membrane like structures near vacuum extremals.

In living matter Bose-Einstein condensates of dark matter at magnetic flux quanta near vacuum extremals carrying both em and Z^0 magnetic fields are in fundamental role. Even neutral atoms with net weak isospin spin which is non-vanishing for nuclei for which proton and neutron numbers are different, couple to the classical Z^0 field so that a plasma like state would be in question.

Tornadoes and hurricanes provide the first example of self-organizing systems which might also correspond to systems for which some space-time sheets are near vacuum extremals. Auroras represent a second phenomenon possibly involving supra currents of Cooper pairs and of exotic ions. Lightnings, sprites and elves might also involve higher levels of dark matter hierarchy. p-Adic length scale hypothesis and the hierarchy of Planck constants provide a strong grasp to these far from well-understood phenomena and allow to build rather detailed models for them as well as to gain concrete understanding about how dark matter hierarchy manifests itself in the electromagnetic phenomena at the level of atmosphere.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. There are concept maps about topics related to the contents of the chapter prepared using CMAP realized as html files. Links to all CMAP files can be found at <http://tgdtheory.fi/cmaphtml.html> [L5]. Pdf representation of same files serving as a kind of glossary can be found at <http://tgdtheory.fi/tgdglossary.pdf> [L6]. The topics relevant to this chapter are given by the following list.

- Magnetic body [L9]
- Basic Mechanisms associated with magnetic body [L2]
- Bio-anomalies [L3]
- Pollack's observations [L10]

- Cell membrane anomalies [L4]
- DC currents of Becker [L7]
- High temperature superconductivity [L8]

2 Empirical Support For Ionic Super-Conductivity As A Fundamental Control Mechanism

The notions of ionic channels and pumps associated with cell membrane are central for the standard cell biology [I14]. 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 [I9, I7, I3, I15, I6]. One of the pioneers in the field has been Gilbert Ling [I9], 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 [I8]) gives an excellent layman summary about the paradoxical experimental results¹.

It was a pleasant surprise to find that these experimental findings give direct support for the role of supercurrents and Josephson currents in biocontrol. In fact, the experimental data lead to an archetype model cell homeostasis as a flow equilibrium in which very small densities of super-conducting ions (also molecular ions) and ionic supercurrents at cellular and other super-conducting space-time sheets dictate the corresponding densities at the atomic space-time sheets. Z^0 super-conductivity in principle allows to generalize the model also to the control of the densities of neural atoms and molecules at atomic space-time sheets.

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 [I7] has demonstrated this at cellular level by using a centrifuge and cells for which cell membrane is cut open: centrifugal accelerations as high as 1000 g fail to induce the separation of the intracellular water.

The dipolar nature of biomolecules and induced polarization are basis prerequisites for the formation of gels. Ling raises the cohesion between water and protein molecules caused by electric dipole forces as a fundamental principle and calls this principle association-induction hypothesis [I9]. This cohesion gives rise to liquid [F11] [D1] like structure of water implying among other things layered structures and internal electric fields orthogonal to the plane of the layers [I13, I11, I9]. For instance, cell membranes can be understood as resulting from the self-organization of liquid crystals [K4]. The fundamental importance of electret nature of biomatter was also realized by Fröhlich [I10] 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-electro-chemistry. The development of the theory has occurred through gradual improvements saving the existing theory.

The development began from the basic observation that cells are stable gelatinous entities not mixing with the surrounding water. This led to the hypothesis that cell membrane takes care that the contents of the cell do not mix with the cell exterior. It was however soon found that cell membrane allows some ions to flow through. The interaction between theory and experiment led gradually to the notions of ion channel and ion pump, which are still central for the standard paradigm of the cell [I14]. Note that also “electric pump” taking care that membrane potential is preserved, is needed.

¹I am grateful for “Wandsqueen” for sending me the relevant URL address and for Gene Johnson for very stimulating discussions.

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 [D1] would have probably led to different ideas about how homeostasis between cell interior and exterior is realized [I13, I11, I9].

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 [I8] 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 [I8] ! 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 [K6] 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 [I9] by exposing cell to a cocktail 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 [I16] (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 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 [I15] 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 [I6] 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 [I3] 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 [K5]. 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 Could The Notion Of The Many-Sheeted Space-Time Solve The Paradoxes?

The basic paradoxes are related to the universality of the ionic currents challenging the notion of ionic channels and the absence of metabolically driven chemical pumps assignable to cell membrane. Chemical pumps take care that the differences of the chemical potentials associated with the two sides of the cell membrane remain non-vanishing just like ordinary pump preserves a constant pressure difference. Also “electrical pump” taking care that the potential difference between the cell exterior and interior is preserved is needed. The experiments suggest strongly that both chemical pumps and “electrical pump”, if present at all, need very low metabolic energy feed.

Many-sheeted space-time (see **Fig.** <http://tgdtheory.fi/appfigures/manysheeted.jpg> or **Fig. 9** in the appendix of this book) allows following interpretation for the puzzling findings.

1. What have been identified as pumps and channels are actually ionic receptors allowing the cell to measure various ionic currents flowing through membrane.
2. Pumps are not needed because the cell interior and exterior correspond to disjoint space-time sheets. The currents run only when flux tube (JAB) is formed and makes the current flow possible. The fact that the formation of JABs is a quantal process explains the quantal nature of the currents. Channels are not needed because the currents run as supercurrents (also the cyclotron states of bosonic ions define Bose-Einstein condensates) along cell membrane space-time sheet. The absence of dissipation would explain why so little metabolic energy feed is needed and why the ionic currents are not changed when the cell membrane is replaced by some other membrane. JABs could be formed between the space-time sheets representing lipid layers or between cell exterior/interior and cell membrane space-time sheet. The formation of JABs has also interpretation as a space-time correlate for the generation of quantum entanglement.

Note that the most recent TGD view about JABs differs from the original one. The recent belief is that boundaries- and just JABs- are not allowed by the boundary conditions: space-time sheets with boundary are replaced with their double covers. Furthermore, elementary particles and also larger systems correspond to space-time regions which as lines of generalized Feynman diagrams have Euclidian signature of the induced metric. This suggests that magnetic flux tubes as deformations of cosmic strings have Euclidian signature of metric too. This is quite possible and in the simplest situation would require that string world sheet has Euclidian signature of the induced metric. JABs in this sense would serve as correlates of quantum entanglement between system that they connect together.

Double cover property means that JABs identified as Kähler magnetic flux tubes have cross section, which are closed surfaces, and thus can carry quantized Kähler magnetic flux. These flux tubes would provide correlates for the magnetic fields known to exist in cosmological scales but not possible in standard cosmology due to the fact that needed currents should be coherent in long scales. For monopole fluxes no currents are needed.

3. The universality of the currents suggests that the densities of current carriers are universal. The first interpretation would be in terms of an ordinary-dark-ordinary phase transition. Ordinary charge carriers at space-time sheets associated with cell interior and exterior would be transformed to dark matter particles at the cell membrane space-time sheet and flow through it as supercurrents and then transform back to ordinary particles (reader is encouraged to visualize the different space-time sheets). This phase transition could give for the currents their quantal character instead of the formation of JABs. Of course, the formation of JABs might be prerequisite for this phase transition.
4. The ion densities in cell interior and exterior are determined by flow equilibrium conditions for currents traversing from super-conducting space-time sheets to non-super-conducting space-time sheets and back. Ion densities would be controlled by super-conducting ion densities by an amplification mechanism made possible by the electret nature of the liquid crystal state. The dissipation by the currents at the atomic space-time sheets associated with cell interior and exterior is very weak by the weakness of the electric fields involved and at cell membrane space-time sheet superconductivity means absence of dissipation.

One must of course be cautious in order to not draw too strong conclusions. Besides basic ions cell membrane is non-permeable to various polar molecules such as the basic building bricks of DNA and amino-acids. The safest assumption is that genetically coded pump and channel proteins make possible the transfer. One must of course consider the possibility that channels and pumps are used to make the transfer of basic ions more effective. Taking this into account, the proposed vision does not differ so radically from the standard one as one might think first and only the model for nerve pulse generation must be modified radically.

2.3.1 Many-sheeted cell

TGD based model of nerve pulse and EEG relies on the notion of the many-sheeted space-time. There is entire hierarchy of space-time sheets so that one can assign to cell and its exterior atomic space-time sheets forming join-along boundaries condensate of units of size of about 10^{-10} meters, lipid layer *resp.* cell membrane space-time sheets with thickness of order $L(149) \simeq .5 \times 10^{-8}$ meters *resp.* $L(151) \simeq 10^{-8}$ meters, and cellular space-time sheets with size of order few microns. These space-time sheets are certainly not the only ones but the most important ones in the model of EEG and nerve pulse.

1. Water molecules at the atomic space-time sheet can form flux tube condensates and the strange properties of water inside the cell can be understood if these lumps in the cell interior have size larger than the flux tubes connecting atomic space-time sheet of cell interior to that of cell exterior. Liquid crystal structure indeed gives rise to layered crystal like structures of water.
2. Cell membrane space-time sheets have size of order cell membrane thickness and are assumed to be super-conducting. The lipid layers of the cell membrane define space-time sheets of thickness of about 50 Angstrom, which could act as parallel super-conductors connected by Josephson junctions.
3. Cellular space-time sheets have size of order cell size and are multi-ion super-conductors. Also they are connected to each other by flux tubes serving as Josephson junctions. Also charged organic molecules could form super-conductors and be transferred by the same mechanism between cell interior and exterior. In TGD framework also classical Z^0 fields are present and Z^0 super-conductivity is possible and could make possible neutral supra currents and control of the densities of the neutral atoms and molecules.

Neuronal and cellular space-time sheets of size of order cell size are assumed to be parts of the magnetic flux tube like structures associated with Earth's magnetic field. Earth's magnetic field inside organisms could contain closed circuits and it is conceivable that the notion of magnetic circulation containing neural circuitry as a sub-circuitry makes sense. Large value of \hbar makes possible high T_c superconductivity. Only protonic Cooper pairs are possible at room temperature besides electronic and neutrino Cooper pairs using the proposed criterion super conductivity. Bose-Einstein condensates of bosonic ions at cyclotron states define also superconductors and at $k = 4$ level of dark matter hierarchy the cyclotron frequencies in Earth's magnetic field correspond to energies above thermal energy. These frequencies are in alpha band for most biologically relevant bosonic ions.

Electronic Josephson currents through cell membrane oscillate with a frequency which is given by the membrane potential $eV = 70 \text{ meV}$: this predicts that the emission of infrared photons as a signature of a living cell. Super currents transform to Ohmic currents when they enter to the atomic space-time sheets.

Also present are "many-sheeted circuits" for which currents flow along super-conducting space-time sheets go to atomic space-time sheets where they flow as very weak Ohmic currents, and run back to super-conducting space-time sheets. The currents flowing in closed circuits traversing both cellular and atomic space-time sheets are in flow equilibrium. Because of the high value of the cell membrane electric field, the ionic currents flowing at cell membrane space-time sheets would give rise to high dissipation. The ohmic currents from the cell exterior to interior can however enter to the super-conducting cell membrane space-time sheet and back to the atomic space-time sheet of the cell interior and thus avoid the dissipation.

This picture suggests that the flow of particles between the cell interior and exterior takes mainly via the cell membrane space-time sheet. This would mean that $k = 169$ cell interior space-time sheet has permanent bridges to the $k = 151$ cell membrane space-time sheet, which in turn has only temporary bridges to the $k = 169$ cell exterior space-time sheets.

The character of the ionic currents through cell membrane is highly relevant for the model of the nerve pulse. The development of the model of nerve [K16] [K16] has taken a long time and the original hypothesis about the decisive role of the ionic Josephson currents turned out to be wrong. The recent version of the model assumes that the reduction of charge entanglement between magnetic body and neuron interior made possible by charged W MEs leads to a exotic ionization of the Ca^{++} Bose-Einstein condensate. Exotic $Ca^{++,+}$ Bose-Einstein condensate reduces the membrane resting potential below the threshold for the generation of nerve pulse. The random generation of JABs makes possible flow of ionic currents and leads to the generation of nerve pulse. One cannot exclude the possibility that a portion of em or Z^0 ME drifting along the axon with the velocity of nerve pulse and connecting cell exterior and cell membrane space-time sheets defines the JAB: in the earlier version of the model Z^0 ME was responsible for the reduction of the membrane potential.

2.3.2 Faraday's law of induction in the many-sheeted space-time forces electrical non-equilibrium

Faraday's induction law in many-sheeted space-time gives strong constraints on the electric fields over the cell membrane region at various space-time sheets. Suppose that cellular space-time sheet and some other space-time sheets, say cellular and cell membrane space-time sheet, are in contact so that one can form a closed loops traversing along both space-time sheets. Faraday's law implies that the rotation of electric field around a closed loop traversing first from cell exterior to interior at cellular space-time sheet, going to the atomic space-time sheet and returning back to cell exterior and down to cellular space-time sheet must be equal to the time derivative of the magnetic flux through this loop. Since magnetic flux cannot grow indefinitely, the time average of this potential difference is vanishing. During the generation of nerve pulse the situation might change but only for a finite duration of time (of order millisecond).

Thus in electrostatic equilibrium there must be same exterior-interior potential difference over all space-time sheets in contact with cellular space-time sheets and the variation of potential difference at cellular space-time sheets induces automatically an opposite variation at other space-time sheets. This means that the supercurrents at cellular space-time sheets can indeed control potential differences at other space-time sheets, in particular at atomic space-time sheets. Faraday's law in the many-sheeted space-time also implies that Ohmic currents at atomic space-time sheets cannot destroy the potential difference except for a finite period of time.

Faraday's law makes also possible a gauge interaction between dark and ordinary matter. The changes of dark matter charge densities induce changes of electric field patterns at dark matter space-time and once JABs are formed between dark matter space-time sheet and space-time sheets at lower level of dark matter hierarchy, closed many-sheeted circuits become possible and voltage differences along space-time sheet at different levels of dark matter hierarchy correspond to each other.

Massless extremals (MEs, topological light rays) serve as correlates for dark bosons. Besides neutral massless extremals (em and Z^0 MEs) TGD predicts also charged massless extremals obtained from their neutral counterparts by a mere color rotation (color and weak quantum numbers are not totally independent in TGD framework). The interpretation of the charged MEs has remained open hitherto. Charged W MEs could induce long length scale charge entanglement of Bose-Einstein condensates by inducing exotic ionization of ionic nuclei. State function reduction could lead to a state containing a Bose-Einstein condensate in exotically ionized state.

In this manner the charge inside neuron and thus by Faraday's law membrane potential could be affected by magnetic body. The generation of nerve pulse could rely on the reduction of the resting potential below the critical value by this kind of mechanism inducing charge transfer between cell interior and exterior. The mechanism might apply even in the scale of magnetic body and make possible the control of central nervous system. Also remote mental interactions, in particular telekinesis, might rely on this mechanism.

2.3.3 Flow equilibrium in many-sheeted space-time

The notion of many-sheeted space-time suggests that cell interior and exterior could be regarded as a system in “many-sheeted flow equilibrium” so that the ion densities at atomic space-time sheets are determined by the ion densities at the super-conducting cellular space-time sheets and by the drift velocities by the basic formula $n_1/n_2 = v_2/v_1$ for flow equilibrium.

1. Cell exterior and interior understood as many-sheeted structures are in ionic flow equilibrium holding true for each ion type. The ionic currents run along circuits which traverse along super-conducting space-time sheets, enter into atomic space-time sheets and back to super-conducting space-time sheets.
2. To understand what is involved consider the simplest possible closed circuit connecting atomic and cellular space-time sheets. The ionic supercurrent $I_{i,s}$ flowing from a super-conducting space-time sheet to the atomic space-time sheet is transformed to Ohmic current $I_{i,O}$ in the atomic space-time sheet and in flow equilibrium one has

$$I_{i,s}(int) = I_{i,s} = I_{i,O}(ext) = I_i(membr) .$$

3. Ionic supra current is sum of two terms.

$$I_{i,s} = I_{i,s|J} + I_{i,s|d} .$$

The first term is the oscillatory Josephson current associated with the Josephson junction connecting interior and exterior cellular space-time sheet. The second term is direct super-current

$$I_{i,s|d} = \frac{1}{m_i} n_{i,s} \nabla \phi = \frac{n_{i,s} K_i}{m_i} ,$$

where ϕ is the phase of the super-conducting order parameter, and m_i is the mass of the ion. K_i is the quantized momentum like quantum number associated of superconducting loop (assuming for simplicity that current is constant).

4. Ionic Ohmic current is equal to

$$I_{i,O}(int) = \frac{n_i(int) q_i E_{int}}{k_i(int)} ,$$

$$I_{i,O}(ext) = \frac{n_i(ext) q_i E_{ext}}{k_i(ext)} .$$

Here k_i is linear friction coefficient. Since cell exterior and interior are in different internal states, k_i is different for cell interior and exterior. E is the weak internal electric field made possible by liquid crystal property which is also different for the interior and exterior. Flow equilibrium conditions give for the ratio of the ion densities in interior and exterior

$$\frac{n_i(int)}{n_i(ext)} = \frac{v_i(ext)}{v_i(int)} = \frac{E_{ext} k_i(int)}{E_{int} k_i(ext)} .$$

Thus in flow equilibrium the ratio of the internal and external ion densities differs from unity and is determined by the ratio of the ionic drift velocities, which are different in cell interior and exterior.

5. The densities of the super-conducting ions at super-conducting space-time sheet determine the corresponding ion densities at the atomic space-time sheet

$$\frac{n_i(int)}{n_{i,s}} = \frac{v_{i,s}}{v_i(int)} = \frac{K_i k_i(int)}{m_i E_{int}} ,$$

$$\frac{n_i(ext)}{n_{i,s}} = \frac{v_{i,s}}{v_i(ext)} = \frac{K_i k_i(ext)}{m_i E_{ext}} .$$

Obviously, super-conducting ion densities control the ion densities at the atomic space-time sheets. Very weak electric fields E_{ext} and E_{int} and high values of friction coefficients k_i make possible a large amplification of the superconducting densities to the non-super-conducting ionic densities at atomic space-time sheet. Thus the fact that liquid crystals allowing weak but stable electric fields orthogonal to the layer like structure is crucial for the mechanism.

6. Also flow equilibrium requires metabolism to keep the currents at the atomic space-time sheets flowing. There are two options.
 - i) Assuming that the current flows through cell membrane as an Ohmic current, the power dissipated in the circuit is equal to

$$P = I_i(int)(V_{int} + V_{memb} + V_{ext}) = I_{i,s}(V_{int} + V_{memb} + V_{ext}) .$$

Since supercurrents and thus also Ohmic currents are weak and electric fields are weak in cell interior and exterior, also dissipation can be extremely low in these regions. The dominating and problematic term to the dissipation comes from the membrane potential which is very large.

- ii) An alternative option is that the current flows through cell membrane region as a supercurrent by going from atomic to cell membrane space-time sheet and returning back to atomic space-time sheet. This gives

$$P = I_{i,s}(V_{int} + V_{ext}) .$$

In this manner huge amount of metabolic energy would be saved and it is quite possible that this is the only sensible manner to understand the experimental results of Ling [I9].

2.3.4 Refinements and generalizations

The proposed oversimplified model allows obviously refinements and variants. For instance, current circuits could run from exterior cellular space-time sheet to cell membrane space-time sheet and run only through the cell interior. In this case only the ionic concentrations in the cell interior would be controlled: this does not look a good idea. This option might be necessary in the case that cell exterior cannot be regarded as an electret carrying weak but stable electric field.

Several super-conducting space-time sheets are probably involved with the control and complex super-conducting circuits are certainly involved. The structure of the cell interior suggests a highly organized ohmic circuitry. In particular, cytoskeleton could be important carrier of currents and atomic space-times sheets of the microtubules could be in crucial role as carriers of the ohmic currents: there is indeed electric field along microtubule. The collagenous liquid crystalline networks [I13, I11] are excellent candidates for the carriers of weak ohmic currents in the inter-cellular tissue. Fractality suggests that also structures like proteins, DNA and microtubules are in a similar flow equilibrium controlled by super-conducting ion densities at protein/DNA/microtubule space-time sheets and probably also larger space-time sheets.

Bioelectromagnetic research provides a lot of empirical evidence for the existence of the direct current ohmic circuits, mention only the pioneering work of Becker and the work of Nordenström [J2, J3]. For instance, these direct currents are proposed to be crucial for the understanding of the effects of the acupuncture. The ancient acupuncture, which even now is not taken seriously by many skeptics, could indeed affect directly the densities and supercurrents of ions at super-conducting space-time sheets and, rather ironically, be an example of genuine quantum medicine.

2.3.5 Explanation of the paradoxes in terms of many-sheeted space-time

The qualitative predictions of the flow equilibrium model conform with the experimental facts discussed above.

1. One can understand how a gelatinous lump of matter can be a stable structure if the interior of the cell is in a gelatinous state in length scales larger than the size of the Josephson junctions at atomic space-time sheet. This means that water inside cell consists of coherent lumps larger than the size of Josephson junction and cannot leak to the exterior. If the

exterior of the cell forms single large space-time sheet or consists of sheets connected by Josephson junctions with size larger than the typical size for the coherent lumps of water in cell exterior, cell exterior behaves like ordinary mixture of water and chemicals.

2. The amplification mechanism of supercurrents relying crucially on liquid crystal property implies that although liquid crystal pumps and metabolism are needed, the amount of metabolic energy can be extremely small. Absolutely essential is however that ohmic currents run through the super-conducting short circuit provided by the cell membrane space-time sheet.
3. The currents for various ions do not depend at all on the properties of the cell membrane but are determined by what happens on cellular and other superconducting space-time sheets. In flow equilibrium supercurrents and Josephson currents are identical with currents through cell membrane at atomic space-time sheet. The observed quantal nature of the ionic currents supports their interpretation as faithful atomic level images of supercurrents.
4. Since various ionic currents at the cellular space-time sheets dictate the ionic currents at the atomic space-time sheets, the selectivity of the cell membrane would seem to be only an apparent phenomenon. One must however be very cautious here. The self-organizing cell membrane might have the virtue of being co-operative and develop gradually structures which make it easier to establish the flow equilibrium. For large deviations from the flow equilibrium, ohmic currents are expected to flow through the atomic space-time sheet associated with the cell membrane since super-conducting currents become overcritical and super-conductivity is spoiled. Also the proteinic Josephson junctions between lipid layer space-time sheets might be crucial. Thus the notions of channel and pump proteins might make sense in the far from flow equilibrium regime where the currents through membrane region are dominantly ohmic.

To sum up, one could see super-conducting space-time sheets as controllers of the evolution of the cellular and other biological structures and the model of organism could be specified to some degree in terms of the densities and currents of the super-conducting particles at various space-time sheets besides the values quantized magnetic fluxes associated with various many-sheeted loops. Setting up the goal at controlling space-time sheets would force the atomic space-time sheets to self-organize so that the goal is achieved. This clearly provides a quantum mechanism of volition. A fascinating challenge is to apply this vision systematically to understand morphogenesis and homeostasis.

Needless to say, the notion of many-sheeted current circuitry would have also revolutionary technological implications since all undesired dissipative effects could be minimized and currents at atomic space-time sheets would be used only for heating purposes! Of course, many-sheeted current circuitries would also make possible quantum computer technologies.

2.3.6 Bio-control as a control of quantum numbers characterizing supercurrents

The magnetic quantum numbers K_i which together with the densities of super-conducting ions characterize the densities of various ions at atomic space-time sheets. Thus magnetic quantum numbers associated with super-conducting circuits formed by magnetic flux tubes indeed characterize biological information as speculated already more than decade ago on basis of mathematical necessity. Direct ohmic currents and supercurrents determine these quantum numbers only partially since in super-conducting circuit integer valued magnetic flux can flow without any induced current in the circuit. In presence of dissipation the currents in super-conducting circuit are minimal needed to guarantee quantized flux through the circuit.

In this picture biocontrol boils down to the changing of the various integers characterizing the phase increments over closed superconducting loops. If nerve pulse involves induction of supra current compensating the deviation of the magnetic flux in circuit from integer multiple of flux quantum, this can be achieved. The coupling of super-conducting circuits with MEs makes it possible for MEs to affect the magnetic quantum numbers by time varying or constant magnetic fields.

1. If dissipation is slow, supercurrents and thus also ionic concentrations can suffer a large change and the homeostatis of neuron changes for a period determined by the rate of dissipation for supercurrents.

2. The induced a supercurrent could also dissipate rapidly to minimal supercurrent required by the quantization of the magnetic flux: the quantized part of the magnetic flux of external perturbation penetrates to super-conductor and is expected to affect the super-conducting part of the system. This does not of course occur permanently for oscillating em fields. The deviation of the external magnetic flux from a quantized value is coded to a small supercurrent. This mechanism combined with stochastic resonance possible for SQUID type circuits [D3] makes it possible to “measure” extremely weak magnetic fields of MEs by amplifying them to biological effects.

MEs can also form junctions (possibly Josephson-) between two super-conducting circuits. In this case a constant electric field associated by ME defines the frequency of the induced Josephson current: the weaker the potential difference, the slower the oscillation period. This mechanism might explain why the effects of ELF em fields in living matter occur in intensity windows.

2.3.7 The role of the cell membrane

What is the role of the cell membrane in TGD inspired picture about cell? Very much what it is found to be. Cell membrane recognizes various organic molecules, interacts with them, and possibly allows them to go through. A protein in the cell membrane might act as an effective channel or pump but this function would be only apparent in case of ions. Only if cell membrane space-time sheet has join along boundaries bonds/magnetic flux tubes contacts with the cell interior, can ions and proteins enter cell interior through the membrane space-time sheet. One must also consider very seriously the possibility that cell membrane space-time sheet is a carrier of supercurrents participating in the control of the physics at atomic space-time sheets.

This vision conforms with a computer-ageist view about cell membrane as an interface between computer and clients. Against the fact that tools (proteins) and symbols (DNA) emerge already at atomic length scale, it would indeed seem rather strange that cell would reduce to a bag of water containing mixture of chemicals. This view conforms also with fractality. Skin is the largest connected part of the nervous system and cell membrane could be also seen as the skin of neuron and thus a part of the nervous system of cell, specialized to receive signals from the external world.

In this vision cell is much more like a living, intelligent computer than a sack of ion-rich water, and cell membrane is its interface with the external world. Proteins and biomolecules are messages/messengers, and cell membrane allows them to attach to the receptor only if a number of conditions are satisfied.

In many cases it is not necessary for the messenger to continue its travel to the interior since electromagnetic and electromechanical communications with the cell nucleus are possible by liquid crystal property of cell structures. TGD suggests MEs (“massless extremals”) and magnetic flux tubes carrying ionic super-conductors as a universal tool for these communications, and the simplest hypothesis is that the fractally scaled down versions of the communications in the cell length scale are realized also in the interior of the cell and inside cell nucleus, and even at the level of DNA. The interaction of MES and topologically quantized magnetic fields could solve many of the paradoxical features related with the phenomenon of pleiotropy discussed briefly in [K13]. In particular, electromagnetic passwords and commands analogous to computer language commands based on suitable frequency combinations or even amplitude modulated field patterns could be involved. For instance, in case of DNA SQUID type mechanism combined with stochastic resonance could make possible the activation of specified genes by using specific frequency combinations associated with MEs.

2.4 Water Memory, Homeopathy, And Acupuncture

Further guidelines for TGD based view about biocontrol and coordination were provided by the empirical evidence for water memory and various effects involved with it [I4] [I5]. In [K10] a detailed mechanism of homeopathy and water memory based on the model of biocontrol in terms of many-sheeted ionic flow equilibrium is discussed.

1. *Transfer of homeopathic potency to non-atomic space-time sheets is not enough*

Many-sheeted ionic flow equilibrium suggests a possible mechanism of homeopathy: the extremely low densities of homeopathic remedies are at the controlling super-conducting space-time

sheets where the control is. Thus homeopathy could be seen as a high precision medicine minimizing the amount of the remedy needed rather than some kind of magic treatment. This cannot be however the whole story. As already explained the study of homeopathic effects suggest an electromagnetic representation of the biomolecules based on frequencies [I2] and it is possible achieve the healing effect by transferring mere frequencies instead of using homeopathic potency.

2. Mechanisms of frequency imprinting and entrainment

According to [I2], the homeopathic remedies seem to be characterized by frequencies varying in the range containing at least the range $10^{-3} - 10^9$ Hz suggesting that electromagnetic fields at specific frequencies characterize the homeopathic remedy. These frequencies can be imprinted into water and also erased. Rather remarkably, the removal of Earth's magnetic field erases the imprinted frequencies.

One the other hand, the studies of acupuncture support the existence of certain highly coherent endogenous frequencies [I2] at which em radiation has strong effects. The fact that these frequencies can entrain to exogenous frequencies suggests a mechanism of homeopathy based on entrainment. Effects are observed at pairs of high and low frequencies and the ratio of these frequencies is constant over all acupuncture meridians with a standard derivation of ± 15 per cent. The first branch is at GHz range: in particular the frequencies 2.664 GHz, 1.42 GHz and 384 MHz have unexpected properties. The second branch of frequencies is in ELF range, in particular Schumann frequency 7.8 Hz accompanies 384 MHz.

Consider now the explanation of the observations of Smith and others in in TGD framework using the proposed model assigning to magnetic flux tubes parallel MEs making magnetic flux tube effectively a magnetic mirror.

1. The basic idea is that water forms representations for chemicals it contains in terms of transition frequencies of the chemical which become frequencies of MEs and structures of water generating these MEs by emission and absorption processes. Also representations of representations are possible. The molecule of a homeopathic potency is characterized by characteristic frequencies associated with its transitions as well as ELF frequencies. Of course, also transitions of a complex formed by molecule of the potency and water molecule could be involved.

Water represents the transition frequencies of the potency molecule as transition frequencies of water molecules or of structures which correspond to space-time sheets of various sizes. This conforms with the fact that frequency imprinting disappears after thorough drying and returns when water is added and that also bulk water without any potency allows frequency imprinting. In the frequency range studied by Smith rotational transition frequencies of water and of the space-time sheets containing water in liquid crystal form provide a good candidate for a representational mechanism. ELF frequencies correspond now to the magnetic transitions of these space-time sheets behaving like point like objects in Earth's magnetic field.

2. The simplest assumption is that the ELF branch of the frequency spectrum corresponds to the magnetic transition frequencies in Earth's magnetic field whereas the high frequency branch corresponds to the characteristic frequencies $f = c/L$ of MEs parallel to the magnetic flux tubes. This assumption conforms with the crucial role of Earth's magnetic field in the erasure of the imprinted frequencies. Also the importance of 7.8 Hz Schumann frequency for the heart chakra [I2] can be understood.

The singly ionized Ca, Ar, and K (all 7.5 Hz for $B = .5 \times 10^{-4}$ Tesla) and Cl (8.5 Hz) have cyclotron transition frequencies near to Schumann frequency. For LC water blobs the ELF frequencies are below 1 Hz and the requirement that water blob has size smaller than radius of magnetic flux tube of Earth's magnetic field allows ELF frequencies down to $1/f \sim 1000$ years so that all biologically relevant length scales are covered. Quite interestingly, the frequency f_h corresponding 1000 years is 20 Hz by the scaling law suggested by Smith and corresponds to the lower bound for audible frequencies and that also language involves subneuronal mimicry by LC water blobs. A fascinating possibility is that subneuronal LC water blobs could be responsible for all biorhythms and be involved also with our long term memories.

3. Frequency entrainment for both ELF and high frequency branches can be understood if both the thickness and length of the magnetic flux tubes are subject to a homeostatic control.

The assumption that the total magnetic energy of the flux tube remains constant during the frequency entrainment together with the magnetic flux quantization implies that the ratio S/L of the area S of the magnetic flux tube to its length L remains constant during entrainment. Thus the ratios f_h/f_{ELF} of the magnetic transition frequencies to characteristic frequencies of MEs would be homeostatic invariants in agreement with the empirical findings. The value of the ratio is in good approximation $f_h/f_{ELF} = 2 \times 10^{11}$.

4. The electromagnetic signature of the homeopathic potency corresponds to MEs stimulated by the electromagnetic transitions associated with the potency molecule. Since these frequencies are also transition frequencies for water molecules or space-time sheets contain water in liquid crystal form a resonant interaction is possible and em fields of MEs can be amplified/replicated by the transitions associated with these structures.
5. According to [I2], coherence propagates with a light velocity whereas coherent domain of size L diffuses with a velocity given by the scaling law $v \propto Lf$. In TGD the natural interpretation for the velocity of coherence propagation is as a signal velocity inside ME (possibly representing external em field). v is in turn associated with the motion of ME transversal to some linear structure along it: this effect is not possible in Maxwell's theory since particle-field duality is not realized at the classical level. The velocities are reported to be of order few meters per second and of the same order of magnitude as nerve pulse conduction velocity and phase velocities for EEG waves. This relationship is of the same form as the scaling law which relates together the phase velocity of EEG wave (velocity of EEG ME in TGD framework) and the size L of corresponding structure of brain or body. For instance, scaling law relates the size L for brain structures and corresponding magnetic sensory canvas with much larger size $L_c = c/f$ [K17]. Scaling law would give $v/c = f_{ELF}/f_h$ and velocity of order mm/s for the motion of transversal MEs along magnetic flux tubes: this velocity is considerably smaller velocity than m/s reported in [I2].

A detailed model for various homeopathic effects is discussed in [K10]. The model leads to a generalization of the view about many-sheeted DNA with magnetic mirrors transversal to DNA coding the electromagnetic structure of the organism and allows to understand introns as chemically passive but electromagnetically active genes. Magnetic mirrors provide also a recognition mechanism fundamental for the functioning of the bio-system: consider only the ability of amino-acids to find corresponding RNA triplets, the self assembly of tobacco mosaic virus and the functioning of the immune system. Magnetic mirrors can also serve as bridges between sender and receiver of intent in remote healing and viewing and these processes could be seen as scaled-up version of those occurring routinely endogenously.

3 The Roles Of Josephson Radiation, Cyclotron Radiation, And Of Magnetic Body

Before representing any detailed model for hearing, it is good to summarize the vision about the roles of Josephson radiation, cyclotron radiation, and of magnetic body on basis of the proposed general view about qualia and sensory receptors. The representation below is somewhat out of date and the updated and considerably more detailed view can be found in [K25].

3.1 The Role Of Josephson Currents

The general vision is that Josephson currents of various ions generate Josephson photons having dual interpretations as bio-photons and EEG photons. Josephson photons can in principle regenerate the quale in the neurons of the sensory pathway. In the case of motor pathways the function would be different and the transfer of metabolic energy by quantum credit card mechanism using phase conjugate photons is suggested by the observation that basic metabolic quanta 2 eV *resp.* 4 eV are associated with smooth muscle cells *resp.* skeletal muscle cells.

As already found in the previous section, the energies of Josephson photons associated with the biologically important ions are in general in visible or UV range except when resting potential has the value of -40 mV which it has for photoreceptors. In this case also IR photons are present.

Table 1: Cyclotron frequencies of quarks and electron in magnetic field $B_{end} = .2$ Gauss for standard vacuum with very small Z^0 field and nearly vacuum extremal.

fermion	$f_c(e)/MHz$	$f_c(u)/MHz$	$f_c(d)/MHz$
standard	.564	.094	.019
nearly vacuum extremal	8.996	2.275	.947

Also the turning point value of membrane potential is +40 mV so that one expects the emission of IR photons.

Josephson photons could be used to communicate the qualia to the magnetic body.

1. If Josephson currents are present during the entire action potential, the entire range of Josephson photons down to frequencies of order 2 kHz range is emitted for the standard value of \hbar . The reason is that lower frequencies corresponds to cycles longer than the duration of the action potential. The continuum of Josephson frequencies during nerve pulse makes it possible to induce cyclotron transitions at the magnetic body of neuron or large structure. This would make possible to communicate information about spatial and temporal behavior of the nerve pulse pattern to the magnetic body and build by quantum entanglement a sensory map.
2. The frequencies below 2 kHz could be communicated as nerve pulse patterns. When the pulse rate is above $f = 28.57$ Hz the sequence of pulses is experienced as a continuous sound with pitch f . f defines the minimum frequency for which nerve pulses could represent the pitch and there remains a 9 Hz long range to be covered by some other communication method.
3. The cyclotron frequencies of quarks and possibly also of electron would make possible a selective reception of the frequencies emitted during nerve pulse. Same applies also to the Josephson frequencies of hair cell (, which does not fire). If the value of Planck constant is large this makes possible to communicate the entire range of audible frequencies to the magnetic body. Frequency would be coded by the magnetic field strength of the flux tube. Two options are available corresponding to the standard ground state for which Z^0 field is very weak and to almost vacuum extremals. For the first option one as ordinary cyclotron frequencies. The cyclotron frequency scales for them differ by a factor

$$r(q) = \frac{Q_{eff}(q)}{Q_{em}(q)} = \frac{\epsilon(q)}{2pQ_{em}(q)} + 1 \text{ per, } \epsilon(u) = -1, \epsilon(d) = 1$$

from the standard one. For $p = .0295$ one obtains $(r(u), r(d), r(e)) = (24.42, 49.85, 15.95)$. The cyclotron frequencies for quarks and electron with masses $m(u)=2$ MeV, $m(d)=5$ MeV, and $m(e)=.5$ MeV are given by **Table 1** for the two options. If one assumes that B_{end} defines the upper bound for field strength then the standard option would require both d quark and electron. For dquark with kHz CD the upper bound for cyclotron frequencies would be 20 kHz which corresponds to the upper limit of audible frequencies.

4. Besides cyclotron frequencies also the harmonics of the fundamental frequencies assignable to quark and electron CDs could be used and in case of musical sounds this looks a highly attractive option. In this case it is now however possible to select single harmonics as in the case of cyclotron transitions so that only the rate of nerve pulses can communicate single frequency. Lorentz transform sub-CD scales up the frequency scale from the secondary p-adic time scale coming as octave of 10 Hz frequency. Also the scaling of \hbar scales this frequency scale.

3.2 What Is The Role Of The Magnetic Body?

The basic vision is that magnetic body receives sensory data from the biological body- basically from cell membranes and possibly via genome - and controls biological body via genome. This

leaves a huge amount of details open and the almost impossible challenge of theoretician is to guess the correct realization practically without any experimental input. The following considerations try to clarify what is involved.

3.2.1 Is magnetic body really needed?

Libet's findings and the model of memory based on time mirror hypothesis suggests that magnetic body is indeed needed. What is the real function of magnetic body? Is it just a sensory canvas? The previous considerations suggest that it is also the seat of geometric qualia, in particular the pitch of sound should be coded by it. It would be relatively easy to understand magnetic body as a relatively passive sensory perceiver defining sensory map. If one assumes that motor action is like time reversed sensory perception then sensory and motor pathways would be just sensory pathways proceeding in opposite time directions from receptors to the various layers of the magnetic body. Brain would perform the information processing.

Certainly there must exist a region in which the motor and sensory parts of the magnetic body interact. What comes in mind is that these space-time sheets (or actually pairs of space-time sheets) are parallel and generate wormhole contacts between them. This interaction would be assignable to the region of the magnetic body could receive positive energy signals from associative sensory areas and send negative energy signals to motor neurons at the ends of motor pathways wherefrom they would propagate to premotor cortex, supplementary motor cortex and to frontal lobes where the abstract plans about motor actions are generated.

3.2.2 Is motor action time reversal of sensory perception in zero energy ontology?

One could argue that the free will aspect of motor actions does not conform with the interpretation as sensory perception in reversed direction of time. On the other hand, also percepts are selected -say in binocular rivalry [J7]. Only single alternative percept need to be realized in a given branch of the multiverse. This makes possible metabolic economy: for instance, the synchronous firing at kHz frequency serving as a correlate for the conscious percept requires a lot of energy since dark photons at kHz frequency have energies above thermal threshold. Similar selection of percepts could occur also at the level of sensory receptors but quantum statistical determinism would guarantee reliable perception. The passivity of sensory perception and activity of motor activity would reflect the breaking of the arrow of time if this interpretation is correct.

3.2.3 What magnetic body looks like?

What magnetic body looks like has been a question that I have intentionally avoided as a question making sense only when more general questions have been answered. This question seems however unavoidable now. Some of the related questions are following. The magnetic flux lines along various parts of magnetic body must close: how does this happen? Magnetic body must have parts of size at least that defined by EEG wavelengths: how do these parts form closed structures? How the magnetic bodies assignable to biomolecules relate to the Earth sized parts of the magnetic body? How the personal magnetic body relates to the magnetic body of Earth?

1. The vision about genome as the brain of cell would suggest that active and passive DNA strands are analogous to motor and sensor areas of brain. This would suggest that sensory data should be communicated from the cell membrane along the passive DNA strand. The simplest hypothesis is that there is a pair of flux sheet going through the DNA strands. The flux sheet through the passive strand would be specialized to communicate sensory information to the magnetic body and the flux sheet through the active strand would generate motor action as DNA expression with transcription of RNA defining only one particular aspect of gene expression. Topological quantum computation assignable to introns and also electromagnetic gene expression would be possible.
2. The model for sensory receptor in terms of Josephson radiation suggests however that flux tubes assignable to axonal membranes carry Josephson radiation. Maybe the flux tube structures assigned to DNA define the magnetic analog of motor areas and flux tubes assigned with the axons that of sensory areas.

3. A complex structure of flux tubes and sheets is suggestive at the cellular level. The flux tubes assignable to the axons would be parallel to the sensory and motor pathways. Also microtubules would be accompanied by magnetic flux tubes. DNA as topological quantum computer model assumes and the proposed model of sensory perception and cell membrane level suggests transversal flux tubes between lipids and nucleotides. The general vision about DNA as brain of cell suggest flux sheets through DNA strands.

During sensory perception of cell and nerve pulse the wormhole flux tube connecting the passive DNA strand of the first cell to the inner lipid layer would recombine with the flux tube connecting outer lipid layer to some other cell to form single flux tube connecting two cells. In the case of sensory organs these other cells would be naturally other sensory receptors. This would give rise to a dynamical network of flux tubes and sheets and axonal sequences of genomes would be like lines of text at the page of book. This structure could have a fractal generalization and would give rise to an integration of genome to super-genome at the level of organelles, organs and organism and even hypergenome at the level of population. This would make possible a coherent gene expression.

4. This vision gives some idea about magnetic body in the scale of cell but does not say much about it in longer scales. The CDs of electrons and quarks could provide insights about the size scale for the most relevant parts of the magnetic body. Certainly the flux tubes should close even when they have the length scale defined by the size of Earth.

Additional ideas about the structure follow follow if one assumes that magnetic body acts a sensory canvas and that motor action can be regarded as time reversed sensory perception.

1. If the external world is represented at part of the magnetic body which is stationary, the rotation of head or body would not affect the sensory representation. This part of the magnetic body would be obviously analogous to the outer magnetosphere, which does not rotate with Earth.
2. The part of the magnetic body at which the sensory data about body (posture, head orientations and position, positions of body parts) is represented, should be fixed to body and change its orientation with it so that bodily motions would be represented as motions of the magnetic , which would be therefore analogous to the inner magnetosphere of rotating Earth.
3. The outer part of the personal magnetic body is fixed to the inner magnetosphere, which defines the reference frame. The outer part might be even identifiable as the inner magnetosphere receiving sensory input from the biosphere. This magnetic super-organism would have various life forms as its sensory receptors and muscle neurons. This would give quantitative ideas about cyclotron frequencies involved. The wavelengths assignable to the frequencies above 10 Hz would correspond to the size scale of the inner magnetosphere and those below to the outer magnetosphere. During sleep only the EEG communications with outer magnetic body would remain intact.
4. Flux quantization for large value of \hbar poses an additional constraint on the model.
 - (a) If Josephson photons are transformed to a bunch of ordinary small \hbar photons magnetic flux tubes can correspond to the ordinary value of Planck constant. If one assumes the quantization of the magnetic flux in the form

$$\int BdA = n\hbar$$

used in super-conductivity, the radius of the flux tube must increase as $\sqrt{\hbar}$ and if the Josephson frequency is reduced to the sound frequency, the value of \hbar codes for the sound frequency. This leads to problems since the transversal thickness of flux tubes becomes too large. This does not however mean that the condition might not make sense: for instance, in the case of flux sheets going through DNA strands the condition might apply.

- (b) The quantization of magnetic flux could be replaced by a more general condition

$$\oint (p - ZeA)dl = n\hbar , \quad (3.1)$$

where p represents momentum of particle of super-conducting phase at the boundary of flux tube. In this case also $n = 0$ is possible and poses no conditions on the thickness of the flux tube as a function of \hbar . This option looks reasonable since the charged particles at the boundary of flux tube would act as sources of the magnetic field.

- (c) Together with the Maxwell's equation giving $B = ZeNv$ in the case that there is only one kind of charge carrier this gives the expression

$$N = \frac{2m}{RZ^2e^2} \quad (3.2)$$

for the surface density N of charge carrier with charge Z . R denotes the radius of the flux tube. If several charge carriers are present one has $B = \sum_k N_k Z_k e v_k$, and the condition generalizes to

$$N_i = \frac{2m_i v_i}{RZ_i \sum_k Z_k v_k e^2} . \quad (3.3)$$

It seems that this condition is the most realistic one for the large \hbar flux sheets at which Josephson radiation induces cyclotron transitions.

3.2.4 What are the roles of Josephson and cyclotron photons?

The dual interpretation of Josephson radiation in terms of bio-photons and EEG photons seems to be very natural and also the role of Josephson radiation seems now relatively clear. The role of cyclotron radiation and its interaction with Josephson radiation are not so well understood.

1. At least cell membrane defines a Josephson junction (actually a collection of them idealizable as single junctions). DNA double strand could define a series of Josephson junctions possibly assignable with hydrogen bonds. This however requires that the strands carry some non-standard charge densities and currents- I do not know whether this possibility is excluded experimentally. Quarks and antiquarks assignable to the nucleotide and its conjugate have opposite charges at the two sheets of the wormhole flux tube connective nucleotide to a lipid. Hence one could consider the possibility that a connection generated between them by reconnection mechanism could create Josephson junction.
2. The model for the photoreceptors leads to the identification of bio-photons as Josephson radiation and suggests that Josephson radiation propagates along flux tubes assignable to the cell membranes along sensory pathways up to sensory cortex and from there to motor cortex and back to the muscles and regenerates induced neuronal sensory experiences.
3. Josephson radiation could be used quite generally to communicate sensory data to/along the magnetic body: this would occur in the case of cell membrane magnetic body at least. The different resting voltages for various kinds of cells would select specific Josephson frequencies as communication channels.
4. If motor action indeed involves negative energy signals backwards in geometric time as Libet's findings suggest, then motor action would be very much like sensory perception in time reversed direction. The membrane resting potentials are different for various types of neurons and cells so that one could speak about pathways characterized by Josephson frequencies determined by the membrane potential. Each ion would have its own Josephson frequency characterizing the sensory or motor pathway.

The basic questions concern the function of cyclotron radiation and whether Josephson radiation induces resonantly cyclotron radiation or vice versa.

1. Cyclotron radiation would be naturally associated with the flux sheets and flux tubes. The simplest hypothesis is that at least the magnetic field $B_{end} = .2$ Gauss can be assigned with the some magnetic flux quanta at least. The model for hearing suggests that B_{end} is in this case quantized so that cyclotron frequencies provide a magnetic representation for audible frequencies. Flux quantization does not pose any conditions on the magnetic field strength if the above discussed general flux quantization condition involving charged currents at the boundary of the flux quantum are assumed. If these currents are not present, $1/\hbar$ scaling of B_{end} for flux tubes follows.
2. The assumption that cyclotron radiation is associated with the motor control via genome is not consistent with the vision that motor action is time reversed sensory perception. It would also create the unpleasant question about information processing of the magnetic body performed between the receipt of sensory data and motor action.
3. The notion of magnetic sensory canvas suggests a different picture. Josephson radiation induces resonant cyclotron transitions at the magnetic body and induces entanglement of the mental images in brain with the points of the magnetic body and in this manner creates sensory maps giving a third person perspective about the biological body. There would be two kind of sensory maps. Those assignable to the external world and those assignable to the body itself. The Josephson radiation would propagate along the flux tubes to the magnetic body.
4. There could be also flux tube connections to the outer magnetosphere of Earth. It would seem that the reconnections could be flux tubes traversing through inner magnetosphere to poles and from there to the outer magnetosphere. These could correspond to rather low cyclotron frequencies. Especially interesting structure in this respect is the magnetic flux sheet at the Equator.

3.3 Magnetic Homeostasis And Magnetic Circulation?

The possible importance of the precise value of the local magnetic field for say memetic code [K9] suggests that living matter has learned to control local magnetic field inside magnetic flux tubes just as it controls salt level of biological water.

3.3.1 Variation of the local strength of B_{end}

B_{end} -which is assigned to the magnetic body of particular body part- should scale as $1/\hbar$ to maintain the constant ratio of Josephson and cyclotron frequencies. This predicts hierarchy of cyclotron frequency scales coming in octaves if one accepts that the preferred levels of dark matter hierarchy come as $r = \hbar/\hbar_0 = 2^{k_d}$ with values of k_d fixed by Mersenne hypothesis introduced in introduction and discussed in detail in [K5]. Cell differentiation could lead to the differentiation of the local value of k_d and the value could vary even inside single cell nucleus.

Also a slight variation of the strength of B_{end} for a given value of r is possible. The condition that the ratios of Josephson frequencies and cyclotron frequencies remain constant means that the scalings of B_{end} and membrane resting potential are identical. Also the relative variation of EEG frequency scale would be same as that of the resting potential. The variation of resting potential is 10 per cent as is also that of EEG frequency scale so that this prediction is correct. Since the resting potential is characteristic of cell type [K5], also the value of B_{end} for corresponding part of magnetic body would be such. In the model of hearing the variation of both k_d decomposing the frequencies into octaves and smaller variations of B_{end} allowing to decompose octaves into smaller intervals would make possible to sense the pitch of the sound [K15]. This sense would be essentially a sensory quale assignable to magnetic body.

3.3.2 Magnetic circulation

There is a rather precise analogy with blood flow since both incompressible velocity field of blood and magnetic field are divergenceless: one can imagine magnetic flux to flow along "B-veins" (magnetic flux tubes) along organism or at least CNS. Variation of the magnetic field strength would be forced by the variation of the thickness of the flux tube since magnetic flux is conserved

just as the variation of the thickness of blood veins affects blood flow. Artificial small alteration of local magnetic field from outside would only interfere with this control.

For instance, alpha peak drifts in Hz range and this could be due to the variation of the value of local magnetic field varies as much as 10 per cent. If this variation is due to the homeostatic variation of the local magnetic field, absolute variation should increase for higher frequencies: at the upper end of gamma band it would be 9 Hz. An alternative explanation for drifting is in terms of amplitude modulation: amplitude modulation of frequency f_1 by frequency f implies that original frequency is split to frequencies $f_1 \pm f$. In this case the amplitude of drifting does not depend on frequency.

The analogy with blood flow suggests that one could speak about B -circulation completely analogous to blood circulation: B -circulation could be crucial for bio-system to act as macroscopic quantum system. B -circulation would naturally accompany neural circuitry. It could be also accompany ordinary blood circulation physically or could form an independent system. The association with blood circulation would provide prerequisites for quantum control of also blood circulation and metabolism. The control could be based on MW frequency Josephson currents associated with ELF em fields inducing conformational changes of proteins coherently in large regions in turn giving rise to needed synchronous biochemical self-organization processes.

3.3.3 Temperature dependence of the local magnetic field strength

EEG frequencies are known to change with [I17] [J13] in the sense that the increase of the temperature raises the peak frequency of the power spectrum. This need not mean that the individual EEG frequencies are affected since the distribution of these frequencies could be affected due to the effects on the ionic conductances.

On the other hand, the equilibrium potentials for various ions are proportional to the temperature. In TGD framework this would predict that also EEG frequency scale is proportional to T so that the effect of temperature could be understood at least partially. Of course, very large drop of temperature known to induce sleep EEG involves dropping of higher EEG bands from the spectrum. The maximal reduction of body temperature have been to about 1 degree C and correspond to 10 per cent reduction of absolute temperature. 10 per cent variation is also characteristic variation of EEG band positions.

As far as nerve pulse generation is considered small reduction of temperature should lead to reduced membrane potential and if the value of the potential inducing nerve pulse does not follow, this would lead to a level of arousal. Maybe this could explain the stimulating effect of cold.

The question is whether cyclotron frequency scale follows the scale of the resting potential. If this is not the case, the communications to the magnetic body suffer from temperature changes since resonance conditions are lost. This could partially explain why a serious hibernation leads to a lower level of arousal. Cyclotron frequency scale can follow the change of the temperature as long as the transversal size scale of the magnetic flux quanta can react on the changes of the temperature and by flux conservation induce a change of the magnetic field strength. It is however highly questionable whether this is possible at distant parts of the magnetic body if it indeed can have the size scale of Earth.

The results of Blackman [J4] suggesting that ELF effects with given frequency disappear when body temperature is not in the range 36 – 37 C inspires the hypothesis that quantum critical high T_c superconductivity and almost vacuum extremal property of the cell membrane space-time sheet are possible only in the range 36-37 C. This obviously provides a more plausible explanation for the effect of hibernation. In this picture the extreme importance of temperature regulation for the functioning of organism could be seen as a prerequisite for continual quantum control by magnetic transition frequencies.

Circadian temperature variation can be something like 20 Kelvins, which means relative variation about 10 per cent for poikilotherms, which is of same order as alpha frequency drifting. The relative width of the cyclotron resonance would be from this about 7 per cent ($\Delta f/f = \Delta B/B \propto \Delta T/T$). The relative variation of the membrane resting potential as a function of temperature is predicted to be same.

3.3.4 Why the increase of the local magnetic field strength by factor of ten does not raise alpha band to heaven?

The increase of the local magnetic field strength by a factor 10 – 20 is known to induce stress [J5] and confuse biological timekeeper mechanisms but it certainly cannot raise alpha band above 100 Hz as as a very naive standard physics based application of the cyclotron frequency hypothesis would suggest.

In standard physics picture one could indeed argue that the increase of the strength of the local magnetic field interferes directly with bio-control and has catastrophic consequences. This is not the case of B_{end} corresponds to so large value of Planck constant that cyclotron energy corresponds to the energy of visible or UV photon and if the local magnetic field corresponds to the ordinary (or just different) value of Planck constant. That the variation local magnetic field has effect can be understood if the flux tubes of the dark magnetic field B_{end} are in contact with the those of the local magnetic field presumably having standard value of Planck constant. This would be classical interaction between visible and dark sectors of “world of classical worlds”. One can of course imagine also other interaction mechanisms.

3.4 Some Remarks And Questions

3.4.1 Synchronizing effect of Earth’s magnetic field

Earth’s magnetic field could act as grand synchronizer of biorhythms of even separate organisms. Magnetic homeostasis does not prevent the effects due to the variation of Earth’s magnetic field on human consciousness.

The close correlation of various cycles of biological and brain activity, in particular sleep-wake cycle, with periodic circadian variations of the geomagnetic field [J5], is consistent with this. Magnetic storms change temporarily the value of the local magnetic field and also this should have effects on consciousness. The statistics about mental hospitals supports this view [J5]. Also Persinger has proposed that the modulations of Earth’s magnetic field caused by geomagnetic perturbations have effect on human consciousness [J5, J10]. Michael Persinger has studied extensively the effects of Schumann resonances on brain and has even explained religious and UFO experiences as correlates of this interaction [J10].

Also the diurnal changes of magnetic field caused by Moon having period of 25 hours are known and this variation seems to provide fundamental biological clock which sets on in absence of the normal 24 rhythm regulated by sunlight. The diurnal variations of the geomagnetic field are also responsible for sleep-awake rhythm: the increased melatonin secretion during dark hours correlate with the variation of Earth’s magnetic field.

It is also known that that the exposure to magnetic fields 10-20 times geomagnetic field induces stress in rabbits and slowed reaction time in humans; that the absence of geomagnetic field leads to a complete de-synchronization of biorhythms and that the synchronization of ELF biorhythms is coupled to ELF geomagnetic pulsations [J5]. In particular, pineal gland serves as biological timekeeper with cyclotron frequency of Co^{2+} ion defining the basic time unit of .1 seconds.

Dr. Phil Callahan [I1] claims on basis of intensive experimental work that there is a tendency of political strifes and wars to concentrate on regions where Schumann resonances are weak. This would not be surprising since Schumann resonances act as collective bio-rhythms if vertebrate brains are connected to the magnetic body of Earth.

3. What happens to astronaut’s magnetic body

There is an old objection against the notion of magnetic body. If the local value of Earth’s magnetic field is crucial for the brain functioning, astronauts should experience grave difficulties or at least dramatic changes in the character of consciousness. A possible estimate for the weakening of the local magnetic field is based on the scaling law $B \propto 1/r^3$ for dipole field. In this case a rough estimate for the relative change of the EEG frequency scale is $\Delta f/f = 3\Delta R/R \sim 6$ per cent for satellites moving below the ionosphere. This should affect the state of consciousness.

As a matter fact, there is reported evidence [J6, J12] that cosmonauts spending months in MIR had strange altered states of consciousness involving among other things precognition of the difficulties to be countered by MIR and receiving advices and identification experiences with other people and life forms, even dinosaurs of ancient Earth!

In the many-sheeted space-time the situation looks like following.

1. Only the levels k_d for which the size scale is between the size scale of personal magnetic body and the distance travelled could have been affected.
2. Astronauts could have drawn the magnetic flux sheets connecting them to the magnetic body of Earth and higher level magnetic bodies with them but long period could have led to a loss of the connections to the magnetic body of Earth.
3. At the level of cell nuclei nothing dramatic need happen. Energetically the stretching magnetic flux sheets associated with DNA is not a problem since the energy densities involved are rather tiny. Furthermore, if the flux sheets carry homological monopole flux, they could highly stable against increase of length since they would have magnetic monopole wormhole contacts at their ends.
4. A long period in space without contact with magnetic Mother Gaia might relate to the strange experiences reported by astronauts. One might imagine that the magnetic body of say solar system or even galactic magnetic body replaces Earth's magnetic body as a kind of fundamental reference frame. For instance, the third person perspective could rely on the inner magnetosphere which is at rest with respect to rotating Earth and the outer magnetosphere which does not rotate with Earth would provide even higher level reference system which begins to dominate in this kind of situation.
5. The experiences are consistent with TGD based view about geometric time and possibility of geometric memories extending beyond the duration of individual life cycle. There is also a consistency with Mersenne hypothesis summarized in the introduction and with the vision about long term memory inspired by this hypothesis [K5]. If one takes seriously the report about dinosaurs, which lived for $\sim 10^8$ years ago, the level $k_{eff} = 163 + k_d = 257$, which corresponds to Josephson period of about 10^8 years could have contributed to the conscious experience of astronauts. Therefore $k_d = 94$ characterizes the value of Planck constant as $r = \hbar/\hbar_0 = 2^{k_d}$. $k_{eff} = 257$ is consistent with Mersenne hypothesis. One has $257 = 239 + 18$, where $k_{eff} = 239$ is member of the twin pair (239, 241) of Gaussian Mersennes suggested to be responsible for long term memory. $257 - 239 = 18$ in turn equals to the difference $107 - 89 = 18$ corresponds to the ratio of hadronic p-adic length scale $k = 107$ and intermediate boson length scale $k = 89$ defined by Mersenne primes. One cannot of course take the individual numbers deadly seriously: what is important the general view about memory based on hierarchy of weak physics assigned to Mersennes and their Gaussian counterparts suggests an explanation for the reported transpersonal memories.

5. *What the reduction of Earth's magnetic field means?*

The strength of Earth's magnetic field has reduced 50 per cent during last 1.000 years. The fact that an exponential evolution of civilization has occurred during this period, is perhaps not an accident. Surprisingly many magnetic transition frequencies happen to be near to Schumann resonance frequencies which do not depend on the strength of the magnetic field. If the scale of dark magnetic field B_{end} has followed the scale of B_E the the weakening of B_E during this period has reduced cyclotron frequency spectrum of heavy ions from 3 – 8 Hz range to the range 1.5 – 4 Hz but leaving the spectrum of Schuman resonances unchanged. Rather remarkably, delta frequencies near 3 Hz correspond to a peak in the frequency spectrum of so called sferics associated with lightning activity [J8].

These observations suggest the emergence of strong interaction between brain and higher levels of the self hierarchy based on spherics and Schumann resonances. Assuming temporal linearity, the reduction of Earth's magnetic field has been 25 per cent after Newton and 5 per cent during last 100 years. Perhaps an exponential development of mathematical consciousness made possible by the activation of cyclotron frequencies of heavy ions with high nuclear and electronic angular momenta and allowing large number of conscious-to-us magnetic transitions, and possibly also involving some kind of fine tuning is taking place.

The weakening of Earth's magnetic field probably relates to a forthcoming change in the polarity of Earth's magnetic field. One might guess that the personal magnetic bodies are not affected

Table 2: The ions for which electronic spin vanishes in ground state and minimum spin flip frequency f_{flip} is below 90 Hz. f_{flip} is defined as $f_{min} = 2f_L/Jm$, where J is nuclear spin. *Ag* allows two stable isotopes with almost same abundances and the values of f_{flip} are given for both.

Ion	(Z, A, S)	f_1/Hz	f_{flip}/Hz	J
<i>Cl</i>	(17, 35, F)	8.5	82.2	3/2
<i>K</i>	(19, 39, F)	7.5	39.1	3/2
<i>Rb</i>	(37, 85, F)	3.5	81.0	5/2
<i>Y</i>	(39, 89, F)	3.4	41.2	1/2
<i>Rh</i>	(45, 103, F)	2.9	26.6	1/2
<i>Ag</i>	(47, 107, F)	2.8	34.2 (39.2)	1/2
<i>Ir</i>	(77, 193, F)	1.6	17.0	3/2
<i>Au</i>	(79, 197, F)	1.5	14.0	3/2

appreciably during this period but that the violent change of Earth's magnetic field induces dramatic effects on collective aspects of consciousness at $k_d = 44$ level as the findings of Callahan suggest.

3.4.2 What about spin flips?

The natural question is whether also spin flips to which Larmor frequencies are associated could be important. If anomalous magnetic moment vanishes Larmor frequency differs by a factor 1/2 from cyclotron frequency: $f_L = f_c/2$ so that spin flip frequency is same as cyclotron frequency. For atomic nuclei the Larmor frequency tends to be larger than cyclotron frequency as the table of Appendix demonstrates. The effects of em fields in living matter at Larmor frequencies have not been however reported.

The natural expectation is that Larmor frequency behaves in the same manner as cyclotron frequency in the scaling of Planck constant and this is indeed the case since spin scales as \hbar_{eff} . This allows to consider the possibility that also spin flip transitions are of interest and perhaps define correlates for sensory qualia.

Spin flip frequencies are in general of order few hundred Hz for $B = .2$ Gauss. The eight ions listed in **Table 2** have however exceptionally low Larmor frequencies and, very importantly, the singly ionized states have vanishing electronic spin for all ions except Rh and IR for which electronic configuration corresponds to $J - e = 2/2$ (non-vanishing electronic spin implies that the Larmor frequency of ion is of order $f_L = f_c(e)/2 \simeq 3 \times 10^5$ Hz). This suggests that electromagnetic spin flip transitions for these ions at least could be related to our consciousness. Note that K, Ag and Au have spin flip frequencies near to the harmonics of the fundamental frequencies of exotic supersymplectic representations important in EEG frequency range. Note that the spin flip frequency of *K* is 39.1 Hz which is in 40 Hz thalamocortical resonance band. The spin flip frequency 82.2 Hz for *Cl* might relate to the resonance frequency 80 Hz associated with retina.

4 Model For Ionic Superconductivity

In this section the model for ionic superconductivity is constructed as a straightforward generalization of the TGD based model of high T_c electronic superconductivity [K2]. There is however a exotic delicacy involved. TGD based model of atomic nucleus predicts that fermionic ions can have bosonic chemical equivalents for which one of the color bonds connecting nucleons to nuclear string is charged. Dark fermionic ions like Na^+ , K^+ , and Cl^- could appear as Cooper pairs or be exotic ions of this kind having different mass number and be able to form Bose-Einstein condensates.

The new model for the topological condensation at magnetic flux quanta of endogenous magnetic field differs radically from the earlier model and allows to understand that effects of ELF em fields on brain. Bose-Einstein condensates of bosonic ions are predicted to be of special importance for the functioning of living systems. Also a quantitative understanding of the effects of Schumann resonances and EEG emerges.

4.1 Model For Ionic Superconductivity

TGD leads to a model of electronic super-conductivity based on the notion of magnetic flux tube pair. Exactly the same mechanism is expected to work also in the case of ions and the only differences come from the different mass and charge of ion.

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

This model applies to both electrons and fermionic ions and if the proposal that h_{eff} is proportional to the mass of ion, it predicts same binding energies for all Cooper pairs as their spin-spin interaction energy. This hypothesis predicts universal spectrum of bio-photons energies if they result from dark photons and is motivated by the identification of gravitational Planck constant [K18] with h_{eff} . In this case binding energies would be in eV range and much above thermal energy at room temperature.

2. Mersenne hypothesis discussed in the introduction is assumed and makes possible precise quantitative predictions using scaling arguments. With the motivation coming from the model of cell membrane as Josephson junction it is also assumed that magnetic field scales as $1/\hbar$ and that the supra currents at the boundaries of flux tubes guarantee that the quantization condition $\oint (p - eA) \cdot dl = 0$ is satisfied. This allows the flux tubes to have a fixed transversal size (cell membrane thickness) irrespective of the value of Planck constant. The original hypothesis was that $B_{end} = 0.2$ Gauss and its p-adically scaled variants (powers of two) could define preferred values of endogenous magnetic field. If biophotons result when dark photons with h_{eff} proportional ion mass are ordinary photons, they have a universal energy spectrum in visible and UV range, which directly corresponds to the spectrum of magnetic fields strengths and for flux tubes carrying monopole flux to the spectrum for the thickness of the flux tube. This would suggest effectively continuum of values of B_{end} .
3. In the case of bosonic ions there is no need for Cooper pairs and super-conductivity could be due to the Bose-Einstein condensation of ions. TGD based nuclear physics also predicts exotic ions, which are chemically like their fermionic counterparts but are actually bosons. This is made possible by the possibility of the color flux tubes connecting nucleons to nuclear string to carry charges 1, 0, -1.

4.2 Super Conductors Of Exotic Bosonic Counterparts Of Fermionic Ions

If ion is boson, no Cooper pairs is needed in order to have a super conductor, and Ca^{++} and Mg^{++} ions at dark magnetic flux tubes with large value of Planck constant could give rise to high T_c super-conductors in this manner. Fermionic ions (Na^+ , K^+ , Cl^- , ..) would not define supra currents. The explanation of the effects of ELF em fields on vertebrate brain however suggests cyclotron Bose-Einstein condensates of also ions behaving chemically like fermionic ions. Also the model of nerve pulse requires Josephson currents of ions which are chemical equivalents of fermionic ions.

TGD based nuclear physics [L1] allows this kind of ions. The model indeed predicts the possibility of exotic nuclei for which one or more color bonds connecting nucleons to the nuclear string are charged. These exotic nuclei with electronic states identical to those of genuine ions could save the situation. **Table 3** describes how cyclotron frequencies for $B = .2$ Gauss of the most important ions are modified in the simplest replacements with exotic ions. For instance, the notation Mg_-^{++}

Table 3: The modification of cyclotron frequencies of most important ions are modified by simplest replacements with exotic ions

<i>Ion</i>	f_c/Hz	<i>Pseudo-ion</i>	f_c/Hz
$^{23}Na^+$	13.1	$^{19}Ne_+$	15.7
$^{23}Na^+$	13.1	$^{24}Mg_{-}^{++}$	12.5
$^{39}K^+$	7.7	$^{40}A_+$	7.5
$^{39}K^+$	7.7	$^{40}Ca_{-}^{++}$	7.5
$^{35}Cl^-$	8.6	$^{40}A_-$	7.5

(4.1)
Table 4: The first columns give the cyclotron frequencies and cyclotron energies for biologically relevant bosonic ions in $B_{end} = .2 \times 10^{-4}$ Tesla. The third column gives cyclotron energy.

Ion	f_1/Hz	E_1/eV
$^6Li^+$	50.1	3.3
$^{24}Mg^{2+}$	25.0	1.65
$^{16}O^{2-}$	37.6	2.48
$^{32}S^{2-}$	18.8	1.24
$^{40}Ca^{2+}$	15.0	.99
$^{55}Mn^{2+}$	11.4	.75
$^{56}Fe^{2+}$	10.8	.71
$^{59}Co^{2+}$	10.0	.66
$^{64}Zn^{2+}$	9.4	.62
$^{80}Se^{2-}$	7.6	.5

tells that there is double electronic ionization and electron shell of Argon as usual but that one color bond is negatively charged.

$f_c(K^+)$ and $f_c(Cl^-)$ are replaced with the frequency 7.5 Hz and one can do only using the cyclotron frequencies $f(Ca^{++})/2 = 7.5$ Hz, $f_c(Mg^{++}) = 12.5$ Hz, and $f(Ca^{++}) = 15$ Hz. The nominal values of the lowest Schumann frequencies are 7.8 Hz and 14.3 Hz. All ions with relevance for nerve pulse and EEG could be bosonic ions or bosonic pseudo-ions. I do not know how well the needed ionization mechanisms are understood in the standard framework.

4.3 More Quantitative Picture About Bose-Einstein Condensates

Cyclotron frequencies of biologically important ions in the endogenous magnetic field $B_{end} = 0.2$ Gauss are involved with the effects of ELF em fields on vertebrate brain and are also central in the model of EEG [K5]. This motivates a more detailed study of these frequencies. Also the cyclotron frequencies of biologically important molecules are interesting.

4.3.1 Bose-Einstein condensates of bosonic ionized atoms

The number of elements for which ions are bosons is not very large. **Table ?? lists the cyclotron frequencies of bosonic ions which are biologically important for $B_{end} = .2 \times 10^{-4}$ Tesla.**

The table inspires some comments.

1. For Li^+ the dominating isotope $^7Li^+$ is fermion. $^6Li^+$ is boson and its abundance is 5 per cent. Li^+ ions are used as medications in mania and represents mood stabilizer [J1]. A possible explanation is that the cyclotron oscillations of Bose-Einstein condensate of $^6Li^+$ ions serve as a biological clock helping to stabilize the mood. The cyclotron frequency is however 50 Hz and higher than thalamocortical resonance frequency having nominal value 40 Hz.

An alternative explanation for the effect of Li^+ is based on the observation that ${}^7Li^+$ has cyclotron frequency equal to 42.9 Hz for $B_{end} = .2 \times 10^{-4}$ Tesla, which is at the upper limit of the 40 Hz resonance band. The presence of lithium ions or their Cooper pairs could enhance thalamocortical resonance.

These hypothesis could be tested by looking whether the use of pure $A = 6$ ($A = 7$) isotope of Li^+ amplifies the beneficial effect and the use of $A = 7$ ($A = 6$) isotope nullifies it.

2. For Mg^{2+} cyclotron energy corresponds to the energy of photon of green light. Chlorophyll is not able to convert nutrients to sugar without magnesium, which suggests that cyclotron transitions of Mg BE condensate are at least partially responsible for the green color of plants. Mg BE condensate could control the coherent occurrence of photosynthesis in the size scale of plant.
3. For oxygen ion the cyclotron frequency is 37.6 Hz and rather near to ~ 40 Hz thalamocortical resonance frequency, which suggests that the cyclotron transitions of oxygen ions might play key role in inducing coherent firing of neurons at this frequency. This would mean that oxygen would be much more than a mere provider of metabolic energy. Note also that $\Delta n = 3$ cyclotron transition of Na^+ ion corresponds to frequency 39 Hz and might be involved with the synchronous firing.
4. Ca^{2+} ions play a unique role in the functioning of living matter. In particular, calcium waves appearing in a wide range of time scales are known to serve a crucial role in nervous system [J9]. Ca^{2+} corresponds to .99 eV cyclotron energy scale, which is twice the energy of metabolic energy quantum. Hence one can ask whether the cyclotron transitions of Ca^{2+} BE condensate could induce a collective emission of metabolic energy quanta and in this manner induce coherent metabolic activity in the scale of entire body.
5. The cyclotron frequencies Mn, Fe, Co, Cu, and Zn are in alpha band and corresponding cyclotron energies are somewhat above metabolic energy quantum. These energy quanta could drive protons from larger space-time sheet to $k = 137$ atomic space-time sheet. 10 Hz frequency is known to define an important biological clock and Co ions could be essential for the functioning of this clock. $n = 3$ multiple of Co^{2+} cyclotron frequency corresponds to the 30 Hz threshold of gamma band known to be important for cognition. Also $3f_c(Fe^{2+}) = 32.2$ Hz and $3f_c(Mn^{2+}) = 34.2$ belong to gamma band. The presence of Bose-Einstein condensates of these ions in length scale of $5L(212) = 141$ km could mean that these bio-rhythms are shared by different organisms inside regions of this size.
6. The fact that the cyclotron frequency of Se^{2-} ion, which is known to be a biologically important trace element, corresponds to the nominal value of the metabolic energy quantum, raises the question whether Selenium BE condensate might act as a metabolic synchronizer.

4.3.2 Cyclotron frequencies and Schumann frequencies

Even in the case that Cooper pairs of fermionic ions are not thermally stable, the cyclotron transitions of fermionic ions like K^+ , Cl^- , and Na^+ are expected to be important. In Table 5 cyclotron frequencies and energies of some fermionic ions are given. Notice that the cyclotron energy of K^+ ion corresponds to metabolic energy quantum. Quite generally fermionic ions cannot be involved with the generation of Josephson part of EEG.

The first thing to notice is the close relationship of cyclotron frequencies with the lowest resonance frequencies in the spectrum of geo-electromagnetic field starting from 5 Hz, so called Schumann frequencies [F5], are 7.8, 14, 20, 26, 33, 39 and 45 Hz. 5 Hz corresponds roughly to the threshold 4 Hz of theta frequency range below which EEG

Table 5: The first columns give cyclotron frequencies and corresponding cyclotron energies for some ions in $B_{end} = .2 \times 10^{-4}$ Tesla for some fermionic ions.

Ion	f/Hz	E_c/eV
${}^7Li_+$	42.9	
F^-	15.8	1.04
Na^+	13	.86
Al^+	11.1	.73
Cl^-	8.5	.56
K^+	7.5	.50
Cu^+	4.8	333.9
Ag^+	2.8	.18
I^+	2.4	.16
Au^+	1.5	.10

spectrum lies during sleep which suggests that wake-up state involves the coupling of brain with geo-electro-magnetic activity. 7.8 Hz corresponds to the threshold for alpha waves associated with wake-up state without cognition; 14 Hz corresponds to threshold of 13 Hz for beta waves accompanying cognitive activities, and 33 Hz is quite near to the threshold 30 Hz for gamma waves known to be important in the temporal coding of sensory data.

Consider now examples of cyclotron frequencies keeping in mind that Schumann frequencies vary typically within 1 Hz interval around their mean values [F5].

1. As already noticed, the frequencies, which are multiples of 15 Hz can be assigned to Ca^{2+} ion. The excitations $n = 3, 5, 7, ..$ correspond to the frequencies 45, 75, 105, ... Hz. All these frequencies have been observed. The two lowest frequencies correspond to Schumann frequencies 14 and 45 Hz with accuracy of 1 Hz.
2. Na_+ has $A = 23$ and gives $f = 13$ Hz. This is the lower bound for the frequency of beta EEG waves which are associated with conscious cognition. This would suggest that the presence of em field of 13 Hz frequency correlates with large fluxes of Na_+ ions through the axonal cell membrane during nerve pulse generation. This could result from increased amplitude of Na_+ Josephson current facilitating the emission of nerve pulses at the second half of the EEG cycle. Silencing of mind by meditation or closing eyes reduces amplitudes associated with EEG frequencies below 13 Hz and conscious cognition disappears.
 $n = 3$ excitation of Na_+ corresponds to 39 Hz, which is one of the Schumann frequencies and quite near to the 40 Hz resonant frequency associated with the thalamocortical circuit. This could correspond to jumping of Na_+ ions from ground state to $n = 3$ state or vice versa. $n = 5$ quantum jumps correspond to 65 Hz which is average EEG frequency during REM sleep! Thus 13, 39 and 65 Hz frequencies correspond to the basic signatures of conscious cognition. The two lowest transition frequencies correspond to Schumann frequencies 14 and 45 Hz within accuracy of 1 Hz.
3. K_+ has $A = 39$ and gives $f = 7.5$ Hz, which is theta frequency rather near to the lowest Schumann resonance frequency 7.8 Hz. K_+ ion flux could correlate with em fields in the range of the alpha frequencies creating cyclotron resonance. Theta activity dominates during sleep and Adey's observations [J5] demonstrate that 7 Hz ELF field increases reaction times. Second and third transition frequencies are within 1.5 Hz Schumann frequencies 20 and 37.5 Hz.
4. Cl_- ion has $A = 35$ and gives $f = 8.5$ Hz. Chloride ion has inhibitory effect. $n = 3, 7, ..$ excitations correspond to 25.5, 42.5 Hz, ... Rather interestingly, frequencies

rather near to 40 Hz associated with thalamo-cortical loops appear as excitations for all ions relevant to nerve pulse activity. Note that 39 Hz is also Schumann frequency. Two lowest transition frequencies of Cl_- are quite near to Schumann frequencies 7.8 and 25 Hz.

5. Fe^{2+} has $A = 56$ and corresponds to 10.7 Hz. $3f_c(Fe^{2+}) = 32.2$ Hz is rather near to Schumann frequency 33 Hz whereas Co^{2+} corresponds to 10 Hz in excellent accuracy. Co has especially large nuclear magnetic moment and serves as a natural magnet. Fe^{2+} and/or Co^{2+} could be present in magnetic sensory organ possessed also by humans making it possible to navigate using magnetic fields. Yarrow suggests that Co makes B_{12} magnetic vitamin [J5] so that it can serve as fundamental biological clock at frequency very precisely equal to 10 Hz. Co is carried by B_{12} vitamin and is known to be important for normal consciousness: among other things the lack of B_{12} causes fatigue, blurred vision and cognitive problems.
6. Mg^{2+} has $A=24$ and $f = 25$ Hz which is near to Schumann frequency: $n = 3$ corresponds 75 Hz. Charged polypeptides could also form BE condensates and be involved with cyclotron mechanism: they are rather heavy and their cyclotron frequencies are in Hz range. Negatively charged organic molecules are indeed known to be present in neurons.

To sum up, surprisingly many magnetic transition frequencies are near to Schumann frequencies which suggests strong resonant interaction between brain and geoelectromagnetic fields.

4.3.3 What about proton's cyclotron frequency?

There are good reasons to expect that the cyclotron frequency of proton and its odd harmonics play an important role in brain functioning. The cyclotron frequency of proton in $B_{end} = .2$ Gauss is $f(p) = 300$ Hz. The frequency associated with $n = 3$ transition would be $3f(p) = 900$ Hz. Third harmonics of cyclotron frequencies of many ions with f_c in alpha band belong to gamma band known to relate to cognition. Perhaps this is true also in the case of proton.

The duration of single bit of the memetic codeword consisting of 127 bits and having total duration defined by the p-adic timescale $T_{M_{127}}^{(2)} = .1$ seconds corresponds to the frequency $f_m = 1027$ Hz. This frequency is by 10 per cent higher than the cyclotron frequency of proton for $B_{end} = .2$ Gauss. If magnetic homeostasis is realized, as will be discussed later, and if it allows 10 per cent variation of the strength of magnetic field as the width 1 Hz of alpha band suggests, it is possible to realize this frequency as proton's cyclotron transition frequency.

The frequency of neuronal synchronization, which is obviously associated with cognitive processing, is $\simeq 1$ kHz and might well be identifiable with f_m . The maximum rate of neuronal firing is slightly below kHz: this rate however corresponds to the rate of quantum jumps rather than oscillation frequency at space-time level.

4.3.4 Bose-Einstein condensates of bosonic molecular ions

Also biologically relevant bosonic molecular ions such SO_4^{2-} , CO_3^{2-} , NO_3^- , NO_2^- could form Bose-Einstein condensates. The cyclotron frequencies for bosonic molecular ions satisfying the thermal stability condition $A \leq 233 \times Z$ at room temperature are typically in theta and delta band and above $f_{min} = 1.29$ Hz.

DNA is negatively charged and an interesting question is whether DNA satisfies the stability condition. The molecular weights of DNA nucleotides A, T, C, G are 132, 126, 96, 149. The molecular weight of deoxyribose sugar attached to the nucleotide is 100 and that of phosphate group PO_4^{2-} is 95. Altogether this makes molecular weights 327, 321, 291, 344. Since phosphate group is doubly charged this structure has cyclotron energy which is higher than thermal energy. Also DNA sequences satisfy

the thermal stability condition. The presence of DNA Bose-Einstein condensates at magnetic flux quanta could mean that DNA can be transferred between different organisms along these space-time sheets and that DNAs of different organisms of same species could form quantum coherent systems inside regions where magnetic field can be regarded as a constant.

5 Atmospheric Phenomena And Super-Conductivity

There is a lot of evidence that various electromagnetic time scales associated with the atmospheric phenomena correspond to those associated with brain functioning. If magnetic sensory canvas hypothesis holds true, this is just what is expected. In this section these phenomena are considered in more detail with the aim being to build as concrete as possible vision about the dynamics involving the dark matter Bose-Einstein condensates at super-conducting magnetic flux quanta. If almost vacuum extremals are in question, a strong analogy with living matter is implied and both em and Z^0 fields are present. In case of cell membrane this assumption is highly successful.

One particular consequence is that there is a coupling to left handed weak nuclear isospin proportional to neutron proton difference as well as coupling to nuclear electromagnetic charge Z which dominates for heavier nuclei and gives rather large coupling (here it is essential that atomic electrons do not condense at the almost vacuum extremal). This means that the system behaves like plasma such that all particles have same sign of net weak isospin. Either opposite Z^0 charge carried by neutrinos or ionization is necessary in order to achieve stability. Also large parity breaking is implied in macroscopic length scales. One implication would be vortices with a preferred direction of rotation.

5.1 Tornadoes As A Macroscopic Quantum Phenomenon Involving Super-Conductivity?

Tornadoes represent a piece of not completely understood atmospheric physics. To mention just two questions which have received no satisfactory answer.

1. What makes possible the ability of tornado to preserve its structure and coherence?
2. What makes possible the coherent rotation of matter inside tornado?
3. How to understand various luminous phenomena associated with the tornadoes [H3, H1, H5] ?

Classical Z^0 forces and the vision about magnetic flux tubes as bio-superconductors suggests a new approach to the physics of tornados possibly providing also answers to these questions. My own attempts to understand tornadoes have been based on three separate approaches. Tornado as a magnetic spiral vortex carrying em and Z^0 magnetic fields, tornado as an analog of a rotating magnetic system known as Searl device, and tornado as a system for which the interactions between visible and dark matter are essential.

The most recent approach to tornadoes and rotating magnetic systems relies on the recent model of cell membrane as almost vacuum extremal and assumption that tornades could be seen in many respects as p-adically scaled up variants of the axonal membrane. The combination of this line of approach with the earlier ones, probably not mutually consistent in every detail, will be discussed in the sequel.

5.1.1 Tornadoes as magnetic spiral vortices near vacuum extremals?

The basic idea is that tornadoes are a phenomenon involving complex many-sheeted space-time topology and classical em and Z^0 magnetic fields in an essential manner

making tornadoes macroscopic quantum systems in meteorological length and time scales.

1. A partial answer to the question relating to the stability and coherence is self-organization, which in fact implies in TGD context that tornado has “self” and is conscious in some primitive sense. In standard physics context the ability of tornado to have a well defined macroscopic structure despite the locally chaotic nature of the hydrodynamic flow involved, is not easy to understand. In particular, self-organization does not as such explain the coherent rotation of the matter inside tornado. The almost vacuum extremal property is characteristic aspect of cell membrane [K5], which suggests that tornado or at least the boundary layer between exterior and interior of tornado corresponds to almost vacuum extremal so that tornado might be perhaps compared to neuronal axons in some respects. Self organization is indeed associated with strong gradients and the boundary layer certainly represents this kind of region.
2. In TGD framework the answer to the question relating to the rotation of matter inside tornado is that tornado or its boundary corresponds to magnetic flux tube with em and Z^0 magnetic fields -or more generally -a more complex structure consisting of magnetic flux quanta, say a hierarchy of hollow flux tubes inside hollow flux tubes.
3. One expects that these Z^0 ions rotate with almost the same rotation velocity and in the same direction in the Z^0 magnetic field associated with the space-time sheet of the tornado. Although rotation velocities can have both signs, coherent motion in single direction can occur stably and large parity breaking favors the other direction of rotation. Z^0 magnetic field is generated if all screening neutrinos do not co-rotate with the matter or if the screening of nuclear Z^0 charge by neutrinos is not complete. Conducting and super-conducting neutrinos are expected to be unable to follow the rotation of the nuclei whereas the neutrinos below Fermi surface should co-rotate with matter so that Z^0 magnetic field can be generated. Situation is completely analogous to that of an electric conductor.
4. Neutral atoms and molecules are highly charged Z^0 ions with effective charge proportional to nuclear charge if electrons do not condense on almost vacuum extremal. The quantization of em and Z^0 magnetic field of tornado to flux tubes suggests strongly itself and the classical orbits of Z^0 ions in the average Z^0 magnetic field correspond to Z^0 magnetic flux tubes with a helical shape. In the case of tornado these flux tubes are expected to have spiral like structure implied by garden hose instability and provide an example of spiral waves which seem to be a very general phenomenon in excitable media. Just like the flux tubes of the magnetic field, also Z^0 magnetic flux tubes are expected to be super-conducting. One of the first proposals of TGD inspired view about supra phase was that also super-fluidity might involve Z^0 magnetic vortices [K11] but at that time I did not realize that almost vacuum extremals- which I was of course well aware- might be in question.
5. Also the vortices of any hydrodynamic flow could involve Z^0 magnetic boundary layers at least: in particular, the mechanism inducing transition from super-fluidity to ordinary fluid flow is generation of Z^0 magnetic vortices at critical velocities which are much lower than those predicted by hydrodynamical arguments [K11]. The leakage mechanism of radial em or Z^0 supra currents from magnetic flux tubes might be involved with the dissipation and also with sonoluminescence [C1]. Also TGD inspired cosmology and classical view about gravitational fields relies on the approximation that cosmologies can be idealized with vacuum extremals [K22].

To build a more quantitative picture one needs some information about the model for almost vacuum extremals.

1. In the model of cell membrane as almost vacuum extremal electrons are not assumed to condense at the almost vacuum extremal space-time sheets since this would not be consistent with atomic physics. Nuclei however feed their Z^0 charges to these space-time sheets. Neutral atoms for $N - Z > 0$ have left-handed weak isospin equal to $(Z - N)/2$ and same vectorial charge proportional to $\sin^2(\theta_W)Z$. The classical Z^0 field is for vacuum extremal proportional to em field and this allows to use only em field and effective em charge expressible as

$$Q_{eff} = -\frac{Z - N}{2p} + 2Z + q_{em} \ , \ p = \sin^2(\theta_W) \ . \quad (5.1)$$

Z denotes proton number, N neutron number, and q_{em} the charge due to ionization in units of proton charge. What is remarkable that even neutral atoms have large effective em charge due to the charge of protons. There is also an axial coupling to the classical Z^0 field causing large parity breaking effects. The value of Weinberg angle for almost vacuum extremals is not expected to be same as for far from vacuum extremals. The model for photoreceptors fixes p to be $p = .0295$ to be compared with $p \simeq .23$ for standard model vacuum. Just fixing the value p predicts correctly the frequencies of peak sensitivity for the four types of photoreceptors [K5].

Radiation at visible photon energies is the signature of tornadoes [H2] difficult to understand in the standard physics framework. Also rotating magnetic systems [H4] exhibit similar strange characteristics. Same applies to sonoluminescence [C1]. One can consider two mechanisms generating radiation at visible and UV frequencies.

1. First mechanism is based on Josephson radiation. The almost vacuum extremal property, the suggested membrane like structure at the boundary of tornado, and the hypothesis that scaled up variant of axonal membrane with an appropriate value of Planck constant could in question suggests that there is also an electric field over the membrane. T TGD based model for rotating objects also predicts radial electric field [K22] and there is also a kinematic effect producing this kind of electric field [K1]. From the vanishing of total Lorentz force one has $E = \omega\rho B$, where B is the strength of the magnetic field, ω the angular velocity of rotation, and ρ is the distance from the rotation axes. For $\omega k/\rho$ outside the rotating magnetic system voltage is same for all flux sheets and voltage is

$$V = k\Delta RB = \omega R\Delta RB \ .$$

If the value of the analog of membrane potential is same as for cell membrane, one would have electric strength ~ 9.5 V/m for the minimal sized vortex. This condition would relate the magnetic field strength to the basic parameters of the tornado. This kind of assumption is of course somewhat ad hoc and only its success can justify it.

Superconducting atoms and molecules would be Z^0 ions with effective em charge proportional to the total nuclear charge Z and gain in this electric fields energies comparable in visible and UV range (few eVs) and one expects that the dark Josephson radiation at low frequencies is generated providing the system with the analog of EEG. The leakage of dark Josephson photons and Z^0 ions to the ordinary space-time sheets and their interaction with atoms and molecules could in turn induce ordinary ionization which might be required also by the stability of the system. This would explain the visible light from this kind of systems. The rotation frequency of the system might directly relate to the frequency of dark Josephson radiation. The energy spectrum of radiation would serve as a signature allowing to distinguish the model from models explaining the radiation in terms of atomic transitions.

2. One can consider also second mechanism. The mechanism for the breaking of the ordinary super-conductivity in the case of the magnetic flux tubes is based on the idea that for curved flux tubes ionic current with an overcritical ion velocity leaks along flux tubes from the magnetic flux tubes to non-super-conducting space-time sheets. The reason is simply the inertia of the charged particle. This process implies the generation radiation in case of the ordinary electromagnetic ions. This process occurs in the reconnection of magnetic flux tubes and more generally, when the curvature of flux tube becomes very large so that the inertia of the particle drives it to a larger space-time sheet. The model applies also to Z^0 magnetic case and if the particles are ordinary em ions, the generation of radiation is expected also now. Of course, also the collisions of neural particles generate also radiation but much more weakly. It is of course possible that stability condition requires also ordinary ionization of atoms.

This mechanism, besides providing a model for dissipation, might explain also the luminous phenomena associated with tornadoes [H3, H1, H5]. Tornadoes are expected to involve also ordinary magnetic fields and corresponding flux tube structures so that also they could give rise to luminous phenomena by the same mechanism as in the case of auroras.

5.1.2 Rotating magnetic systems as dark matter systems analogous to neuronal axon

A useful analogy for the tornado is provided by rotating magnetic system known as Searl device [H4]. This system is reported to start to spontaneously accelerate at certain critical rotation frequency. The TGD inspired model for the system is discussed in [K1]. Spontaneous acceleration is accompanied by spontaneously occurring concentric cylindrical magnetic walls of thickness $\simeq .5$ cm with mutual distance of $\simeq .5$ m. What is intriguing that the spontaneous acceleration starts at 9.1 Hz rotation frequency and acceleration continues up to 10 Hz after which the experimentation becomes impossible due to the problems with the mechanical stability. 10 Hz corresponds to the alpha band of EEG and to the fundamental frequency of electron's CD. There is also a strong parity breaking involved: depending on the direction of rotation the weight of the system either decreases or increases, which suggests that some space-time sheets involved correspond to almost vacuum extremals: this could also explain the problems with stability.

These observations suggest that it might make sense to apply the idea about scaled up cell membrane to the boundary layer and magnetic flux walls associated with the rotating magnetic system. There are several scales and possibly also several values of Planck constant involved.

1. The radius of the rotating magnetic system is about 1 m and corresponds to the p-adic length scale $k = 204$ which corresponds to 1.2 m. This would suggest $k_d = 204 - 163 = 41$. Note that one has $h_{eff} = nh$, where n is product of distinct Fermat primes and power 2^{k_d} . The distance between magnetic walls is about .5 m and would correspond to $k_d = 39$. The thickness of the magnetic walls is about 5 cm corresponding to about $k_d = 32$. It is difficult to say anything definite about the thickness of the boundary layer assignable to the rotating magnetic system. 1 mm is one estimate based on the fact that the cylindrical rollers are at this distance from the central cylinder. This would suggest $k = 184$ and $k_d = 21$. The corresponding dark photon frequencies are 320 Hz, 1280 Hz, .66 MHz, and .32 GHz. Note that the second frequency corresponds to the 1.28 kHz frequency assignable to the CD of quark.
2. The very special role of 10 Hz frequency suggests the value $k_d = 2^{46}$. Note that the time scale of electron's CD is in question. Of course, several dark values of Planck constant are possible.
3. One can also consider the possibility that magnetic walls of thickness 5 cm could be dark matter systems with thickness allowing an interpretation as scaled up

counterparts of cell membran of thickness 10 nm. The ratio of these scales is 5×10^6 . This would give $k_d = 2^{45}$ not far from the value deduced from 10 Hz critical rotation frequency. Here one must however notice that cell membrane thickness is not affected in the scalings of Planck constant so that also other values of Planck constant are possible.

The idea about a strict scaling of the cell membrane suggests that there is also an electric field orthogonal to the boundary layer. From the vanishing of the total Lorentz force one has $E = \omega\rho B$, where B is the strength of the magnetic field, ω the angular velocity of rotation, and ρ is the distance from the rotation axes. For $\omega = k/\rho$ outside the rotating magnetic system voltage is same for all flux sheets and voltage is $V = k\Delta RB$.

If the value of the analog of membrane potential is same as for the cell membrane, one would have electric strength ~ 9.5 V/m. Superconducting atoms and molecules in in this field would gain energies of UV photons and highly energetic dark Josephson radiation at these frequencies would be generated providing the system with the analog of EEG. If the voltage is same also in the case of cell membrane, dark Josephson radiation at frequencies determined by the value of the Planck constant is generated. The rotation frequency of the system -very near to 10 Hz- might relate to the frequency of Josephson radiation.

Magnetic walls could contain dark matter Bose-Einstein condensates in cyclotron state carrying maximal magnetic field of $B = .05$ Tesla [K1], [H4]. Magnetic walls could serve as angular momentum and energy storages from which the system draws energy by time mirror mechanism (see Fig. <http://tgdtheory.fi/appfigures/cat.jpg> or Fig. ?? in the appendix of this book), which means sending of negative energy phase conjugate photons absorbed by the Bose-Einstein condensate.

One can imagine several interpretation for the ionization of the air.

1. One already discussed explanation for the ionization of air would be in terms of energetic dark atoms and molecules and dark Josephson radiation leaking to the space-time sheets carrying visible mater. For instance, for N_2 and O_2 molecules one has Z_{tot} equal to 15 and 16 respectively, and the energies of UV photons are in few eV scale for cell membrane potential and could ionize molecules [K5].
2. The observed ionization of the air in the vicinity of the rotating system could be also understood in terms of an Ohmic current generated by the radial vacuum electric field implied by the rotating magnetic field. Since the electric field corresponds to a non-vanishing vacuum charge density, this current charges the rotating magnetic system. Current carriers drop from atomic space-time sheets to larger space-time sheets at the boundary of the system liberating their large zero point kinetic energy of order 1 keV. The resulting voltage allows in principle to use the system as an over-unity device by adding load to a wire connecting the system to ground. The model leads to the proposal that rotating magnetic flux quanta provide a fundamental mechanism leading to the generation of plasmoids, which can be regarded as primitive living systems [I12].

5.1.3 Tornadoes as dark matter systems

The identification of tornadoes as large \hbar systems is suggested by the ability to self-organize and preserve the self-organization pattern for relatively long periods of time. Dark matter would imply self organization and make the system living in a primitive sense.

The identification of tornadoes as rotating magnetic systems near vacuum extremals would allow to interpret the luminous phenomena associated with tornadoes [H3, H1, H5] in terms of a plasma resulting by the mechanisms proposed in previous section. The angular momentum stored to dark Bose-Einstein condensates at the magnetic walls would provide angular momentum and energy for the tornado.

As a matter fact, the formation of these Bose-Einstein condensates could force the rotation of tornado by angular momentum conservation.

The already discussed model of the boundary layer between rotating magnetic system and external world as a scaled up variant of cell membrane space-time sheet applied to the boundary layer between tornado and external world would make essentially the same predictions if one assumes that the voltage through the layer is same as in the case of the cell membrane. In particular, ionization is expected by the atoms and molecules gaining energies corresponding to photons in visible and UV regions and the resulting ions would in turn generate Josephson photons.

There are several kinds of tornadoes [H2]. For supercell tornadoes called twisters the width is usually below $d = 90$ m but can sometimes extend over 1.6 km. Wind velocity is typically $v_0 = 160$ km/h = 44 m/s at the outer boundary. This gives a rough estimate for the angular velocity at the outer boundary as $\omega = v/d$. The rotation frequency is $f = 1/2\pi \simeq .16 \simeq 2^{-6} \times 10$ Hz in this particular case. For a radius of 1.6 km and same wind velocity one would have $f \simeq 8.8$ mHz $\simeq 2^{-10} \times 10$ Hz. By the basic rule the values of k_d vary in the range [52, 56] with p-adic length scales $163 + k_d$ in the range [215, 218]. The length scale range would be [40, 113] m. What is encouraging that the lower limit corresponds to the radius of the minimum sized tornado. The upper limit is too small by an order of magnitude. The interpretation suggested by the interpretation in the case of rotating systems is that 114 m would correspond to the thickness of the boundary layer between tornado and exterior world. For the minimal tornado the boundary layer would cover the entire interior.

5.2 Auroras As An Astrophysical Quantum Phenomenon?

Auroras are perhaps the most magnificent electromagnetic phenomenon in the atmosphere. The mechanism generating the auroras is not completely understood. What is however known that auroras involve the motion of ions along flux lines of Earth's magnetic field acting effectively as current wires. This suggests that the ionic currents could be supra currents running along the flux tubes of the magnetic field of Earth or its dark counterpart $B_{end} = 2B_E/5$ suggest to exist on basis of findings about the effects of ELF em fields on vertebrate brain [K5]. Hence auroras could be a directly visible macroscopic quantum phenomenon! In the following a model of auroras based on this vision and explaining the latest findings about them is developed.

5.2.1 Basic facts, ideas and puzzles related to auroras

Auroras occur at heights of 56-970 km along a circle surrounding the magnetic North (South) pole [F14]. Magnetic storms accompany auroras and auroras are especially intense during sunspot maxima. Protons and electrons of the solar wind are known to flow along magnetic flux lines acting effectively as current wires. Some mechanism accelerates electrons and protons during their travel to the pole region where they collide with the ions (mainly oxygen and nitrogen) of the ionosphere and generate visible light. The spectral lines correspond to ionic transitions and each color corresponds to a particular ion dominating at a particular height.

A brief summary of the basic ideas and problems related to the auroras is in order before representing TGD based model.

1. The reconnection of solar magnetic field lines carried by solar wind with the field lines of Earth's magnetic field was proposed by James Dungey as a mechanism explaining the energetics of the auroras. There is indeed increasing empirical support for the view that the reconnection of the magnetic field lines of Sun and Earth accompanies [F14] [F4, F9, F3]. What would happen would be that the reconnected nearby opposite fields lines form a tightly bent U-shaped structure which straightens and acts as a catapult giving recoil energy to the plasma ions flinging in the direction of Earth. The highly energetic protons and electrons of the solar wind would flow towards Earth and collide with the ions of atmosphere

and generate the auroras in this manner. The detailed understanding of the reconnection mechanism is lacking and here TGD suggests microscopic topological description relying on magnetic flux tubes.

2. The problem of the reconnection mechanism is how the solar and earthly magnetic flux lines running in opposite directions and carrying opposite currents know of each other and can change their direction so that the lines can meet. In TGD framework the reconnection of the magnetic flux tubes could be seen as a process changing space-time topology and this process is now one of the basic mechanisms of TGD inspired quantum biology [K8]. At the point of reconnection magnetic field becomes zero in Maxwell's theory and it is thought that the charged particles must be able to leave the flux lines by some unknown mechanism so that demagnetization occurs. TGD in turn suggests that inertial effects force ions flow to larger space-time sheets along join along boundaries bonds.
3. An electric field parallel to the magnetic flux lines has been postulated as the mechanism of acceleration: empirical evidence for the existence of this electric field has been found quite recently [F8]. Two U shaped potential regions with positive *resp.* negative charges have been found at heights 5000-8000 km *resp.* 1500-3000 km. It is convenient to christen lower U shaped region as \cap and the upper one as \cup . The negatively charged region feeds electrons to the aurora region and positively charged region sucks them back. There is however no consensus about how this kind of electric field is generated and how it could be stable.

5.2.2 A TGD inspired model for auroras

There are several poorly understood aspects related to the modelling of auroras. TGD approach provides new views to these problems. The following vision is perhaps the most plausible option discovered hitherto.

The basic condition is that cyclotron energies are above thermal energy. This allows to deduce lower bound the value of Planck constant assignable to the magnetic flux quanta. For $B_{end} = .2$ Gauss the cyclotron frequencies of electron and proton are 6 MHz and 300 Hz respectively and the formula $E = .41 \times 10^{-14} r \times (f/Hz)$, $r = \hbar/\hbar_0$, allows to deduce the estimate for the minimum value of Planck constant in terms of thermal energy and cyclotron frequency as

$$r = 2^{k_d} \geq \frac{E_{th}}{E}, \quad \frac{E}{eV} = .41 \times 10^{-14} \times \frac{f_c}{Hz} \times \frac{B}{B_{end}}. \quad (5.2)$$

Here power of two for r is assumed for simplicity. This gives the frequency as

$$\begin{aligned} k_d(e) &\geq k_d(e, min) = 28.71 + 1.44 \times (\log(\frac{E_{th}}{eV}) - \log(\frac{B}{B_{end}})) \text{ (electron) } , \\ k_d(p) &\geq k_d(e, min) + 11 \text{ (proton) } , \\ k_d(I) &\geq k_d(p, min) + \log(\frac{A}{Z}) \text{ (ion) } , \\ \frac{E_{th}}{eV} &= 2.22 \times 10^{-4} \times \frac{T}{K} . \end{aligned} \quad (5.3)$$

Both electronic and protonic supra currents flow for $k_d > k_d(e, min) + 11$. I refers to ion with charge Z and mass number A .

1. The ionosphere of Earth is at room temperature roughly below 85 km and at temperature 1200 K at upper layers. For B_{end} both electronic and protonic currents incould flow as supra currents if this condition is satisfied for temperature roughly room temperature for $k_d(p) = k_d(e) \geq 34$ below 85 km and for $k_d(p) = k_d(e) \geq 36$ at the upper layers.

2. The reconnection of field lines generalizes to reconnection of magnetic flux tubes. The large inertia of ions in reconnection process from solar wind flux tube can induce their leakage and subsequent transfer to the upper magnetic flux tube in reconnection process. This would accumulate negative charge to the lower and positive charge to the upper U shaped flux tube.
3. The rapid straightening of the lower U shaped flux tube behaving like rubber band provides the mechanism of acceleration and brings ions of solar wind to the ionosphere where the collision with the flux tubes of inner magnetosphere induces the collision of electrons and ions and generates auroras. The liberation of cyclotron energy of electrons in cyclotron transitions of Bose-Einstein condensate of Cooper pairs of electrons and protons, and possibly even of exotic O^+ ions makes possible ionization and electronic excitations of ions involved.

1. *Could em currents flow along magnetic flux quanta of solar and Earth's magnetic field as supra currents?*

The question is under what conditions the statement that charged particles move along the flux lines of Earth's magnetic field without appreciable dissipation translates in TGD framework to supra currents flowing along the flux tubes of Earth's magnetic field.

1. Consider first the flux tubes of solar wind. The solar wind is made of Hydrogen (95 per cent) and Helium (4 per cent) and Carbon, Nitrogen, Oxygen, Neon, Magnesium, Silicon and Iron ($\simeq 1$ per cent). The temperature is $T \simeq 15$ eV. The magnetic field has strength ~ 10 nT. Both proton and electron Cooper pairs cyclotron energies would be above thermal energy at $k_d(p, min) \geq 56$ levels of dark matter hierarchy.
2. Consider next flux tubes in magnetotail. In magnetotail the field strength of Earth's magnetic field is around 30 nT in the lobes of the inner magnetosphere at the night side of Earth and temperature is around .5 eV (metabolic energy quantum again). This gives $k_d(p, min) = 50$ to be compared with $k_d(p, min) \geq 56$ for solar wind meaning that the reconnection process involves a phase transition changing the value of Planck constant.
3. An interesting question is whether Bose-Einstein condensates of exotic O^+ ions could be present near polar regions where field is stronger. What is known that cyclotron resonance frequencies of O^+ and H^+ ions appear in the frequency spectrum of electric fields in the aurora regions [F6]. This however requires only $k_d \geq 53$ since magnetic field is much stronger and near to $B_E = .5$ Gauss. What is interesting and perhaps of significance is that O^+ exotic ion would be the heaviest possible ion forming Bose-Einstein condensates and also the dominating one besides proton.

2. Radii of flux quanta

The gyroradius p_T/ZeB , where p_T is momentum transversal to B , of proton *resp.* electron of solar wind in the magnetotail is known to be about 700 km *resp.* 20 km whereas the radii of the magnetic flux tubes would be in the range in 10-100 micrometers for ordinary value of \hbar and minimal magnetic flux. One must of course notice that currents at the boundaries of flux quanta allow to have arbitrary radii of flux quanta and this is the only sensible option in biomatter. One can consider several scaling laws for the the radius of the flux tube.

p-Adic length scale hypothesis suggests that scaling law could be $R \propto \sqrt{r}$, $r = \hbar/\hbar_0$. Also the radii of cyclotron orbits scale as $\sqrt{rn/eB}$, where n labels the cyclotron states. For B_{end} and for $r = 1$ the minimum radius would be about 5 μm . If the flux quantization in standard form is satisfied for B_{end} with $k_d(p, min) = 36$, the radius is about 1 m. For solar wind with $k_d(p, min) = 56$ and $B = 10$ nT this would give minimal

radius of about 5 km. For tail with $B = 30$ nT and $k_d(p, min) = 50$ this would give 23 km which is slightly larger than electron's gyroradius. The value of gyroradius gives a condition on n if one assumes that the situation is semiclassical. For proton would have $n \simeq 926$ in tail.

The gyroradii of ions are smaller than the radii of flux tubes if one assumes standard flux quantization. If the radii of flux tubes are comparable than gyroradii, the ions can leak out from solar flux tube in the reconnection process. This would be essential for how the negatively and positively charged regions are generated in the reconnection process.

3. Reconnection mechanism

In TGD framework one can understand how reconnection can occur. The helical structure of the flux tubes implies that they can be in transversal direction to the average magnetic field and this means that flux tubes can meet each other in U-shaped manner. Thus the process of reconnection would be a genuine quantal and topological transition for which the flux quantization would be essential.

It seems natural to expect that the location of the reconnection region is determined from the requirement that the flux tubes of solar wind and Earth's magnetic field have same thickness so that also local magnetic fields have the same strength from flux quantization. In Maxwell's theory this corresponds to the fact that the two magnetic fields sum up to zero. The reconnection process should be also energetically favored.

4. Acceleration mechanism

One can regard Earth's magnetic field as a collection of magnetic flux tubes containing matter and analogous to rubber strings. For instance, the rotation of the magnetic flux tubes could be essential prerequisite for the stability of curved flux tubes. Also the idea about catapult action meaning that the reconnected U shaped magnetic flux tube in East-West plane, briefly \cap , rapidly straightens and becomes a flux tube in ionosphere and collides with flux tubes of ionosphere looks natural. $k_d \geq 56 \rightarrow k_d \geq 50$ phase transition would naturally accompany this process.

The collision of flux tubes would in turn induce the collision of ions and electrons inside them and generate auroras. For $k_d = 56$ at solar wind flux tubes the high energy scale $E_c = 15$ keV of the cyclotron energy states of electrons would induce ionization of atoms in the magnetic flux tubes and induce generation of visible light in atomic transitions of ions and also generation of X rays and perhaps even gamma rays. Even when the phase transition to $k_d \geq 50$ state occurs inside ionosphere, the cyclotron energy scale is 1.44 eV, which is in infrared. Here one must of course be careful to notice that this energy is just the minimum energy. One can think that the charged particles of solar wind end to large n cyclotron states at magnetotail and end up to lower energy states by emission of cyclotron radiation. Analogous collision of flux tubes could explain generation of X and gamma rays associated with lightnings.

5. Formation of return current and generation of strong voltage between reconnection region and aurora region

This picture allows also to understand why a return current from aurora region to \cup is formed and what might cause the strong voltage of about 10^4 Volts between the top of \cap and ionosphere.

The formation of the return current of electrons suggests the presence of closed electric field lines so that electric field would not be conservative. These closed field lines would correspond to closed structures formed from magnetic flux tubes carrying electric field. This means that there must be time varying magnetic flux through the surface, call it X^2 , orthogonal to Earth's surface and extending from the aurora region in ionosphere to \cup . This is the case if the highly curve \cap contracts (recall the rubber band analogy) to a relatively straight flux tube inside ionosphere in magnetic East-West direction. The change of the magnetic flux through X^2 would be the magnetic flux carried by this flux tube. Of course, several flux tubes might be involved.

The generalization of the flux quantization condition to time domain reads as

$$2e \int_0^T V dT = nr\hbar_0 ,$$

where T is the time during which flux tube traverses the boundary of ionosphere. The condition follows from Faraday's induction law and magnetic flux quantization, and relates the change of flux to the time and non-conservative voltage around flux loop. If n refers to the flux of single flux tube of Earth's magnetic field in which case it would have radius $R_n = \sqrt{n} \times 23$ km, $n \geq 1$ by the requirement that electron gyroradius is smaller than R_n .

This condition allows to estimate the value of T using the estimate $V = 10^4$ V [F2] for the voltage between recombination region and auroral region. For B_{tail} and $k_d = 56$ this gives $T = n \times 49$ s for the time during which the flux tube traverses the boundary of the ionosphere. In [F8] 200 s time scale is associated with the straightening process on basis of experimental data so that $n = 4$ suggests itself. This would support the idea about quantal process. This would mean radius 46 km safely above the electronic gyroradius 20 km. The velocity of straightening for the flux tube would be $v \sim 2R_1/T \simeq .25$ km/s.

7. Generation of regions of positive and negative charge

The proposed reconnection mechanism provides also insights to the mechanism leading to the generation of negative charge to the top of \cap at height 1500-3000 km above Earth and positive charge to the bottom of \cup at 5000–8000 km above Earth [F8]. The formation of these regions can be indeed understood: due to the small inertia of electron Cooper pairs of solar wind and the fact that the electronic gyroradius 20 km is smaller than the radius of flux tube of Earth's magnetic field in magnetotail for $k_d = 56$, electrons are not expected to leak out of the flux tube in the reconnection process. Ions are however much more massive and their gyroradius (700 km for proton) is much larger than 20 km so that they are expected to leak out in the reconnection process and end up to \cap thus providing it with a positive charge.

5.2.3 Auroras, meteors, and consciousness?

There are claims that auroras generate audible sounds [F14]. These sounds have not been detected by acoustic means. Magnetic sensory canvas hypothesis could explain this. The magnetic storms accompanying auroras should affect also our personal auditory canvases. In particular, Schumann resonances which could correspond either MEs parallel to the magnetic flux tubes or oscillations of the magnetic flux tubes, are excited. Higher Schumann resonances are in the audible range and could directly give rise to extrasensory perception of sounds.

There is also some other evidence for the sensory canvas hypothesis. Since 16th century it is known that also meteors produce audible sounds. What is mysterious that there is no time lag due to the propagation through the atmosphere. The explanation is that it is very low frequency em waves which propagate to Earth and generate sounds by interacting with the objects at the surface of Earth. Joined by the International Leonid Watch - Croatia (ILWC) project, a group of scientists presented the first instrumental detection of elusive electrophonic meteor sounds. In November 1998, the researchers from the Croatian Physical Society and the University of Kentucky organized an expedition to Mongolia to observe the anticipated Leonid meteor shower and shed some light on the phenomenon [F10]. The complete data analysis revealed two electrophonic (electronically detected) sounds that provided several important clues about the nature of this longstanding astronomical mystery. It became clear that sounds were created when the meteors were crossing night-time ionosphere. The existing theories cannot however completely explain the phenomenon. The energy of meteor does not seem to be high enough to invoke the electric fields needed to explain the electronically recorded sounds, and strangely enough, the frequencies are much lower than expected, in the region 20-40 Hz.

Magnetic flux quanta as carriers of the electromagnetic perturbations might allow a better understanding of the phenomenon. Perhaps the audible sounds, in contrast to the electronically recorded ones which seem to be of much lower frequency, are in fact generated by the direct perturbations of magnetic auditory canvas: this would explain why there is no lag due to the propagation through atmosphere. Electronically recorded sounds could be induced by the em perturbations propagating along magnetic flux tubes at Schumann frequencies and the mirrors might act as resonators amplifying the em fields (electroacoustic sounds had frequency spectrum in the region of lowest Schumann frequencies). Notice that magnetic flux tubes of length shorter than Earth's circumference would give rise to higher resonance frequencies than Schumann frequencies.

There are also reports that seeing auroras can cause a loss of consciousness. This effect might not be only due to the depth of the aesthetic experience. The effects of magnetic storms on patients of mental hospitals are also well documented. If our sensory representations are indeed realized at magnetic flux tube structures associated with Earth's magnetic field, one is led to ask whether the dissipative processes associated with auroras destroying ionic supra currents might indeed affect directly our consciousness, inducing even a loss of consciousness.

The magnetic flux tube structures associated with the sensory canvas could also experience the pressure of the solar wind and change their shape during night time. Also this might correlate with the fact that we usually sleep during night time and daytime consciousness differs from nighttime consciousness.

5.3 Lightnings, Sprites, Elves, And The Hypothesis Of Magnetic Sensory Canvas

In 1920s, the Scottish physicist C. T. R. Wilson predicted the existence of brief flashes of light high above large thunderstorms [D2, D2]. Almost 70 years later, Bernard Vonnegut of SUNY Albany realized that this prediction could be tested by studying the videos of Earth's upper atmosphere recorded by space shuttle astronauts. William Boeck and Otha Vaughan from NASA decided to look for the evidence and they indeed found it. Also John Winkler and his colleagues had serendipitously observed a flash in moonless night time skies over Minnesota in 1989. These findings inspired two field programs (led by Walter Lyons and Davis Sentman respectively) to study the new phenomena and it soon became clear that the flashes are in fact a common phenomenon in the mesosphere.

Sentman and Lyons found two broad classes of flashes [F13, F15]: sprites and elves. These short lived luminous phenomena are associated with large thunder storms called mesoscale convective systems often covering entire states in the Great Plains of the US in summertime. These migratory regions contain often regions of active convection adjacent to the regions of weaker stratiform convection. Ground flashes with a negative polarity (Earth surface corresponds to the negative electrode) dominate in the active convection regions whereas the less frequent but more energetic flashes with positive polarity (Earth surface corresponds to positive electrode) predominate in the stratiform regions. The great majority of sprites and elves are initiated by ground flashes of the latter type. Elves and very low frequency perturbations from electromagnetically pulsed sources are centered above vertical channels to ground whereas sprites lie above horizontally extensive spider lightnings in the lower portion of the stratiform cloud.

My own interest on these phenomena was stimulated by the article [F7] according to which neither the origin of the blue light accompanying sprites nor the fast rate for the development of sprites are well-understood. The obvious strategy is to find whether the notion of many-sheeted space-time could provide an improved understanding of these phenomena.

The notion of many-sheeted space-time is crucial for TGD based model of brain involving in an essential manner also the notion of the magnetic sensory canvas: the magnetic flux tube structures involved can have size comparable to Earth's size. An

interesting question is whether one could somehow relate the notion of sensory magnetic canvas to the electromagnetic phenomena occurring in the atmosphere. Rather encouragingly, the basic dynamical time scales of lightnings, sprites and elves correspond to those associated with brain. This inspires some speculations about how magnetic bodies and atmospheric electromagnetic phenomena might relate.

5.3.1 Lightnings

A good summary about basic facts concerning lightnings [F12], sprites and elves can be found in Wikipedia [F1]. Lightnings are classified to positive and negative lightnings depending on whether the electron current is from ground to cloud or vice versa. The following brief summary gives a rough account of what happens in case of negative lightning for which electron current flows to ground.

An initial discharge, (or path of ionised air), called a “stepped leader”, starts from the cloud and proceeds generally downward in a number of quick jumps, typical length 50 meters, but taking a relatively long time (200 milliseconds) to reach the ground. This initial phase involves a small current and is almost invisible compared to the later effects. When the downward leader is quite close, a small discharge comes up from a grounded (usually tall) object because of the intensified electric field.

Once the ground discharge meets the stepped leader, the circuit is closed, and the main stroke follows with much higher current. The main stroke travels at about 0.1 c and has high current for .1 m or so. It may persist for longer periods with lower current.

In addition, lightning often contains a number of restrikes, separated by a much larger amount of time, 30 milliseconds being a typical value. This rapid restrike effect was probably known in antiquity, and the “strobe light” effect is often quite noticeable.

Positive lightning does not generally fit the above pattern.

Positive lightnings are rare but more energetic. The typical voltages, electric fields, and durations of strikes involved with positive *resp.* negative lightnings are 1 GV, 10^5 V/m and 1 ms *resp.* 1 GV, 10^4 V/m and .1 ms. During positive lighting there is a huge amount of VLF and ELF radiations which implies that lightning induces effects in ionospheric scale.

The notions of leader emerging from cloud and streamer emerging from ground and meeting before the strike are well established. The development of leader means that air becomes conductive in a stepwise manner by ionization. Stepped leaders are associated with negative lightnings and dart leaders with positive lightnings. Lightnings are accompanied by X ray bursts with duration $< .1$ ms. with X ray energies up to few hundred keV. The bursts are presumably generated during stepped leader and dart leader phase. Also gamma ray bursts have been observed.

Runaway breakdown is a generally accepted mechanism in the theory for the formation of lightnings. It is assumed that cosmic ray strikes atmospheric molecular and releases extremely energetic electrons having enhanced free path length of tens of centimeters. Electrons are accelerated in the electric field of storm and ionize further molecules and initiate the runaway breakdown at higher which then proceeds downwards. Conductive path with a length of typically 50 m is created. There are however some problems. The rate for the strikes by cosmic rays having sufficient energy is $50/\text{km}^2$ and too low to explain the number of lightnings during thunderstorm. Also the measured X ray burst intensity is only 5 per cent of the predicted value.

5.3.2 Sprites

Sprites come in several varieties and these complex structures have been dubbed with descriptive names like carrots, angles, jellyfish and A-bombs. The simplest sprites are so called C sprites which have transversal size of order 200 m and height of order 10 km and form structures resembling Fourth of July fireworks. The vertical extension

of sprites can be as high as 60 km and there lower end is typically at the height of 30 km (for illustrations of sprites and elves see [F7]).

In Wikipedia [F12] sprites are characterized as follows.

Sprites are now well-documented electrical discharges that occur high above the cumulonimbus cloud of an active thunderstorm. They appear as luminous reddish-orange, neon-like flashes, last longer than normal lower stratospheric discharges (typically around 17 milliseconds), and are usually spawned by discharges of positive lightning between the cloud and the ground.

Sprites can occur up to 50 km from the location of the lightning strike, and with a time delay of up to 100 milliseconds. Sprites usually occur in clusters of two or more simultaneous vertical discharges, typically extending from 65 to 75 km above the earth, with or without less intense filaments reaching above and below. Sprites are preceded by a sprite halo that forms because of heating and ionisation less than 1 millisecond before the sprite.

The structure of sprite resembles that of a botanic tree consisting of roots (negative end), trunk and branches (positive end). This bi-directional structure of the sprite suggests two separate processes: the first process proceeds upwards and is followed by a second process proceeding downwards. The blue color of the lower part of the sprite (roots) is known to be due to the transitions of N_2^+ ions whereas the red color of the upper part is due to the transitions of N_2 molecules.

Wilson's theory suggests that the process associated with trunk and branches of the tree corresponds to a dielectric breakdown induced by the ionization of molecules by electrons flowing upwards in the electric field generated by the spider lightning. The dipole field associated with the lightning behaves as $1/z^3$ as function of height from the pancake like electronic reservoir located at the thunder cloud at height of order 10 km. Since the dielectric strength (the critical electric field causing the ionization of molecules) is proportional to the density of the molecules, which decreases exponentially with height, the dielectric breakdown is predicted to begin from higher heights above thunder cloud and cause a cascade like electron current.

The expression for the drift velocity of electron in an external electric field is obtained from the condition

$$\frac{m_e v^2}{2} = eEl \quad , \quad l = \frac{1}{n\sigma} \quad . \quad (5.4)$$

Here σ denotes the total scattering cross section for the scattering of electrons on molecules and l denotes the length of the average free path of electron. The condition simply states that the kinetic energy gained in the field between two interactions equals to the work done by the electric field on electron.

Ionization becomes possible when the kinetic energy is above the ionization energy E_{ion} of the molecules of the atmosphere. This condition determines the critical value of the electric field as

$$eE_{cr} = 2E_{ion}n\sigma \quad . \quad (5.5)$$

The critical value of the electric field is proportional to the density n of the molecules decreasing exponentially with height. The values of the dipole moment p characterizing the electric fields generated by lightnings range from 10 to more than 10^3 coulomb kilometers (for the convenience of the reader we notice that one coulomb corresponds roughly to 10^{19} electronic charges). Assuming the distance scale $z \sim 40$ km, dipole moment $p \sim 10^3$ Ckm, and collision cross section $\sigma \sim \text{Angstrom}^2$, one finds that the critical drift velocity is of the same order of magnitude as the observed velocity .1 c for the generation of sprite. In [F7] it has been stated that the predicted critical drift velocity tends to be too small.

The negative end of the sprite (roots) accompanied by blue light suggests that the N_2^+ ions created in the electronic ionization run downwards in this region. The mechanism leading to the the transitions of N_2^+ ions generating blue light is most

naturally the collisions of N_2^+ ions with N_2 molecules. This assumption conforms with the basic facts about sprite formation and structure: the intensity of the blue light is comparable to that of red light, the blue end of the sprite develops later than the red end, the blue emission is at the lower end of the sprite, and the branching of the lower end proceeds downwards. Note that the critical velocity for the ionization of N_2 molecules by collisions with N_2^+ molecules is proportional to $1/\sqrt{M(N_2)n}$ and thus considerably smaller than in case of electron for given values of n and E . This together with the larger density of N_2 molecules implies that the lower part of the sprite is generated more slowly.

A priori also sprites for which thunder cloud carries positive charge are possible. Only two cases of sprites associated of this kind have been found, and according to [F7] this asymmetry is not yet well-understood. A possible explanation is following. When cloud is negatively charged, the pancake like electronic reservoir located at the thunderstorm provides the seed electrons initiating the ionization cascade providing new current carrying electrons. When the cloud is positively charged, the electrons would propagate downwards from upper part of atmosphere to the direction in which drift velocity decreases. There are however no seed electrons now. There is however a reservoir of positive N_2^+ ions in thunder cloud and they might be able to generate the dielectric breakdown. It is quite possible that the typical seed density is simply too low for this in most cases. These infrequent sprites should have blue or pink-blue upper end ($N_2^+ - N_2$ collisions can also excite N_2 molecules) and should develop with much more slower rate.

If the collisions with the electrons were responsible for the transitions of N_2^+ ions (as believed in [F7]), the intensity of the blue light would be by several orders of magnitude weaker from the fact that the density of N_2^+ ions is of the same order as that of electrons from the requirement of overall charge neutrality, and from the fact that the density of N_2 ions is much higher than that of electrons (there are roughly 1 electron per 10 billion N_2 molecules [F7] at the upper portion of the sprite).

5.3.3 Elves

In Wikipedia [F12] elves are characterize in the following manner.

Elves often appear as a dim, flattened, expanding glow around 400 km (250 miles) in diameter that lasts for, typically, just one millisecond [7]. They occur in the ionosphere 100 km (60 miles) above the ground over thunderstorms. Their colour was a puzzle for some time, but is now believed to be a red hue. Elves were first recorded on another shuttle mission, this time recorded off French Guiana on October 7, 1990. Elves is a frivolous acronym for Emissions of Light and Very Low Frequency Perturbations From Electromagnetic Pulse Sources. This refers to the process by which the light is generated; the excitation of nitrogen molecules due to electron collisions (the electrons having been energized by the electromagnetic pulse caused by a positive lightning bolt).

Elves are thus a phenomenon occurring above ionosphere rather whereas sprites are ionospheric phenomena. This allows to understand why they occur for positive lightnings (electrons flow from ground to cloud).

In case of elves the ionization mechanism differs from that for sprites. The radiation from the lightning decays with distance as $1/z$ and this guarantees that the threshold for the breakdown is exceeded as long as lightning current is sufficiently large. The observations show that there is a time lapse of order 10 ms between the lightning and the generation of elve: this lapse is consistent with the propagation of radiation with light velocity. Observations show that peak currents of 70 A or greater are required.

Electronic plasma frequency defined as

$$f_p^2 = \frac{n_e e^2}{m_e} \quad (5.6)$$

plays an important role in understanding the electromagnetic phenomena in atmo-

sphere. Plasma frequency defines the cutoff frequency for waves which can propagate inside sprite: what this means is that frequencies lower than f_p are reflected. The observations about reflections of em waves on sprites show that f_p is in the range 2–25 kHz which means that the density of electrons is in the range 10^4 to 10^6 cm^{-3} , somewhat more dilute than in aurora borealis and slightly above the electron concentration in the daytime E region of the ionosphere. VF and ELF em waves can propagate in the 80-90 km thick wave guide below ionosphere and sprite activity generates ELF waves, which are especially strong at Schumann resonance frequencies and serve as a global signature for them.

5.3.4 Dark matter hierarchy, lightnings, sprites, and elves

What is known about sprites and elves might be marginally understood in the framework of standard physics. The model for the leaders based on runaway breakdown induced by cosmic rays is however inconsistent with empirical facts and dark Bose-Einstein condensates at the flux tubes of Earth's magnetic field provide an alternative model. This inspires the question whether dark matter hierarchy could manifest itself somehow in these phenomena. The first thing one can do is to look whether the time and length scales involved could be assigned with the basic scales of the dark matter hierarchy.

1. Time scales

Millisecond time scale seems to govern the dynamics of both lightnings, sprites and elves. The net time for the formation of stepped leader is about $\tau = 200$ ms and since length scale involved is 10 km this means that generation of single step corresponds to millisecond time scale $\tau_{step} = 1$ ms. Also the time scales of strikes are in millisecond scale: for instance, sprite halos appears millisecond before spire, sprite typically last about 17 milliseconds, and elves last for 1 millisecond. Note that millisecond time scale assignable to d quark CD and 100 ms scale corresponds to electron.

The appearance of millisecond time scale for the main strike and appearance of re-strikes brings strongly in mind nerve pulse generation and nerve pulse sequences having similar time scales. Moreover, delta band of EEG resembles corresponding region of sferics and intense VLF and ELF radiation accompanies positive lightnings. The question is whether the similarity of time scales is a mere accident and whether lightnings could be regarded as sequences of scaled up nerve pulse like discharges involving kHz synchrony related to quark CDs and duration of 100 ms related to the CD of electron.

2. Length scales

One could consider at least half seriously the idea that the region between thunder cloud and Earth with thickness $L \sim 10$ km defining the length of leader is analogous to a scaled up dark variant of cell membrane. Similar idea could apply to the $L \sim 100$ km thick region between ionosphere and Earth surface. The length scale of single step about 50 m and its ratio to the distance $L = 10$ km is 2^{11} and could be understood in terms of the ratio τ/τ_{step} . One could wonder whether this ratio corresponds to proton-electron mass ratio.

1. Dark matter hypothesis implies that scaling proportional to r . The value of Planck constant can be deduced as $r = 2^{k_d} \simeq L/d$, where $d = 10$ nm denotes the thickness of the cell membrane. Note that \sqrt{r} proportionality appropriate for p-adic length scales does not work and these scales could be most naturally assigned with CDs. This gives the estimate $k_d = 40$ for thunder cloud and corresponds to Josephson frequency 640 Hz. For ionosphere one obtains $k_d = 47$, which corresponds to the 5 Hz Josephson frequency assigned with wake-up EEG. 50 km defining the maximum distance between sprites and lightning and would correspond to $k_d = 46$ and 10 Hz Josephson frequency with obvious meaning in biology.

2. The length scale 50 m for the step of the leader could correspond to $k_d = 18$ and Josephson frequency of 2.5 GHz.
3. The generation of lightning could proceed from $k_d = 18$ level to higher levels of dark matter hierarchy. This kind of hierarchical development could explain the sprites and elves as well as strong ELF and VLF is associated with positive lightnings as being to the fact that electron current proceeds upwards and can thus excite $k_d = 40$ ionospheric excitations (sprites) and $k_d = 47$ excitations (elves) above ionosphere.

3. *Dark matter hierarchy and generation of leaders*

Dark matter hierarchy suggests a new kind of mechanism initiating the development of leaders. The dissipation-free acceleration of cyclotron electron Cooper pairs and of ions at the flux tubes in strong electric field and transfer to the atomic space-time sheets could provide a mechanism generating the typically 50 meter long steps of step leaders. The energy of 5 MeV, which corresponds to electron rest mass, would be reached in a free acceleration of proton or electron Cooper pair in an electric field of $E = 10^4$ V/m associated with negative lightnings over distance 50 meters. This corresponds to electron rest mass so that also the generation of gamma rays could be understood. For dart leaders the same energy would be reached during 5 meter long free acceleration, which raises the question whether dart leaders are step leaders with shorter length of the basic step.

Electronic cyclotron energy scale for $k_d = 40$ level of dark matter hierarchy is about $E_c = 2$ keV. Therefore cyclotron photons emitted in the collisions of electron Cooper pairs at the magnetic flux tubes of Earth could be involved with the generation of highly energetic electrons which in turn induce runaway breakdown. This energy is perhaps too small to explain the energies of highest X rays and of gamma rays.

4. *$k_d = 47$ dark matter level and the formation of sprites and elves*

The too low drift velocity of electrons drifting to the trunk and branches of sprite from electron reservoir at the bottom of the cloud is a possible problem in the model for the formation of sprites. Almost dissipation free upwards directed acceleration of Cooper pairs of electrons at $k_d = 47$ magnetic flux tubes would allow much higher drift velocities since the free path of electron Cooper pair would be longer. This would reduce the critical value of the electric field and make the process faster.

The density of N_2 molecules is about $10^3/\mu m^3$ at the upper part of the sprite and one can consider the possibility that at least part of these molecules reside at the magnetic flux tubes of the dark counterpart B_{end} of the Earth's magnetic field B_E which is hypothesized to have the value $B_{end} = 2B_E/5$ on basis of the model explaining the effects of ELF em fields on vertebrate brain (see the appendix of [K3] and [K5]). One can even raise the question whether singly charged exotic N_2^+ ions (behaving like neutral atoms electronically) could be present and define cyclotron condensates. The downwards directed dissipation-free acceleration of N_2^+ exotic ions scattering from ordinary N_2^+ ions could induce the transitions of N_2^+ ions responsible for the blue color in the lower part of sprite.

In the case of elves the ionization mechanism is believed to involve radiation from lightning energizing electrons in turn exciting N_2 molecules. The effect would be stronger if Bose-Einstein condensate of exotic N_2^+ ions is excited coherently by the collisions with energized electronic Cooper pairs.

5.3.5 Atmospheric electromagnetic phenomena and consciousness

The hypothesis about magnetic sensory canvas should be related to experimental reality somehow. The electromagnetic phenomena (such as lightnings, auroras sprites, elves) in the atmospheric waveguide are indeed rather promising in this respect.

1. If the magnetic sensory canvas hypothesis holds true one has the right to expect that brain functioning and these electromagnetic phenomena should possess common time scales. Amazingly, the frequency spectra as well as typical durations for the lightnings, sprites and elves correspond to those associated with brain. The typical duration of lightning is about .1 seconds which is the fundamental time scale of sensory consciousness and defines the duration of the memetic code word. Sprites are generated during one millisecond and typically last 10-100 milliseconds. The spectrum of the spherics associated with the activity of lightnings is in the range 0-25 kHz: this follows from the fact that waves in this frequency range are reflected from ionosphere and propagate in the waveguide defined by the atmosphere. It is perhaps not an accident that this frequency range corresponds to the range of frequencies audible for human brain.

It is also known that hippocampus, which is crucial for long term memories, contains highly ordered magnetite particles (private communication) and responds in complex ways to magnetic perturbations having frequencies in ELF range and amplitudes in picoTesla range. The amplitudes for the perturbations of Earth's magnetic field are also in picoTesla range in theta and alpha range of EEG frequencies. Also alpha waves generate a peak in MEG with amplitude of order picoTesla: presumably this peak corresponds to the lowest Schumann frequency. Also eyes generate static magnetic fields with strength of order 10 picoTesla.

In consistency with the observations of Blackmann and others about the intensity and frequency windows for ELF em fields, these findings encourage to think that brain is indeed sensitive to the perturbations of Earth's magnetic field (note however that the electric fields in these experiments are typically of order 1 – 10 V/m [J11] and roughly two orders of magnitude higher). This would mean also a sensitivity to the perturbations of the magnetic flux tube structures defining the hierarchy of magnetic bodies. These perturbation might directly affect conscious experience (not necessarily at our level of hierarchy) giving rise to effective extrasensory perceptions and the effects at the level of brain would represent a reaction to this kind of conscious experience.

2. There should be also interaction between brain and the electromagnetic phenomena in the atmosphere and Schumann resonances which characterize the perturbations of Earth's magnetic field should be of special importance. In fact, the third person aspect of conscious experience might be due to the cyclotron transitions at flux tubes assignable with dark parts of the Earth's magnetic field [K5]. Lightnings, sprites and elves indeed excite Schumann resonances known to affect strongly human consciousness [J10]. Furthermore, the shape of the frequency spectrum for spherics at delta frequencies resembles delta band of EEG [J8]. The generation of Schumann resonances might mean also a direct interaction with the magnetic sensory canvas and one cannot exclude the possibility that atmospheric phenomena could have role in signalling at the higher levels of self hierarchy. Perhaps the peak in MEG at alpha range results from this kind of interaction.

There are typically few sprites per minute and they generate strong Schumann resonances. One can wonder whether sprites and/or the associated spider lightnings could have correlates at the level of EEG and neurophysiology and perhaps even affect conscious experience, say by causing changes in mood. It should be possible to check whether the EEGs of persons possibly located at different parts of globe display simultaneous correlates for sprites and lightnings.

3. One could go even further and try to test the fractality hypothesis. The ratio of length scales associated with pairs cell membrane-cell, cortex-brain and atmospheric waveguide-Earth are of same order of magnitude. This observation and Mother Gaia hypothesis encourages to consider the possibility that the atmosphere could in some sense be a scaled-up version of cortex, which in turn would be scaled-up version of the cell membrane. For instance, the transversal size of

order 200 m of the smallest sprites (so called C sprites) would correspond to the micron length scale in brain length scale and thus the size of smallest neurons whereas this length scale corresponds to nanometer (DNA size scale) at neuronal level. The height of C sprites which is about 10 km corresponds to the length of about 50 microns which in turn reminds of the lengths of cortical neurons.

4. The geometric appearance of sprites brings in mind the geometry of neurons and one can even play with the thought that sprites and lightnings are associated with pre-existing electric flux tube structures in atmosphere so that lightnings, sprites and elves could be phenomena comparable to nerve pulse activity and graded potentials in brain. The geometric structures associated with sprites resembles the axonal and dendritic geometries for cortical neurons.
5. The most fascinating possibility is that sprites and elves are parts of magnetic bodies made temporarily visible. If so, then one could also consider the possibility that magnetic bodies form a self hierarchy analogous to that formed by monocellulars and increasingly complex multicellulars with cell being replaced with brain/physical body of organism. Various organisms would obviously form the lowest level of this self hierarchy and various levels of collective consciousness would be the electromagnetic analog of the multicellular life.

5.3.6 What auroras, tornadoes, ball lightnings, and cold fusion might have in common?

New physics due to a ground state, which is almost vacuum extremal could be the common demonimator of very large class of anomalous phenomena including auroras, tornadoes, ball lightnings, cold fusion, sonofusion, and last but not least - the entire biology!

If the density of the ions inside magnetic flux tubes is constant, garden hose instability for magnetic field suggests itself strongly. Similar instability might be associated with the flux quanta of the em and Z^0 magnetic fields associated with almost vacuum extremals (this is not assumed about sensory canvas) if they contain Z^0 ions which can be electromagnetically neutral. This kind of instability giving rise to spiral helices is the basic assumption in the TGD based model of tornadoes. This suggests super-conductivity analogous to that in the case of cell membrane for almost vacuum extremals, and since rotating systems probably involve also magnetic fields, phenomena analogous to auroras could be involved also now.

It is indeed well known that luminous phenomena resembling those accompanying ball lightnings [F12] are associated also with tornadoes [H3, H1, H5]). Edward Lewis introduces the notion of plasmoid to explain a wide range of phenomena including ball lightnings and tornadoes. He assigns plasmons even with cold fusion (the damage resulting to Palladium target in cold fusion resembles the traces caused by ball lightnings, [C2]) and super-conductivity (sic!). Although Lewis obviously over-generalizes the notion of plasmoid, one cannot deny that the concept has a strong theoretical appeal in it.

Also sonoluminescence [C1] could involve a phase transition to almost vacuum extremal ground state and the emission of visible light could come from the membrane like boundary layer. The UV photons could generate the observed high temperatures estimated to be as high as 20, 000 K, which corresponds to 2 eV photon energy. In this case the size scale of emitting region is in fact that of cell membrane. The proper identification of essence of plasmons could be the presence of membrane like structures with space-time sheets which are almost vacuum extremals. The presence of magnetic flux quanta far from vacuum extremal is also plausible if one takes the model of quantum biology as a starting point.

The findings of Lewis inspire the following basic ideas about the physics of many-sheeted space-time- some of the allready discussed.

1. The runaway mechanism for ions from the magnetic flux tubes could provide a general mechanism behind luminous phenomena like auroras, lightnings, ball lightnings, sprites, tornadoes, UFOS and various anomalous luminous phenomena such as earth lights in tectonically active areas. Plasmoids could result from Josephson currents alone via the leakage of dark highly energetic particles and dark Josephson photons to visible matter sector. Also analog of nerve pulse could be involved responsible for phenomena like lightning and elves. The unidentified source of energy in these phenomena might be the energy associated with the dark supra currents.
2. The break-down of the dark super-conductivity could be understood in terms of a supra current leakage to non-super-conducting space-time sheets caused by the inertia of the current carriers. The critical temperature could be determined as the temperature below which the join along boundaries bonds between super-conducting and non-conducting space-time sheets are not formed. The temperature of super-conducting space-time sheets could be much more lower than this temperature but this is not necessary if high \hbar dark matter is in question.
3. The Trojan horse mechanism of cold fusion [K20] involves the notion many-sheeted space-time in an essential manner. Perhaps the dark supra currents running at the magnetic flux tube space-time sheets not containing the nuclear Coulombic fields provide the means to circumvent the Coulomb barrier.

6 Appendix

6.1 Hierarchy Of Planck Constants And The Generalization Of The Notion Of Imbedding Space

In the following the recent view about structure of imbedding space forced by the quantization of Planck constant is summarized. The question is whether it might be possible in some sense to replace H or its Cartesian factors by their necessarily singular multiple coverings and factor spaces. One can consider two options: either M^4 or the causal diamond CD. The latter one is the more plausible option from the point of view of WCW geometry.

6.1.1 The evolution of physical ideas about hierarchy of Planck constants

The evolution of the physical ideas related to the hierarchy of Planck constants and dark matter as a hierarchy of phases of matter with non-standard value of Planck constants was much faster than the evolution of mathematical ideas and quite a number of applications have been developed during last five years.

1. The starting point was the proposal of Nottale [E1] that the orbits of inner planets correspond to Bohr orbits with Planck constant $\hbar_{gr} = GMm/v_0$ and outer planets with Planck constant $\hbar_{gr} = 5GMm/v_0$, $v_0/c \simeq 2^{-11}$. The basic proposal [K18] was that ordinary matter condenses around dark matter which is a phase of matter characterized by a non-standard value of Planck constant whose value is gigantic for the space-time sheets mediating gravitational interaction. The interpretation of these space-time sheets could be as magnetic flux quanta or as massless extremals assignable to gravitons.
2. Ordinary particles possibly residing at these space-time sheet have enormous value of Compton length meaning that the density of matter at these space-time sheets must be very slowly varying. The string tension of string like objects implies effective negative pressure characterizing dark energy so that the interpretation in terms of dark energy might make sense [K19]. TGD predicted

a one-parameter family of Robertson-Walker cosmologies with critical or over-critical mass density and the “pressure” associated with these cosmologies is negative.

3. The quantization of Planck constant does not make sense unless one modifies the view about standard space-time is. Particles with different Planck constant must belong to different worlds in the sense local interactions of particles with different values of \hbar are not possible. This inspires the idea about the book like structure of the imbedding space obtained by gluing almost copies of H together along common “back” and partially labeled by different values of Planck constant.
4. Darkness is a relative notion in this framework and due to the fact that particles at different pages of the book like structure cannot appear in the same vertex of the generalized Feynman diagram. The phase transitions in which partonic 2-surface X^2 during its travel along X_l^3 leaks to another page of book are however possible and change Planck constant. Particle (say photon -) exchanges of this kind allow particles at different pages to interact. The interactions are strongly constrained by charge fractionization and are essentially phase transitions involving many particles. Classical interactions are also possible. It might be that we are actually observing dark matter via classical fields all the time and perhaps have even photographed it [K21].
5. The realization that non-standard values of Planck constant give rise to charge and spin fractionization and anyonization led to the precise identification of the prerequisites of anyonic phase [K14]. If the partonic 2-surface, which can have even astrophysical size, surrounds the tip of CD, the matter at the surface is anyonic and particles are confined at this surface. Dark matter could be confined inside this kind of light-like 3-surfaces around which ordinary matter condenses. If the radii of the basic pieces of these nearly spherical anyonic surfaces - glued to a connected structure by flux tubes mediating gravitational interaction - are given by Bohr rules, the findings of Nottale [E1] can be understood. Dark matter would resemble to a high degree matter in black holes replaced in TGD framework by light-like partonic 2-surfaces with a minimum size of order Schwarzschild radius r_S of order scaled up Planck length $l_{Pl} = \sqrt{\hbar_{gr} G} = GM$. Black hole entropy is inversely proportional to \hbar and predicted to be of order unity so that dramatic modification of the picture about black holes is implied.
6. Perhaps the most fascinating applications are in biology. The anomalous behavior ionic currents through cell membrane (low dissipation, quantal character, no change when the membrane is replaced with artificial one) has a natural explanation in terms of dark supra currents. This leads to a vision about how dark matter and phase transitions changing the value of Planck constant could relate to the basic functions of cell, functioning of DNA and amino-acids, and to the mysteries of bio-catalysis. This leads also a model for EEG interpreted as a communication and control tool of magnetic body containing dark matter and using biological body as motor instrument and sensory receptor. One especially amazing outcome is the emergence of genetic code of vertebrates from the model of dark nuclei as nuclear strings [L1, K21], [L1].

6.1.2 The most general option for the generalized imbedding space

Simple physical arguments pose constraints on the choice of the most general form of the imbedding space.

1. The fundamental group of the space for which one constructs a non-singular covering space or factor space should be non-trivial. This is certainly not possible for M^4 , CD, CP_2 , or H . One can however construct singular covering spaces. The fixing of the quantization axes implies a selection of the sub-space $H_4 = M^2 \times S^2 \subset M^4 \times CP_2$, where S^2 is geodesic sphere of CP_2 . $\hat{M}^4 = M^4 \setminus M^2$ and $\hat{CP}_2 = CP_2 \setminus S^2$

have fundamental group Z since the codimension of the excluded sub-manifold is equal to two and homotopically the situation is like that for a punctured plane. The exclusion of these sub-manifolds defined by the choice of quantization axes could naturally give rise to the desired situation.

2. CP_2 allows two geodesic spheres which left invariant by $U(2)$ resp. $SO(3)$. The first one is homologically non-trivial. For homologically non-trivial geodesic sphere $H_4 = M^2 \times S^2$ represents a straight cosmic string which is non-vacuum extremal of Kähler action (not necessarily preferred extremal). One can argue that the many-valuedness of \hbar is un-acceptable for non-vacuum extremals so that only homologically trivial geodesic sphere S^2 would be acceptable. One could go even further. If the extremals in $M^2 \times CP_2$ can be preferred non-vacuum extremals, the singular coverings of M^4 are not possible. Therefore only the singular coverings and factor spaces of CP_2 over the homologically trivial geodesic sphere S^2 would be possible. This however looks a non-physical outcome.
 - (a) The situation changes if the extremals of type $M^2 \times Y^2$, Y^2 a holomorphic surface of CP_3 , fail to be hyperquaternionic. The tangent space M^2 represents hypercomplex sub-space and the product of the Kähler-Dirac gamma matrices associated with the tangent spaces of Y^2 should belong to M^2 algebra. This need not be the case in general.
 - (b) The situation changes also if one reinterprets the gluing procedure by introducing scaled up coordinates for M^4 so that metric is continuous at $M^2 \times CP_2$ but CDs with different size have different sizes differing by the ratio of Planck constants and would thus have only piece of lower or upper boundary in common.
3. For the more general option one would have four different options corresponding to the Cartesian products of singular coverings and factor spaces. These options can be denoted by $C-C$, $C-F$, $F-C$, and $F-F$, where C (F) signifies for covering (factor space) and first (second) letter signifies for CD (CP_2) and correspond to the spaces $(\hat{C}D \hat{\times} G_a) \times (\hat{C}P_2 \hat{\times} G_b)$, $(\hat{C}D \hat{\times} G_a) \times \hat{C}P_2/G_b$, $\hat{C}D/G_a \times (\hat{C}P_2 \hat{\times} G_b)$, and $\hat{C}D/G_a \times \hat{C}P_2/G_b$.
4. The groups G_i could correspond to cyclic groups Z_n . One can also consider an extension by replacing M^2 and S^2 with its orbit under more general group G (say tetrahedral, octahedral, or icosahedral group). One expects that the discrete subgroups of $SU(2)$ emerge naturally in this framework if one allows the action of these groups on the singular sub-manifolds M^2 or S^2 . This would replace the singular manifold with a set of its rotated copies in the case that the subgroups have genuinely 3-dimensional action (the subgroups which corresponds to exceptional groups in the ADE correspondence). For instance, in the case of M^2 the quantization axes for angular momentum would be replaced by the set of quantization axes going through the vertices of tetrahedron, octahedron, or icosahedron. This would bring non-commutative homotopy groups into the picture in a natural manner.

6.1.3 About the phase transitions changing Planck constant

There are several non-trivial questions related to the details of the gluing procedure and phase transition as motion of partonic 2-surface from one sector of the imbedding space to another one.

1. How the gluing of copies of imbedding space at $M^2 \times CP_2$ takes place? It would seem that the covariant metric of CD factor proportional to \hbar^2 must be discontinuous at the singular manifold since only in this manner the idea about different scaling factor of CD metric can make sense. On the other hand, one can always scale the M^4 coordinates so that the metric is continuous but the sizes of CDs with different Planck constants differ by the ratio of the Planck constants.

2. One might worry whether the phase transition changing Planck constant means an instantaneous change of the size of partonic 2-surface in M^4 degrees of freedom. This is not the case. Light-likeness in $M^2 \times S^2$ makes sense only for surfaces $X^1 \times D^2 \subset M^2 \times S^2$, where X^1 is light-like geodesic. The requirement that the partonic 2-surface X^2 moving from one sector of H to another one is light-like at $M^2 \times S^2$ irrespective of the value of Planck constant requires that X^2 has single point of M^2 as M^2 projection. Hence no sudden change of the size X^2 occurs.
3. A natural question is whether the phase transition changing the value of Planck constant can occur purely classically or whether it is analogous to quantum tunnelling. Classical non-vacuum extremals of Chern-Simons action have two-dimensional CP_2 projection to homologically non-trivial geodesic sphere S_I^2 . The deformation of the entire S_I^2 to homologically trivial geodesic sphere S_{II}^2 is not possible so that only combinations of partonic 2-surfaces with vanishing total homology charge (Kähler magnetic charge) can in principle move from sector to another one, and this process involves fusion of these 2-surfaces such that CP_2 projection becomes single homologically trivial 2-surface. A piece of a non-trivial geodesic sphere S_I^2 of CP_2 can be deformed to that of S_{II}^2 using 2-dimensional homotopy flattening the piece of S^2 to curve. If this homotopy cannot be chosen to be light-like, the phase transitions changing Planck constant take place only via quantum tunnelling. Obviously the notions of light-like homotopies (cobordisms) are very relevant for the understanding of phase transitions changing Planck constant.

6.1.4 How one could fix the spectrum of Planck constants?

The question how the observed Planck constant relates to the integers n_a and n_b defining the covering and factors spaces, is far from trivial and I have considered several options. The basic physical inputs are the condition that scaling of Planck constant must correspond to the scaling of the metric of CD (that is Compton lengths) on one hand and the scaling of the gauge coupling strength $g^2/4\pi\hbar$ on the other hand.

1. One can assign to Planck constant to both CD and CP_2 by assuming that it appears in the commutation relations of corresponding symmetry algebras. Algebraist would argue that Planck constants $\hbar(CD)$ and $\hbar(CP_2)$ must define a homomorphism respecting multiplication and division (when possible) by G_i . This requires $r(X) = \hbar(X)\hbar_0 = n$ for covering and $r(X) = 1/n$ for factor space or vice versa.
2. If one assumes that $\hbar^2(X)$, $X = M^4, CP_2$ corresponds to the scaling of the covariant metric tensor g_{ij} and performs an over-all scaling of H -metric allowed by the Weyl invariance of Kähler action by dividing metric with $\hbar^2(CP_2)$, one obtains the scaling of M^4 covariant metric by $r^2 \equiv \hbar^2/\hbar_0^2 = \hbar^2(M^4)/\hbar^2(CP_2)$ whereas CP_2 metric is not scaled at all.
3. The condition that \hbar scales as n_a is guaranteed if one has $\hbar(CD) = n_a\hbar_0$. This does not fix the dependence of $\hbar(CP_2)$ on n_b and one could have $\hbar(CP_2) = n_b\hbar_0$ or $\hbar(CP_2) = \hbar_0/n_b$. The intuitive picture is that n_b - fold covering gives in good approximation rise to $n_a n_b$ sheets and multiplies YM action action by $n_a n_b$ which is equivalent with the $\hbar = n_a n_b \hbar_0$ if one effectively compresses the covering to $CD \times CP_2$. One would have $\hbar(CP_2) = \hbar_0/n_b$ and $\hbar = n_a n_b \hbar_0$. Note that the descriptions using ordinary Planck constant and coverings and scaled Planck constant but contracting the covering would be alternative descriptions.

This gives the following formulas $r \equiv \hbar/\hbar_0 = r(M^4)/r(CP_2)$ in various cases.

$$\begin{array}{cccc}
 C - C & F - C & C - F & F - F \\
 \hline
 r & n_a n_b & \frac{n_a}{n_b} & \frac{n_b}{n_a} & \frac{1}{n_a n_b}
 \end{array}$$

6.1.5 Preferred values of Planck constants

Number theoretic considerations favor the hypothesis that the integers corresponding to Fermat polygons constructible using only ruler and compass and given as products $n_F = 2^k \prod_s F_s$, where $F_s = 2^{2^s} + 1$ are distinct Fermat primes, are favored. The reason would be that quantum phase $q = \exp(i\pi/n)$ is in this case expressible using only iterated square root operation by starting from rationals. The known Fermat primes correspond to $s = 0, 1, 2, 3, 4$ so that the hypothesis is very strong and predicts that p-adic length scales have satellite length scales given as multiples of n_F of fundamental p-adic length scale. $n_F = 2^{11}$ corresponds in TGD framework to a fundamental constant expressible as a combination of Kähler coupling strength, CP_2 radius and Planck length appearing in the expression for the tension of cosmic strings, and the powers of 2^{11} was proposed to define favored as values of n_a in living matter [K5].

The hypothesis that Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1+i)k-1$, $k \in \{113, 151, 157, 163, 167, 239, 241.. \}$ (the number theoretical miracle is that all the four scaled up electron Compton lengths $L_e(k) = \sqrt{5}L(k)$ with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm) define scaled up copies of electro-weak and QCD type physics with ordinary value of \hbar and that these physics are induced by dark variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_a}$, $k_d = k_i - k_j$, and the resulting picture finds support from the ensuing models for biological evolution and for EEG [K5]. This hypothesis - to be referred to as Mersenne hypothesis - replaces the rather ad hoc proposal $r = \hbar/\hbar_0 = 2^{11k}$ for the preferred values of Planck constant.

6.1.6 How Planck constants are visible in Kähler action?

$\hbar(M^4)$ and $\hbar(CP_2)$ appear in the commutation and anti-commutation relations of various superconformal algebras. Only the ratio of M^4 and CP_2 Planck constants appears in Kähler action and is due to the fact that the M^4 and CP_2 metrics of the imbedding space sector with given values of Planck constants are proportional to the corresponding Planck. This implies that Kähler function codes for radiative corrections to the classical action, which makes possible to consider the possibility that higher order radiative corrections to functional integral vanish as one might expect at quantum criticality. For a given p-adic length scale space-time sheets with all allowed values of Planck constants are possible. Hence the spectrum of quantum critical fluctuations could in the ideal case correspond to the spectrum of \hbar coding for the scaled up values of Compton lengths and other quantal lengths and times. If so, large \hbar phases could be crucial for understanding of quantum critical superconductors, in particular high T_c superconductors.

6.2 Cyclotron Frequencies And Larmor Frequencies

The appendix emphasizes the difference between the endogenous magnetic field B_{end} explaining the effects of ELF em fields on vertebrate brain and Earth's magnetic field B_E and lists cyclotron and Larmor frequencies of some ions for B_{end} .

6.2.1 The relationship between the values of the endogenous magnetic field and the Earth's magnetic field

For years I erratically believed that the magnitude of the magnetic field assignable to the biological body is $B_E = .5$ Gauss, the nominal value of the Earth's magnetic field. Probably I had made the calculational error at very early stage when taking Ca^{++} cyclotron frequency as a standard. I am grateful for Bulgarian physicist Rossen Kolarov for pointing to me that the precise magnitude of the magnetic field implying the observed 15 Hz cyclotron frequency for Ca^{++} is .2 Gauss and thus slightly smaller than the minimum value .3 Gauss of B_E . This value must be assigned to the magnetic body carrying dark matter rather than to the flux quanta of the Earth's magnetic

field. This field value corresponds roughly to the magnitude of B_E at distance $1.4R$, R the radius of Earth.

Dark matter hierarchy leads to a detailed quantitative view about quantum biology with several testable predictions [K5]. The applications to living matter suggests that the basic hierarchy corresponds to a hierarchy of Planck constants coming as $\hbar(k) = \lambda^k(p)\hbar_0$, $\lambda \simeq 2^{11}$ for $p = 2^{127-1}$, $k = 0, 1, 2, \dots$ [K5]. Also integer valued sub-harmonics and integer valued sub-harmonics of λ might be possible. Each p-adic length scale corresponds to this kind of hierarchy. Number theoretical arguments suggest a general formula for the allowed values of λ [K7] as $\lambda = n$ where n characterizes the quantum phase $q = \exp(i\pi/n)$ characterizing Jones inclusion [K24]. The values of n for which quantum phase is expressible using only iterated square root operation are number theoretically preferred and correspond to integers n expressible as $n = 2^k \prod_n F_{s_n}$, where $F_s = 2^{2^s} + 1$ is Fermat prime and each of them can appear only once. $n = 2^{11}$ obviously satisfies this condition. The lowest Fermat primes are $F_0 = 3, F_1 = 5, F_2 = 17$. The prediction is that also n-multiples of p-adic length scales are possible as preferred length scales. The unit of magnetic flux scales up as $h_0 \rightarrow h = nh_0$ in the transition increasing Planck constant: this is achieved by scalings $L_e(k) \rightarrow nL_e(k)$ and $B \rightarrow B/n$.

$B = .2$ Gauss would corresponds to a flux tube radius $L = \sqrt{5/2} \times L_e(169) \simeq 1.58L_e(169)$, which does not correspond to any p-adic length scale as such. $k = 168 = 2^3 \times 3 \times 7$ with $n = 5$ would predict the field strength correctly as $B_{end} = 2B_E/5$ and predict the radius of the flux tube to be $r = 18 \mu\text{m}$, size of a large neuron. However, $k = 169$ with flux $2h_5$ would be must more attractive option since it would give a direct connection with Earth's magnetic field. Furthermore, the model for EEG forces to assume that also a field $B_{end}/2$ must be assumed and this gives the minimal flux h_5 . Note that $n = 5$ is the minimal value of n making possible universal topological quantum computation with Beraha number $B_n = 4\cos^2(\pi/n)$ equal to Golden Mean [K23].

An interesting working hypothesis is that B_{end} is the dark companion of the the Earth's magnetic field and that the ratio $B_{end} = 2B_E/5$ holds true in the entire magnetosphere as a time average so that B_{end} would define what might be called the dark magnetosphere of Earth.

6.2.2 Table of cyclotron frequencies and magnetic frequencies

A detailed study of the cyclotron frequencies demonstrates that they indeed seem to correspond to important EEG frequencies. The cyclotron frequencies associated with other singly ionized atoms can be obtained by the formula

$$f = \frac{A}{20} \times f(Ca^{2+}) \quad f(Ca^{2+}) \simeq 15 \text{ Hz} . \quad (6.1)$$

Here the strength of the endogenous magnetic field B_{end} is assumed to be .2 Gauss = 2×10^{-5} Tesla. The

Table 6 lists cyclotron frequencies and their lowest multiples for some of the most important ions.

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Table 6: The first column gives cyclotron frequency in cycles per second for some ions in the endogenous magnetic field $B_{end} = 2B_E/5 = .2$ Gauss explaining the effects of ELF em fields on vertebrate brain ($B_E = .5$ Gauss denotes the nominal of the Earth's magnetic field). The remaining columns give spin or nuclear spin and Larmor frequency f_L .

Elementary particle	f_1/Hz	J	f_L/Hz
e	5.6×10^5	1/2	2.8×10^5
p	300	1/2	419
Bosonic ions			
6Li	50.1	1	88.3
O^{2-}	37.4	0	0
Mg^{++}	25.0	0	0
Ca^{++}	15.0	0	0
Mn^{2+}	11.4	5/2	520
Fe^{2+}	10.8	0	0
Co^{2+}	10.0	7/2	695
Zn^{2+}	9.4	0	0
Se^{2-}	7.6	0	0
Fermionic ions			
${}^7Li^+$	42.9	3/2	489
N^+	21.4	1	60.6
F^-	15.8	1/2	395
Na^+	13.0	3/2	333
Al^+	11.1	5/2	546
Si^+	10.7	0	0
P^+	9.7	1/2	170
S^-	9.4	0	0
Cl^-	8.5	3/2	130
K^+	7.5	3/2	58.5
Cr^-	5.7	3/2	71.1
Cu^+	4.8	3/2	333.9
Ag^+	2.8	1/2	17
I^+	2.4	5/2	420
Au^+	1.5	3/2	21

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